CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
Karen Ross, Secretary

2009
Specialty Crop Block Grant Program – Farm Bill (SCBGP-FB)
FINAL REPORT

USDA, AMS Agreement No:
Specialty Crop Agreement No. 12-25-B-0910

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2009 Specialty Crop Block Grant Program – Farm Bill
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SPECIALTY CROP BLOCK GRANT PROJECTS

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

Project No.: 1	**Project Title:** Best Management Practices for Honey Bees Pollinating California's Specialty Crops	
Grant Recipient: Project Apis m.	**Grant Agreement No.:** SCB09025	**Date Submitted:** December 2012
Recipient Contact: Christi Heintz	**Telephone:** (520) 834-2832	**Email:** christih@cox.net

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Background: The Apiary Inspectors of America (AIA) has been reporting a 30% loss of overwintering bee populations each year. These losses are unsustainable for such a vital component of the food supply. This project implemented an outreach program of Best Management Practices (BMPs) to build a sustainable pollination industry to support California's (CA) specialty crops. An outreach program of BMPs was needed to enhance the competitiveness of CA specialty crops by assuring adequate and complete pollination by a well-managed beekeeping industry. Specifically, this involved a centralized communications campaign using print and electronic media to build and disseminate BMPs for beekeepers and growers. BMP topics included 1) bee nutrition, 2) pest control, 3) disease control, 4) hive management, 5) colony management, 6) transportation, and 7) grower BMP's.

Motivation: Honey bees pollinate a third of the human food supply, including many of CA's specialty crops. Honey bee health has been compromised due to various stressors including Varroa mites, Colony Collapse Disorder (CCD), transportation of colonies across country for pollination services and loss of bee forage resources. BMPs were not an integral part of the beekeeping industry prior to this effort.

Previous SCBGPs: This project complimented the 2007 project, Evaluating Bee Health, wherein objective assessment of bee health was the primary goal. Field and laboratory health indicators were successfully pursued. The current project allowed an update to the Laboratory Directory, one of the deliverables of the 2007 project.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Accomplishments and significant results

- Identified and developed eight areas for BMP emphasis: nutrition; pest and disease control (2); hive, colony and business management (3); transportation; and grower BMPs
- Initiated a BMP webpage that has become the "go to" source of BMP information for beekeepers, receiving up to 250 hits/month and a total of 4,000 hits since inception
- Prepared a trade show booth for dissemination of BMP information, with approximately 11,500 individuals viewing the trade show booth at 27 different meetings and conferences
    - Created an auto-advance, timed and continuous-looped PowerPoint slide show of BMPs for the trade show booth monitor display
- Developed four multi-colored tri-fold BMP brochures: beekeeper BMPs, grower BMPs, a transportation guide, and a Seasonal Guide of BMPs
- Created six multi-colored one page fact sheets targeting six different BMP areas
- Prepared and delivered 33 BMP oral presentations to a collective audience of 3,353 individuals
- Developed four BMP videos and posted them to the BMP website and Youtube: Varroa, Nutrition, Nosema and Transportation
- Completed six elearning modules targeting six different BMP areas
- Expanded enewsletter distribution from periodic publication to each month, increasing subscriber list by two and a half times and emphasizing various BMP areas each month
- Enumerated 65 different publications and/or media hits referencing various aspects of this BMP effort, totaling a circulation of nearly 2.4 million individuals
- Expanded media influence with publication of DeRisi migratory survey, indirectly related to the BMP project, resulting in 6 additional significant media hits with circulation of nearly 7 million

Project Partners

- *Gene Brandi*: as beekeeper - guided project on BMPs, as Project Apis m board member and CA State Beekeeper Association leader – received updates on grant activities
- *Dr. Gordon Wardell*: assisted in development of BMP areas and tracking of management practices leading to strong 8+ frame colonies. Narrated video clips
- *Dr. Eric Mussen*: provided advice and information on BMP categories and conducting outreach, directed others to BMP website and outreach materials
- *Bob Curtis*: instrumental in grower BMPs outreach, provided almond industry feedback
- *Mark Looker*: provided assistance with enewsletter and website, monitored media hits
- *Dr. Gloria DeGrandi-Hoffman*: key expert providing information on nutrition BMPs

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

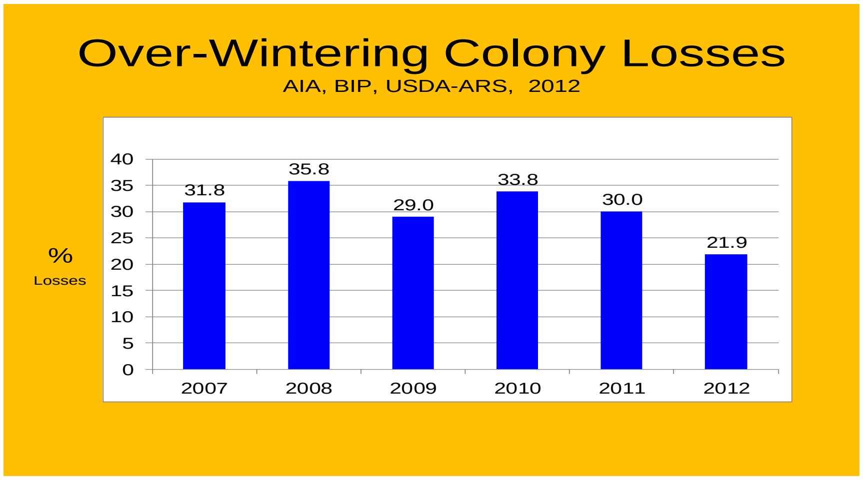
Activities performed to achieve goals and measurable outcomes

- Identified BMP areas of emphasis
- Conducted the first-ever beekeeper BMPs surveys (written and oral surveys)
- Assessed statistics on over-wintering and honey-producing colonies
- Assessed almond crop statistics for adequacy of pollination
- Developed a trade show booth, BMP brochures, one-page fact sheets, a BMP website at http://projectapism.org/content/view/48/43/, elearning modules, video clips, PowerPoint presentations
- Promoted BMPs at 33 different state, regional, national and grower meetings
- Developed expertise in and fine-tuned outreach formats (print, web, video, elearning modules)
- Maintained records of presentations given, trade show attendance, publications and media hits

Actual accomplishments vs. goals

- Develop the BMP topics of bee nutrition, pest control, disease control, hive management and colony management. Accomplished and exceeded expectations. Developed three additional areas: business management, transportation and grower BMPs.
- Specific objectives included developing a centralized communications campaign. Accomplished.
- Produce print media materials including articles, brochures and fact sheets. Accomplished.
- Develop trade show booth, enewsletters, website posts and video clips. Accomplished.
- Create PowerPoint presentations. Accomplished.
- Enumerate elements of the outreach campaign including number of brochures, fact sheets, articles, newsletters, website hits and individuals attending presentations and visiting the trade show booth. Accomplished. 33 oral presentations were given to a collective audience of 3,355. Pam attended 27 conferences and had 11,544 visitors to the project's trade show booths. In addition, 65 articles or documents were prepared that reached a total audience of about 2.4 million readers. Another 6.8 million readers read complementary articles. In addition, project staff researched and wrote 11 BMP brochures and distributed 10,000 copies in total. All of these statistics are detailed in Attachment 1A Deliverables and statistics. The BMP website received up to 250 hits/month and a total of 4,000 hits since inception.
- Surveys were conducted on the initial beekeeper recognition of currently practiced BMPs. Accomplished. Initial beekeeper recognition of BMPs was 3%, while the final beekeeper survey resulted in 60% recognition of BMPs. The surveys were conducted at national meetings.

- Decrease overwintering honey bee losses from 30% to 20%. Accomplished. Initial AIA survey showed 33.8% loss, the most recent survey showed a 21.9% loss rate. The below table illustrates the annual changes and is a copy of the table produced on the Project Apis M. website (www.projectapism.org) within the BMP tab.



- Adequate pollination of the almond crop by honey bees. Accomplished. Though also influenced by water availability, tree nutrition and several other factors, it can be said that honey bees have done a good job of pollinating the almond crop, the largest pollination-dependent crop. Despite bearing acreage increasing by 40,000 ac in the last three years, requiring 80,000 more honey bee colonies, bees have helped produce record yields per acre. In the last three years, yield/acre has risen from 2,220 to 2,690 lb/acre. Record almond crops have also been produced each of the last three years, increasing from 1.6 million to 2.1 million lbs.
- An easy-to-read spreadsheet of elements of the outreach campaign will be developed by Pam and data collected and analyzed quarterly for comparative purposes to evaluation penetration of outreach materials. Accomplished. The spreadsheets are part of Attachment 1A Deliverables and statistics.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Others who have benefited

- 6000 almond growers pollinating 800,000 acres of almonds, requiring 1.6 million colonies
- 43 other specialty crops in CA that require managed honey bees to produce a crop, over $6 billion in pollination-requiring specialty crops
- More than 90 other crops nationwide that require honey bee pollination, nearly $20 billion directly or indirectly dependent on honey bees to produce a crop

- Other bee organizations who have been allowed unrestricted access to all BMP information, articles, newsletters, brochures, and photography resulting from this project
- Numerous honey bee research funding agencies that have been provided information that will improve practical beekeeping management
- The Bee Informed Partnership worked in concert with the objectives of this project to decrease overwintering losses of honey bees
- The USDA National Program Review was provided information on bee research needs that would directly impact beekeeper management practices and improve bee health

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Lessons learned: 1) BMP areas must undergo continual refinement and improvement as new management practices are successfully implemented and as new information is revealed during meetings, conference presentations and interviews, and upon publication of recent research studies.

2) Promoting BMPs via electronic media formats proved to be more technical, more expensive and more time-consuming than originally expected. However, electronic formats were also more popular than expected and worthy of the effort. The learning curve for using electronic formats is steep, but rapid and attainable.

Unexpected outcomes: 1) The impact of this project reached far beyond initial expectations. 2) Requests for BMP literature for meetings project staff could not attend was greater than expected. 3) Become a respected outreach partner in CA border station improvements for bee loads, 4) Media hits that related to this project far surpassed expectations and can be difficult to track whether they be print or web references. 4) The project highlight was the publishing of BMPs with the Coordinated Agricultural Project in joint publications the same month with the two national bee journals and providing article reprints at the trade show booth.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Please see attachments to this Final Report

Note: Nearly all photographs used in the above outreach materials were taken by Christi Heintz and Meg Ribotto in the course of undertaking this BMP project.

USDA Project No.: 2	Project Title: Technology transfer campaign to increase conservation cropping systems and winter cover crop in California specialty crops	
Grant Recipient: California Association of Resource Conservation Districts	**Grant Agreement No:** SCB09033	**Date Submitted:** December 2012
Recipient Contact and Title: Karen Buhr, Executive Director	**Telephone:** 916-524-2100	**Email:** Karen-buhr@carcd.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Despite multiple economic and environmental benefits, conservation tillage (CT) and cover cropping (CC) practices were used on less than 3% of vegetable crop acreage in California's Central Valley (CV) at the beginning of the project. CT reduces costs and coupling CT and CC has recently been shown to increase soil carbon, reduce greenhouse gas emissions (GHG), and reduce negative surface and ground water impacts. Low adoption rates for these conservation cropping systems (CCS) reflects the lack of practical knowledge on how to best implement them within a crop production system, and a general unfamiliarity with the multiple benefits that may result from their use.

The purpose of this project was to increase the adoption of CCS that includes CT both with and without winter cover crops used in specialty crop rotations. Less than 2% of (CV) farmers had adopted these innovative farming systems at the beginning of this project. Farmers had expressed a strong need for science-based, practical, cropping innovations that reduce production costs while improving the quality of the natural resource base. This project was timely to fulfill farmers' needs by creating a multi-media information and media program that increased farmers' knowledge of CCS, increased the future farmers' knowledge of CCS, and increased public recognition of farmers' natural resource stewardship. Increased adoption will also help farmers to access emissions reduction trading programs- a concept that is ripe particularly with the recent passage of legislation to regulate a GHG market. The overall goal was to increase the adoption of CCS from just 2% to over 10% by the end of the third year.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Conservation Agricultural Systems, The Value of Residues in Conservation Agriculture Systems, Conservation Agriculture in Tomato Production Systems, Conservation Agriculture in Dairy Sillage Production Systems, Minimum Tillage Systems, and Coupling Conservation Tillage with Overhead Irrigation show practical hands-on application of CCS. The videos are designed to give farmers an introduction to CCS, highlight the considerations of implementing a CCS system, guide farmers and others to the website to gain additional technical and research information, and provide contact information for key people that can help implement the systems. The videos are presented in a farmer-friendly manner from farmers to farmers with farmers discussing their experience, reservations, and the benefits of CCS. In addition, a high-level production company was utilized that produced well-made videos with a very high production value. These videos will be useful in educating farmers, future farmers and the public for decades. The videos were just released in August of 2012 so information is not yet available on the number of viewers. However, the videos will remain posted on the Conservation Agriculture Systems Institute (CASI) website indefinitely. A large outreach effort was completed to direct the traffic of partners, farmers and other that might benefit from the videos to the website. The videos can be accessed at: http://casi.ucanr.edu/Video_library_636/. The University of California, Davis (UCD) was instrumental in providing the research, location, and direction of the videos. The board of the CCS workgroup also provided a large amount of oversight on the production.

Another key project that was completed during the grant was an outreach effort that included a series of workshops for farmers, partners, researchers and other interested parties. These workshops were wildly successful. The first two years of field days started off small, but with unexpected turnouts. The first year drew about 50 participants; the second drew over 100 participants. The events featured local experts, farmers, and Jeff Mitchell of UCD demonstrating how the systems functioned on the research station in Five Points, California (Ca) and discussed the increased yields and decreased inputs that were enjoyed from the adoption of CCS. The final event grew from a small local field day into a four day tour of the CV complete with world-renowned experts. Researchers, technicians and farmers educated the CV on the successes and latest research on CCS from all over the world including Iowa, Minnesota, Tasmania, and Paraguay. It was an excellent opportunity to show local farmers and experts the international movement towards CCS. It helped spread the message that this was a legitimate practice that held legitimate opportunities for CV farmers. In addition, local experts including Jeff Mitchell were able to gain knowledge that will be useful in the application of CCS in the CV. The technical capacity of Ca experts grew through their participation in the workshops. The four day road show educated over 250 people. In all, the field days reached over 400 people.

In addition, a curriculum for 4-H (youth organization) students was created that will be adopted into 4-H programs across the State. Three annual surveys of CCS practices in CA were performed (the results are reported below). A comprehensive website (http://casi.ucanr.edu/) was developed to host the videos, provide research to the public, provide testimonials both written and recorded recognize early adopters, advertises workshops and events, list many of the participants in the CCS workgroup, and provide contact information for the experts in the field and technical advisors that can help install CCSs. An information booth was taken to the World Ag Expo in Tulare three years in a row.

Perhaps the greatest accomplishment in this project is the ground swelling of support for the CCS workgroup and its efforts. Through the momentum and growth of this project, it was clear that the project needed its own 501c3 (tax-exempt, non-profit) organization that is dedicated specifically to the promotion of CCS. A new institute “CASI” was born. The 501c3 has been applied for. CASI has started an extensive outreach process to develop a membership list, advertise events and new developments, and keep California abreast of the latest developments. This group would not have been established without the help of this specialty crop block grant.

While the practices that were promoted during this project could be beneficial to all crops, the implementation of all of the work was crop-specific to specialty crops - particularly tomatoes. Additional research would be needed to make these practices relevant to other crops such as non-specialty crops (wheat, barley, field corn, soy beans, etc). That is not work the CARCD lab is doing and thus there was no potential for the funding for this project to benefit another crop type. The CARCD lab only works on specialty crops. The workshops and trainings were specific enough to crop type that they would not be useful to people working with other crops. While the hope is that all farming operations adopt these practices, the work in no way benefits any crops but the ones worked on - primarily tomatoes.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
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In addition to the immeasurable ground swelling of support for CCS and the large number of people exposed to CCS, there was a real, measurable goal to achieve. In the project proposal, it was expected that the outreach (videos, website, field days, curriculum, research and publications) would result in the adoption of CCS growing to over 10% of acreage by the end of the grant period. When undertaking the project, this seemed to be a lofty goal. However, the benefits of the systems have proven to sell themselves. Annual surveys of the adoption of CCS practices were conducted to get a baseline and then measure a change in adoption. Data already existed for 2006 at the beginning of the grant period. Surveys were completed in 2008 and 2010. The results have been incredible.

While 2012 results are not yet available, the 2010 results show a larger increase than was expected through the entire three year period of the grant. As a baseline prior to the grant, only 2% of acreage was in CCS. In 2010, over 14% of acreage was in at least some form of CCS. The result is well beyond the total expectations of the grant period in half the time. The 2012 data will surely show increased results. Specifically, no-till increased from 2008-2010 by 19% (27,308 acres in 2008 and 32,387 acres in 2010), mulch till increased by 26% (227,797 acres in 2008 to 286,478 acres in 2010), all minimum till practices increased by 69% (416,035 acres in 2008 to 701,760 acres in 2010). With results like these and the large amount of work that is being done to promote and refine these practices, it is exciting to think what the 2012 and 2014 numbers will demonstrate. For additional statistics and breakdown by county and crop, please see the 2010 results survey (Attachment 1).

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Farmers, technical service providers (including UCCE, RCDs, NRCS and private consultants), Future Farmers of America, researchers, and the people of California all benefitted from the implementation of this grant.

400 people were reached through direct contact workshops, countless people have benefitted from the research, literature and videos. Countless people will benefit from the continued access to these products. Additionally, countless future farmers will be impacted by the curriculum created for the Future Farmers of America.

More specifically, in a study published by Mitchel et al in 2009 (please see the website for details) it was estimated that conversion from till to no till in tomato crops results in the reduction of $83/ acre of cultural costs. An additional study in 2012 showed that cotton results in the reduction of inputs by $70/ acre. A big portion of this is the reduction in use of diesel fuel to power farm equipment. While this number can't be directly translated into the study findings as the changes were not broken out by crop, it is clear that with 701,760 acres in conservation tillage, the economic savings for farmers is dramatic as is the reduction of fuel inputs into agriculture. In addition, adopting CCS practices results in reduced GHG emissions, reduced need for irrigation, reduced water quality impacts, and a greater access to trading markets by farmers.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The CCS workgroup was pleased to find a large amount of support for CCS practices. It can truly be described as a ground-swelling. This put the group in the interesting but exciting place of being able to develop an organization that can solely and completely support the adoption, practice, and research of CCS. The forming of CASI has been the largest learning opportunity gained during this process. It will result in continued attention to important practices that provide great promise to the future of agriculture in California.

The group also was given insight into the length of the creative process in developing videos. The videos were completed in the 3 year grant term, but it took almost the entire 3 years to get the group to agree to the content, vendor, shoot the film and have the film edited.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

All information is available at: http://casi.ucanr.edu/
Attachment 1 – 2010 Tillage Practices Survey Findings (January 15, 2012)

USDA Project No.: 3	**Project Title:** Building Leaders for the Future	
Grant Recipient: California Agricultural Leadership Foundation (CALF)	**Grant Agreement No:** SCB09003	**Date Submitted:** December 2012

CALF declined funding for this project; therefore, the project was not implemented. The California Department of Food and Agriculture (CDFA) submitted requests to United States Department of Agriculture (USDA) to redirect the reverted funds to new projects.

USDA Project No.: 4	Project Title: California Food System Alliance Project	
Grant Recipient: Ag Innovations Network	**Grant Agreement No.:** SCB09034	**Date Submitted:** December 2012
Recipient Contact: Dan Schurman	**Telephone:** 707-823-6111	**Email:** **dan@aginnovations.org**

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The California Food System Alliance Network (Alliance Network) arose in response to the need for better understanding, knowledge and support of specialty crop growers by other groups and the public. The Alliance Network is designed to connect specialty crop growers and producers with the communities they serve, and cultivate untraditional allies with health, environmental, urban and other community stakeholders to co-create a system that better meets the needs of growers and those communities. The relationships developed in the county-based Alliances produce successful, thoroughly vetted projects and initiatives such as addressing the need for farm worker housing, land-use and regulatory policy recommendations, developing market connections between growers and local institutional buyers, hosting local forums and summits on agriculture (ag) and food systems issues, and educational programs for the public. The Alliances act as a clearinghouse for the complex issues that arise on a county level.

Based on the successes of the four original Alliances in Ventura, Santa Barbara, Yolo and San Mateo Counties, the strategy for this project and grant period was to expand the Network regionally and to work in new, agriculturally vibrant areas of the state. The expansion into three new counties involved collaborating with conveners that have been engaged in the Alliance Network in other counties (Farm Bureau, Ag Commissioners offices, etc.), and developing new relationships with emerging stakeholders in the food system, such as the public health community. Sonoma, Santa Clara and Fresno counties were identified and now have active Alliances. These three counties are home to very distinct and important agricultural production systems, have serious, chronic public health issues, and growing populations.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

The Alliance Network expanded from four Alliances to seven, at a rate of one Alliance per year through the grant cycle, thus expanding the statewide network of stakeholders including specialty crop producers of various scales, environmentalists, ag support entities, public health officials and advocates, local business/industry, and various other urban and rural community stakeholders. In every new and existing Alliance, a process was established by Alliance staff to build mutual understandings, identify common goals and interests, and support Alliances to take action by connecting the growing network to state level issues present in multiple counties. The Alliance staff provided programmatic assistance for each Alliance as they engaged with their local community, developed recommendations and programs, and continued to build relationships across sectors and stakeholder groups.

Specific results include:

- Convening and establishment of Alliances in Sonoma, Fresno, and Santa Clara counties.
- Establishment of constitutions, goals, websites, outreach materials, and developed mechanisms for engaging with and tracking media, as well as local decision-makers.
- Establishment of Process Committees in every Alliance. Process Committees are populated by a representative pool of members that work with Ag Innovations Network (AIN) staff to develop agendas, discuss emerging issues within the Alliance, membership, and ensure the Alliance is functioning at its highest possible level.
- Establishment of sub-committees in every Alliance, allowing for multiple projects to be addressed at once. These committees include: Access/Food Security, Land Use/Ag Viability, Policy, Farm Worker Housing, Communications/Outreach & Education, Farm to School/Farm to Institution, Marketing, and various ad hoc committees created to address timely and emerging issues.
- Sonoma, San Mateo and Santa Clara counties have begun and/or completed food system assessments, partnering with local universities, University of California Cooperative Extension (UCCE), and other local agencies to conduct primary research, as well as compile data housed in different agencies/entities.
- Yolo and San Mateo counties are engaged in conducting Feasibility Studies to explore aggregation services that are needed in their respective counties and/or regions to serve specialty crop producers, while simultaneously meeting the demand of local institutions and low-income communities for local, fresh and healthy produce and products.

Throughout the Network, local partners are key to the success of each individual Alliance. In every county, the Ag Commissioner's office (if not the Ag Commissioners themselves) are members of the Alliances, as well as public health officers or their staff, UCCE personnel, ag support organizations such as FarmLink, Community Alliance with Family Farmers (CAFF) and the Farm Bureau, Resource Conservation Districts (RCDs) and Natural Resource Conservation District (NRCD) staff, local educators, urban gardening/farming organizations and advocates, agencies focused on access issues for low-income communities such as food banks, and a variety of other community members. Many of AIN's partners have offices and/or personnel throughout the state that allow them to be represented in multiple counties. Many Alliances have developed strong partnerships with local universities and educational institutions, and have engaged local civic leaders in their work and in key initiatives. These partnerships provide the Alliance with a great amount of resources, credibility, and a rich base of knowledge and expertise that can be referred to as the Alliances begin to address issues and challenges in their local food and agricultural systems.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
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- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

As previously mentioned, the outcome of expanding the Network to seven counties was achieved, with now over 175 Alliance members throughout the state. Alliances held 210 meetings during the grant period, as well as monthly committee meetings in every Alliance, steering committee and ad hoc committee meetings, and three public forums in Yolo, Ventura and Sonoma Counties. All seven Alliances have been engaged in the creation and dissemination of policy papers, policy recommendations and various other publications and letters. The list includes:

- San Mateo County Food System Alliance (SMFSA): *Call-to-Action: A Garden in Every School* & *Producing, Distributing and Consuming Healthy Local Food: Ingredients for a Sustainable Food System.*
- Santa Barbara County Ag Futures Alliance (SBAFA): *Proposed Agricultural Buffer Proposal for Santa Barbara County, Ag Land Buffer FAQ* and a letter supporting the Hibbits Ranch conservation easement.
- Santa Clara County Food System Alliance (SCCFSA): Recommendation letter for the *Draft Morgan Hill Agricultural Policies and Implementation* Program for the development of an ag mitigation policy for the city, and a recommendation letter the Open Space Authority to incorporate ag land preservation into their strategic plan.
- Ventura County Ag and Food Alliance (VAFA): *Like Orange Juice? Protect It*, and article written by Alliance members addressing the Asian citrus psyllid presence in the region and the need for education and prevention, as well as the article *Gypsy-moth Response Speaks to Issue of Community Stewardship* presented on behalf of the Alliance.
- Sonoma County Food System Alliance (SCFSA): *School Food Service Produce Report*, a report of an extensive survey of food service directors in the county conducted by the Alliance, *The Sonoma County Community Food System Assessment*, and *The Report to the Community*, a report and summary of the public Food Forum held in February 2011.
- Yolo County Ag and Food Alliance (YAFA): *Yolo Regional Food Forum Report* and sponsoring and providing content for AB 2881 "*Right to Farm*" legislation.

The development of new leadership outside of production agriculture, that has been educated in the realities of growers and has become an ally of agriculture, has occurred with two new key stakeholder groups: public health officials/advocates and suburban/urban residents. Public health stakeholders have emerged as non-traditional allies of agriculture, and are increasingly engaged in food and agricultural systems work as chronic health issues related to diet grow in the state of California, especially in some of the regions and counties with Alliances present. Additionally, AIN's work in counties with large urban centers, such as Fresno and Santa Clara, as well as counties with growing suburban populations, has lead to the engagement and education of urban and suburban residents. AIN staff have developed processes for developing understandings and creating educational experiences for these stakeholders by coordinating "learning journeys" on farms, dedicating Alliance meetings to ag related issues emerging in the counties, as well as facilitating collective learning around issues such as the Williamson Act, small scale v. large scale agriculture, ag land preservation and mitigation, and more.

Annual surveys of Alliance members throughout the state were conducted by AIN staff at the completion of each calendar year, gathering anonymous, detailed information about the successes of each Alliance, their work areas, the overall engagement of members and the broader community, the effectiveness of the group process, and AIN's services. In the most recent annual survey, conducted in the winter of 2011-2012, some key findings included:

- Over 75% of Alliance members feel the Alliances create mutual respect, understanding, and trust within the group; 85% feel their viewpoint is *always* heard
- 76% feel that members are better equipped to work collectively on food systems issues
- 76% feel new/improved networks and relationships have been built within the Alliance, and between the Alliance and the greater community
- Over 70% say that AIN is highly effective in facilitating dialogue between members of the Alliance
- 80% feel their Alliance is currently working on key issues that will lead to a vibrant, healthy food and agricultural system in their county.

No federal funding was used during the grant period to fund lobbying activities or unallowable political activities of any kind. None of the Alliances engaged in any electoral activity or endorsements, nor state or federal legislative activity.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The primary beneficiaries of the Alliance Network during this grant period include: agricultural stakeholders, from specialty crop producers of all scales (both organic and commercial), ag support entities (including UCCE, FarmLink, the Farm Bureau), and processors/distributors; food access and food security stakeholders; environmental stakeholders; food system workers/labor; public health officials/advocates; local civic officials and community members. The Alliance model ensures that each group, in every county, have a representative membership that includes a member from each of these stakeholder groups as they see fit for their community.

As stated before, there is a profound need for increased communication and understanding amongst these stakeholders. A predominant concern from across the Alliances is a regulatory framework facing specialty crop growers that is uncoordinated, unrealistic and sometimes contradictory. Alliance members' response to this concern has been the formation of policy committees aimed at providing thoroughly vetted recommendations from a diverse group of stakeholders to city, county, regional or even state level entities. An additional concern that has surfaced is the local food distribution system, making the procurement of local and/or healthy produce and products very difficult for local schools and hospitals, and the lack of availability of healthy produce and products for low-income community members, both in urban and rural communities. Alliances have addressed these concerns by forming farm-to-school/farm-to-institution committees that initiate projects on a district or county level to simultaneously open up local markets to producers while ensuring students and patients eat nutritional, healthy food. Additionally, access/food security committees have been formed to work with existing initiatives to increase the access to healthy food products for low-income communities, or simply creating projects from scratch.

Alliance meetings are truly the only forum for ag commissioners, environmental health staff, public health officers and staff, specialty crop producers, access/food security advocates, and community members to interface, collaborate, identify goals and issues that need to be collectively addressed, and where collective learning and trust building occurs. The cross-pollination of these beneficiaries has been a key success of the Alliance Network.

Ag Innovations Network's Alliance Program is designed to serve the needs of the specialty crop production community at large in the target counties. As stated in the grant, the purpose of the Alliance Network is to support specialty crop producers by increasing understanding and knowledge about specialty crop production and by creating projects and activities to support the longevity and viability of specialty crop production in each county. The Network is also designed to connect specialty crop growers and producers with the communities they serve, and cultivate new allies.

In the seven counties supported by the SCBG grant, the Alliance services benefit over 12,000 specialty crop producers (*2007 Census of Agriculture, County Data USDA National Ag Stats Service*).

There were various activities that both generated revenue and developed new markets for specialty crop growers in the seven Alliance counties during the grant period. The activities listed below represent highlights of how project activities connected county specialty crop producers to new markets and customer bases:

1. The Yolo Food Summit, July 2010: More than 65 participants, comprising 40 farmers/ranchers and 25 ag support representatives from Yolo and Solano Counties, gathered to develop recommended specific actions for enhancing the local economy and viability of regional agriculture. Attendees included the Yolo Ag Commissioner, Cooperative Extension, Economic Development, bankers, distributors, a farmer's market manager and the Health Department. The outcome of the summit has included securing funding for an Ombudsman position that will serve specialty crop producers in the county by assisting with navigating permitting and regulatory processes for sustaining and expanding their operations.
2. The Farm to Fork bus tour and forum series in the Santa Barbara Ag Futures Alliance, 2011: This farm tour series brought south county residents to over 8 specialty crop farms, exposing them to local production in their county. The tours were highly successful and were covered by local media. This series reached 295 participants and built critical linkages between the agricultural community and food service directors at schools and local institutions.
3. Farm to School Committees in three counties (Sonoma, San Mateo, Fresno): These committees have worked to increase the amount of specialty crop produce, produced within the counties and throughout California, available in local schools and institutions.

4. Food Service Training, Sonoma Food System Alliance, 2011: The first of two trainings was held in 2011, bringing together over 80 specialty crop producers, local food service staff, parents and school officials to investigate how to increase the amount of specialty crops in schools throughout the county. Direct connections between school food service staff and specialty crop producers were made. For example, Santa Rosa School District has initiated new contracts with local growers as a direct result of this effort.
5. SMFSA Feasibility Study: The San Mateo Food System Alliance secured funding in 2011 to conduct a feasibility study for creating a specialty crop produce aggregation center for south coast producers in the county, to better serve local institutions. The study is currently underway.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

As the Network of Alliances has grown, sharing best practices and instituting new committee structures with the various Alliances has become very important. Committee structures that allow for non-members to participate greatly increases the capacity of the Alliance, and each individual work area allows the Alliances to tap into local expertise, and extends the reach and impact of the Alliances into their communities. AIN staff also started to secure the support of in-kind county staff support through public health departments, which provided vital support to the Alliances by assisting with the production of publications, chairing committees, and more.

Throughout the grant period, AIN staff found ways to continue to engage stakeholders that are often difficult to get to the table, specifically the farm worker community and producers themselves. AIN staff found ways to increase participation from both of these groups by scheduling meetings on preferred days and times, hosting meetings on farms, and continuing to employ the expertise of producer/ag support organizations. Representation of the farm worker/labor community was sought by inviting advocacy groups including the Center for Race, Poverty, and the Environment (CRPE), and by partnering with local, existing initiatives addressing issues facing the labor community such as farm worker housing, etc. AIN staff developed mechanisms for Alliance members to engage these communities to vet key policies and projects as they developed (e.g., educational meetings with guest speakers, etc.).

Finally, the need for networking services across the Alliances grew tremendously during this grant period. Requests for background information on key issues, connecting Alliance members with similar committees and projects in other counties, connecting in-kind county staff to one another, and ongoing updates from other counties, have all increased. This is a function that AIN staff wants to continue to expand and improve upon in creative and efficient ways for members throughout the state.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Alliance network and county Alliances' websites:

http://aginnovations.org/alliances/
http://santaclaracofsa.org
http://sonomacofsa.org
http://yolocoafa.org
http://santabarbaracoafa.org
http://sanmateocofsa.org
http://venturacoafa.org
http://aginnovations.org/alliances/fresno/

Attachments:
Yolo County Alliance Regional Food Forum Report
San Mateo County Alliance "Sustainable Food Brief"
Sonoma County Alliance Community Food Assessment report
Santa Barbara County Alliance Ag Buffer Policy recommendation

USDA Project No.: 5	Project Title: Building Sustainable Farming Systems through Grower & Consumer Outreach	
Grant Recipient: Central Coast Vineyard Team	**Grant Agreement No.:** SCB09019	**Date Submitted:** December 2012
Recipient Contact: Kris Beal	**Telephone:** 805-466-2288	**Email:** kris@vineyardteam.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The Central Coast Vineyard Team will partner with growers, wineries, technical advisors to assist growers in eliminating the use of high risk pesticides, increase water use efficiency, and protect soil and water quality through agricultural outreach, self-assessment, and implementation of the Sustainability in Practice Certification Program, thereby creating a market pull for certified wines that are produced in ways that protect natural and human resources. Not only will this provide market incentives for the adoption and verification of integrated farming practices, but it will promote economic viability of these products by creating product differentiation and preparing growers for additional regulations regarding pesticide use, water quality, and water use.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Technical Ag Outreach & Education

This project was broad in terms of its activities and outreach and extended information to producers beyond the certification program. Throughout the project period, CCVT reached agricultural owners, operators, and managers through tailgate meetings, newsletters, industry presentations, self-assessments, and the Sustainable Ag Expo. CCVT reached nearly 1,000 vineyard professionals at 23 Tailgate Meetings addressing a number of pertinent topics (i.e., irrigation management, integrated pest management, biodiversity and conservation, erosion control, etc.).

The Sustainable Ag Expo is a two educational seminar and tradeshow which showcases industry hot topics, current research, exhibitor innovations. The Expo rotates between Monterey County to San Luis Obispo County every year and attracts farmers, agricultural professionals and pest control advisors. During the project period, 550 people attended the 2010 & 2011 Sustainable Expo, and over 100K acres were represented at each event.

CCVT also conducted self-assessment workshops during the project. As a tool, the Self-Assessment helps educate and guide growers towards adopting new practices that protect both human and natural resources. The current Self-Assessment is taken directly from the SIP Certification Standards in an effort to help guide growers to eventual certification if they so choose. The Self-Assessment Workshops are done early in the year in Monterey, San Luis Obispo, and Santa Barbara Counties. Throughout the project period, 80 growers completed the self-assessments. This represented 27,000 acres, or approximately 27% of the Central Coast winegrape acreage.

Sustainability in Practice (SIP) Certification – Administration & Outreach

The response and growth of the SIP Certification program during the project surpassed all expectations. Each year, the program exceeded the goals for program growth in certified acres and cases. Since the 2008 pilot, certified acres have increased over seven fold from 3,700 to 27,000 acres (2011). The number of certified cases in the market exploded, increasing from 60,000 in 2010 to 330,000 in February of 2012.

Administratively and procedurally, the program continues to run smoothly. The SIP Certification program has been recognized by the Central Coast Regional Water Quality Control Board as qualifying as “low risk” in the agricultural waiver for irrigated lands.

Interest in the program grows, and several wineries (without connections to specific vineyards) purchase SIP Certified fruit and juice. CCVT has been contacted by a variety of agricultural groups regarding possible collaboration for a certification program on non-vineyard crops.

SIP Certified	2008	2009	2010	2011	2012*
Vineyards	17	35	60	143	153
Organizations	14	24	35	49	58
Acres	3,700	11,000	15,000	27,000	29,000
Cases		45,000	60,000	300,000	450,000
Wine Brands		7	14	21	23

*estimates for year end 2012 (based on applications)

At the onset of the project, CCVT hired a communications consultant to help direct and guide staff’s outreach efforts and resources. The plan included a combination of trade, consumer, and press related activities. The goals included growing visibility of the program with trade decision makers, garnering positive press with trade and consumer publications, and outreaching the certification to consumers. Essentially, by growing awareness and positive press of the program and its participants, CCVT could create value for its participants and incentivize certification.

Internally, SIP participants receive regular communications on program deadlines, educational opportunities, and outreach efforts.

Staff conducted 37 educational meetings during the project period. This included 19 hospitality trainings and a variety of presentations. Staff reached 3,000 people through these presentations.

Staff attended 27 consumer wine events (ex. Cal Poly Wine Festival, Monterey Aquarium Cooking for Solutions, Paso Robles Wine Festival, Sunset – Menlo Park, Central Coast Wine Classic, Savor the Central Coast, Golden Glass San Francisco) reaching at a minimum of 45,000 people through presentations, tabling, and advertising.

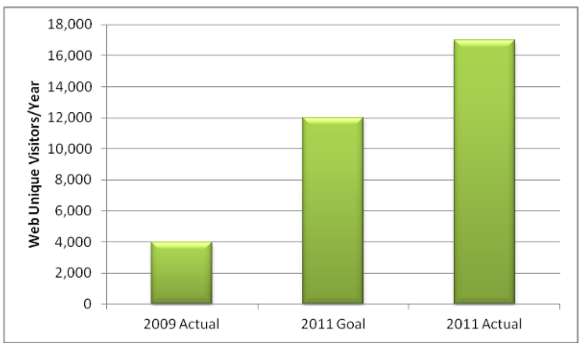
SIP received excellent exposure this period through press releases, advertising (ex. California Grocers Association, Edible Magazine, Wine Business Monthly), influential bloggers (Treehugger), and event sponsorship (ex. Sunset's Savor the Central Coast, Monterey Bay Aquarium, social media tastings).

Staff distributed hard copy and electronic information to 200+ distributors and on-site establishments in two phases, and is continuing to build relationships with these potential customers.

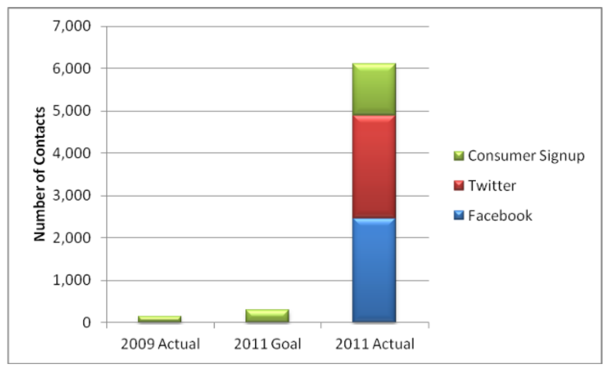
The past three years included significant modifications and additions to the www.SIP Certified.org (formerly SIPTheGoodLife.org). The SIP Certification website has a fresh new look with fully integrated information for both technical and outreach information. Web visitors can now find all SIP related content in one place. Highlights include searchable vineyard and wine listings, a featured blog, and streamlined event information.

All traffic and impressions for website, press, and consumer lists exceeded the project goals.

Web Unique Visitors Per Year
Comparison of 2009 Actual, 2011 Goal and 2011 Actual



Consumer, Twitter and Facebook Contacts
Comparison of 2009 Actual, 2011 Goal and 2011 Actual



Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Metric	Goal	Actual
1. SIP Certified Acres	15,000 acres	27,000 acres certified (2011)
2. SIP Certified Cases	25,000 cases	330,000 cases certified as of February 2012 *Note: The long term goal for this metric is 1M cases by 2020. The project metric could be 250,000 cases by 2012, in which case, the goal has been reached.*

3. Self-Assessment Count	25 – 50 from 2009 to 2011	80 evaluations were completed, representing 27,000 acres
4. sipthegoodlife.org unique visitors per year	2,600 – 4,000 from 2009 to 2011	There were 16,500 unique visitors to the site in 2011.
5. Consumer interest in SIP	Increase direct consumer interest list to 300	Facebook Followers = 2,400 Twitter Followers = 2,000 Email subscribers = 1,200
6. Quantify SIP benefits to vineyards & wineries	Develop method for measuring and capturing benefits to SIP Certified participants	Staff created and distributed surveys and conducted interviews with program participants. There was consensus regarding the following qualitative benefits to certification: • Increased interest in "story" with consumers • Increased interest in "story" with customers/gatekeepers • Improved press relations
7. Quantify press impressions	Develop method for tracking press coverage	Staff subscribed to Google Alerts that included filters for SIP & individual participants. Staff developed a system within the existing database to capture advertising, mentions, articles, etc. There were 30.5M impressions from Oct 2009 to Feb 2012.
8. Quantify changing farming practices	Use self-assessments to determine changes in farming practices	Through the project period, 80 growers completed the self-assessments. This represented 27,000 acres, or approximately 27% of the Central Coast winegrape acreage. There were very few repeat growers in terms of the self-assessment, so it was difficult to track changing practices over time. Rather, staff found that growers were completing the self assessments to qualify them for a farm plan for the water quality regulations.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The primary focus of this project involved the SIP certification of vineyards and the ability to brand specific wines based on the sustainable certification. Throughout this project period, both certified acres and cases increased. Not only did new operations enter the program, but previous operations increased their certified acreage. Only one vineyard over the last 5 years has not renewed. This growth and renewal rate indicate a value of sustainable certification.

We have attempted to quantify this benefit through conversations and surveys. SIP participants, including farmer, winery, and sales representatives, have been sent surveys regarding their level of participation in the program and the benefits that they have seen due to SIP Certification. Participants say that their certification has increased their customer's interest in their "story". This increased interest is greatly beneficial with direct to consumer sales, distributors and product placement. They indicate that certification has helped their press relations and has been beneficial in terms of brand awareness.

It has been difficult to capture and record a specific economic benefit. Nevertheless, we have anecdotal information from several participants. One grower indicated that he sold his fruit as a result of it being SIP certified. One grower indicated that he sold his bulk juice to an independent winery as a result of being SIP certified. One winery indicated that they were given market access as a result of being SIP certified. One winery indicated that they were able to place their wines in Whole Foods as a result of being SIP certified. None of these people have given us a dollar benefit, but all of these stories indicate a direct economic benefit of a sustainable certification.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

This project marked an interesting departure from the typical CCVT work. The organization has a long history of outreach and education to farmers about farming practices. But expanding our communications to include trade, winery, hospitality, press, and consumers was a significant stretch. It was critical to engage communications professionals from the onset and to continue to seek input from project participants. What we have learned is that there is not "one" communications direction that SIP staff should be focusing on. Rather, staff needs to continue building brand awareness on all fronts. In addition, the diversity of SIP certified participants requires that staff be flexible and responsive to different scales and operations. One SIP certified wine brand may only focus on direct to consumer on the Central Coast. Another SIP certified wine brand may sell internationally. Both participants are important to the program, and the program must be responsive to the needs of both operations. We have learned that CCVT staff, with the proper direction and input from participants, is very well equipped to perform a variety of communications tasks and is in the best position to outreach the program. We don't necessarily need to hire "communications experts" to do this task.

Staff was surprised and thrilled by the growth of the program. There is momentum with this growth, that continues to fuel more growth and bring value to the participants, but it was challenging to manage. It required additional investment into the administrative capacity of the organization, development of an improved database, and development of additional rules and policies. Staff continues to learn about the importance of rules and procedures to ensure that the program remains credible, robust, transparent, and free from conflict of interest.

Staff is also extremely excited about the interest expressed by other crop groups and growers. CCVT has a long history and significant credibility with the agricultural community and is in an excellent position to leverage this credibility for possible certification expansion.

Overall, this represented one of the most "different" projects for CCVT – very much outside of the typical comfort zone of the organization – but it has been one of the most successful projects for the group.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Additional pictures documenting the work of this project are included on Attachment 1.

Online Resources

- SIP Brochure
- SIP Tasting Map
- Hospitality Training Sheet
- Shelf Talker
- SIP Upcoming Events
- Newsletter Sample
- 2010 Expo Presentations
- 2011 Expo Presentations

Project No.: 6	**Project Title:** California Specialty Crop Communications Plan	
Grant Recipient: Western Growers	**Grant Agreement No.:** SCB09001	**Date Submitted:** January 15, 2013
Recipient Contact: Cory Lunde	**Telephone:** (949) 885-2264	**Email:** clunde@wga.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Though not directly related to the California specialty crop industry, the passage of Prop 2 in 2008 was the impetus for the implementation of this project. The political defeat at the ballot box demonstrated the need for all of California agriculture to reevaluate the effectiveness of its collective consumer outreach efforts. As demonstrated by the Prop 2 campaign, there was an obvious disconnection between California consumers and the farmers who produce their food supply. To address this challenge, the California Agricultural Communications Coalition (CACC) was formed to conduct consumer research and coordinate the implementation of an inclusive, proactive and positive communications plan for the specialty crop industry.

This block grant project leveraged the findings of the consumer research to develop common messages for the California specialty crop industry and the tools to help specialty crop organizations more effectively communicate the collective value of the industry to the public. Therefore, the primary purpose of this project was to facilitate greater collaboration in consumer messaging and public outreach within the California specialty crop industry – helping to reconnect consumers to the source of their food supply. In doing so, the goal of this project was to improve consumer perceptions of the California specialty crop industry and increase public understanding of the benefits California specialty crop producers provide the state.

This project did not build on any previously funded SCBGP projects.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Formed prior to the execution of this block grant, the CACC steering committee was initially tasked with soliciting and choosing a qualified public relations firm to execute the block grant project activities. After several rounds of solicitations and interviews in January and February of 2010, AdFarm was selected to represent the CACC; they subsequently developed the proposed message concepts and tactics (based on the results of the consumer research) that would form the foundation of the block grant-funded communications plan. The message concepts and tactics were then presented to the specialty crop industry for review and acceptance – the CACC "kick-off" event in March 2010 provided the forum for the members of the CACC to provide their feedback on the work done by AdFarm. Armed with this feedback, AdFarm refined the messages and tactics, which were then approved by the steering committee in April 2010.

Messages

Based on the consumer research and feedback from the coalition members, the steering committee approved the following two sets of statements as the core messages of the CACC: 1) The overwhelming majority of farms in California are multi-generational family farms. These family farmers care for the land, the environment and their local communities. 2) California's multi-generational family farms are at risk of disappearing. The onerous rules and regulations in the state are increasing costs and eroding the ability of California farmers to earn a living.

Tactics

Based on the consumer research and feedback from the coalition members, the steering committee approved the use of social media as the primary tool to deliver the CACC core messages to California consumers. The following social media tactics were approved and executed:

- The www.KnowACaliforniaFarmer.com (KACF.com) website was developed, which served as the primary hub of the block grant-funded communications plan. The KACF.com website was designed to be highly-interactive and provided an outlet for CACC members to communicate their stories directly to consumers using the latest social media technologies, including YouTube videos, blogs, and photo sharing. Additionally, the members-only Communications Toolbox section of the website was created to provide CACC members with access to the core messages, instructions for using the KACF.com website, tips for engaging with consumers using social media, and "how-to" guides for using various social media platforms, including Facebook, Twitter, YouTube, LinkedIn, and WordPress (blogs).

- Social media training was provided for CACC members. Prior to the launch of the KACF.com website, two training sessions for coalition members were held in June 2010. The first, a live training session, was conducted at the California Farm Bureau Federation. The purpose of this training session was to provide CACC members with an overview of how to use the Communications Toolbox and how to upload videos, blogs and photos to the website. Furthermore, the topics of best practices for engaging consumers in social media and how to leverage social media to help change the conversation about California agriculture were discussed. The second training session, a webinar, reviewed the strategies behind the CACC campaign, discussed the type of content that would promote the core CACC messages, showed examples of content that had already been posted to the KACF.com website, and provided suggestions of activities to help generate additional content prior to the public launch of the KACF.com website.

- Additionally, as part on ongoing training, the CACC hosted a weekly email newsletter to help coalition members stay informed on the key issues and events surrounding the California specialty crop industry. The goal of the email newsletters was to provide coalition members with up-to-date information that would spur ideas about what to contribute to the KACF.com website. The email newsletter also provided coalition members with tips on extending the reach of their messages with social media tools and the best ways to engage consumers in productive online dialogue.

The KACF.com website, which went live to CACC members in July 2010, officially launched to the public on September 1st, 2010. Coinciding with the public launch was a coordinated industry and consumer awareness effort. Following the launch of the KACF.com website, routine maintenance was conducted, which made the platform more user-friendly for both CACC members and consumers.

Following the launch of the KACF.com website, extensive industry outreach was conducted, including the presentation of the block grant-funded KACF.com initiative at numerous industry meeting and conventions, including the California Tree Fruit Agreement Symposium, UC Davis New Media Workshop, California Women for Agriculture Annual Convention, Western Watermelon Association Annual Convention, CFBF Young Farmers and Ranchers Annual Convention (as well as several county YF&R events), California Agricultural Leadership Foundation, California Association of Winegrape Growers, Center for Land-Based Learning, and California Cut Flower Commission.

Western Growers, California Farm Bureau Federation, Ag Association Management Services (which represents a number of specialty crop organizations including pears and kiwifruit), and the Agricultural Council of California all made significant in-kind contributions in terms of both staff time and organization resources. These four organizations were represented on the CACC Steering Committee put in place to oversee the block grant activities.

Project staff ensured that the block grant funds were only expended for the benefit of specialty crops. The CACC core messages, KACF.com website, social media training, and all industry outreach and communication were developed solely in conjunction with the California specialty crop organizations listed above (Western Growers, California Farm Bureau Federation, Ag Association Management Services, and Agricultural Council of California) and solely promoted or presented to the memberships of these and other organizations that represent specialty crop producers. With respect to the content on the KACF.com website that featured non-eligible commodities, block grants funds were not used to develop content (i.e. videos, photos, blogs), and no resources were dedicated to posting content to the KACF.com website. All content was developed and posted at the direction and full expense of the respective producers and/or organizations, whether they represented eligible or non-eligible crops. The policy of the KACF.com website was to accept all content that promoted California agriculture and generally utilized the core messages of the CACC, with the rationale being that the broader the reach of the CACC core messages, the greater the value of the KACF.com website to the California specialty crop industry.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The first objective of this project was to facilitate greater collaboration in communication and public outreach among California specialty crop organizations. Since there was no formal coordination of communications and public outreach efforts among California specialty crop organizations, the established target was to present the communication plan to representatives of 30 California specialty crop organizations with 15 of them agreeing to incorporate the plan within their own individual communication activities. During the course of the project, 40 California specialty crop organizations and allied industry members formally agreed to support the KACF.com effort through their signature on a CACC membership agreement form. As the KACF.com plan was developed, the emphasis shifted from this type of abstract support for the CACC to actual participation in the social media trainings and contributions to the KACF.com website. Those targets and performance measures are listed in the section below.

The second objective of this project was to improve consumers' perceptions of the industry, which will increase their understanding of the benefits California specialty crop producers provide the state. In a survey conducted prior to the this project, consumers' baseline perceptions of the industry and understanding of the benefits California specialty crop producers provide the state were established through industry-funded market research. The original intention was to conduct follow-up quantitative market research to ascertain if measurable changes to consumer perceptions were achieved as a result of this project. Due to the expense of conducting a follow up survey relative to the overall block grant award, and the project emphasis on consumer outreach via social media, the CACC Steering Committee determined that such a survey would not be feasible, and that the targets and performance measurements listed below would more accurately reflect the success of the project.

In addition to the goals and outcomes addressed in the project proposal, a number of other performance goals were developed in correlation with the approved tactics and communications plan, which was designed to engage both members of the California specialty crop industry and California consumers in the KACF.com website. As such, the following bi-annual goals targets were established:

CACC Members

- Register 50 new specialty crop industry contributors to the KACF.com website per bi-annual period (for a total of 300 registered contributors).
- Average at least two (2) new pieces of content (videos, photos or blogs) per day over the course of the September 1, 2010 to June 31, 2012 time period.

California Consumers

- 1,000 unique visitors to the KACF.com website per month.
- 250 (25%) repeat visitors to the KACF.com website per month.
- Maintain at least a three (3:00) minute average time spent per visit on the KACF.com website.
- Maintain an average of three (3) pages viewed per visit.

For the time period September 1, 2010, to June 31, 2012 (the official ending date of this block grant project), the following statistics were measured:

CACC Members

- A total of 620 registered contributors to the KACF.com website (well above the 300 target)
- A total of more than 300 videos, 600 pictures, 480 blogs on the KACF.com website, for an average of 2.1 pieces of content per day during the September 1, 2010 to June 31, 2012 time period (slightly above the 2 pieces of content per day target).

California Consumers

- A total of 28,500 unique visitors visited the KACF.com website, an average of 1,295 visits per month (well above the 1,000 visits per month target).
- A total of 14,500 repeat visitors visited the KACF.com website, an average of 660 per month or 51% of the unique visitors (well above the 250/25% repeat visitor's targets).
- An average of 2 minutes and 46 seconds spent on KACF.com per visit (slightly below the 3 minute per visit target).
- An average of 3.03 pages viewed per visit (slightly above the 3 pages viewed per visit target).
- Collectively, more than 28,000 YouTube videos, 50,500 blog posts, and 8,900 photos were viewed by California consumers visiting the KACF.com website during this time period.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The primary beneficiaries of this project were the 620 members of the specialty crop industry directly engaged in the KACF.com website and related CACC activities. These active contributors benefited from the social media training provided by the project, as well as the enhanced ability and opportunity to engage with consumers using various social media platforms, including the KACF.com website. Indirectly, as the CACC core messages reached more than 28,500 unique Californian consumers, the broader specialty crop industry has benefited from – and will continue to benefit from – better informed consumers and a more supportive general public. Furthermore, the 620 contributors to the KACF.com website have stood on the front lines of the social media revolution and have helped put a face on California agriculture and reconnect consumers to the source of their food supply. Ultimately, the KACF.com website has helped to transform how specialty crop farmers communicate with, and relate to, California consumers. It enables the specialty crop industry to share their passion and livelihood with potentially more than 37 million Californians throughout the state, making what they do – and why they do it – much more meaningful and relevant to the general public.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

This project was geared around new technologies and relied on leveraging emerging social media tools to connect California consumes to California specialty crop farmers (and the source of their food supply). Consequently, the success of this project was directly correlated with the level of engagement from California farmers and their representative organizations. We did not experience the widespread adoption of the Know A California Farmer approach that we had hoped for or anticipated. Generally speaking, it was difficult to generate the type of buy-in that is required for a project like this to be an "overwhelming success." We were successful, however, in engaging the early adopters and allowing them to take the lead as the face of the industry. Our belief is that over time the rest of the industry will see the value of using social media to connect with consumers and share their stories. When they are ready, the Know A California Farmer platform will be available.

Remaining Grant Balance

- If there is a remaining balance, explain why the project did not utilize all awarded grant funds.

There was only a minimal $6.10 remaining balance.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

www.KnowACaliforniaFarmer.com, http://www.facebook.com/knowacaliforniafarmer

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 7	**Project Title:** Reducing Our Footprint: Minimizing Greenhouse Gas Emissions and Nitrogen Leaching in Vineyards, and Enhancing Landscape Carbon Stocks	
Grant Recipient: US Department of Agriculture, Agricultural Research Service	**Grant Agreement No.:** SCB09042	**Date Submitted:** December 2012
Recipient Contact: Kerri Steenwerth	**Telephone:** (530) 752.7535	**Email:** kerri.steenwerth@ars.usda.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

In North America, climate change from greenhouse gas (GHG) emissions is predicted to cause significant changes in rainfall patterns, water availability and temperature regime (IPCC, 2007). Given current climate change mitigation policies, global GHG emissions will continue to increase over the next few decades. California recently entered the arena to mitigate its GHG emissions with the passage of the California Global Warming Solutions Act of 2006 [State Assembly Bill (AB) 32]. Although not yet regulated in AB 32, the GHG nitrous oxide (N_2O) produced during agricultural operations presents a significant concern for the state's agricultural industry. GHG emissions from agriculture represent just 8.3% of total GHG emissions in California, but of this, 52.2% is N_2O relative to methane and carbon dioxide (CO_2) (CEC, 2005). Although this seems like a small amount, the global warming potential of N_2O is nearly 300 fold greater than an equivalent amount of CO_2 (IPCC, 2006). These estimates include agricultural production systems like rice and row crops, which use substantially more nitrogen (N), and therefore, are expected to emit greater amounts of N_2O than vineyards. However, little information exists on GHG emissions, especially N_2O, from vineyard systems. The US Department of Agriculture, Agricultural Research Service, (USDA/ARS) will identify how vineyard management practices affect GHG emissions, carbon (C) stocks, and GHG footprints. The study occurred in North Coast and San Joaquin Valley winegrowing regions. Deliverables include: 1) Best management practices to minimize greenhouse gas emissions; 2) Life cycle Assessment (LCA) of winegrape production; 3) Calculation of carbon (C) offsets potentially gained by reductions in N_2O emissions and increases in soil C content; and 4) A decision support system using a web-based Geographic Information System (GIS) to enhance on-farm soil C stocks.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Goal 1. In order to accomplish this goal, an initial planning meeting was conducted with all project participants. After clear concepts and approaches were identified, personnel identified three distinct soil landscape types from which to sample greenhouse gases in Lodi, California. Growers in Lodi were contacted by personnel to determine site suitability. Field equipment for GHG emissions were built. These and other environmental sensors were installed in the nine vineyards where the two years of measurements were to occur. Dr. Toby O'Geen validated the site selection based on his knowledge of Lodi American Viticulture Area (AVA). Technicians developed the field and analytical laboratory procedures for the GHG study. Data were reviewed for quality by technicians in consultation with Dr. Kerri Steenwerth and Dr. Toby O'Geen. Significant effort was spent in troubleshooting and maintaining the gas chromatograph for GHG analysis. Consultation with other research programs on campus was necessary to manage the gas chromatograph. Periodically (every three to four months), Dr. Bill Salas was contacted to ensure that data gathered from the field were useful for DeNitrification – DeComposition (DNDC) model development, which would be used in the creation of the web tools.

When the Wine Institute was funded by the California Department of Food and Agriculture (CDFA), Specialty Crop Block Grant Program (SCBGP) with a later grant titled, "California Wine Climate Protection Initiative: Calculating Scope Three Greenhouse Gas Emissions to Mitigate Climate Change, Reduce Costs, and Address International Market Demand", it was decided that these two projects should complement each other as to not duplicate efforts. These field measurements have been concluded. GHG models were evaluated during the 2012, and data will be processed and readied for peer-reviewed publication. Project 7 was formulated independently and funded prior to the project managed by the Wine Institute. The scope of this study focused on two winegrowing regions, Napa and Lodi, in order to understand effects of vineyard practices on biogeochemical transformations leading to greenhouse gas emissions. Also, this project addresses environmental impacts of producing one ton of grapes using Life Cycle Assessment within Napa and Lodi regions. This differs from the Wine Institute's project because their study focuses on the environmental impacts of one bottle of wine from California.

Goal 2. This portion of the project focused on the development of the LCA model. While a number of LCAs have been conducted to evaluate the environmental performance of a variety of cropping systems, including food, feed, and bioenergy products, few have been conducted for perennial cropping systems (i.e. wine grapes). Translation of LCA results from annual cropping systems for use in evaluating grape growing is therefore challenging, due to the differences in equipment and required maintenance use for each respective cropping system. To conduct the Life Cycle Inventory (LCI), a technician interviewed more growers from more than thirty individual operations in Lodi and Napa, California to gather information regarding typical practices that occur in those regions. This information was used to develop the LCA model that was formulated by graduate student researcher Emma Strong and Dr. Alissa Kendall. Preliminary outcomes from this model were shared with project participants in summer 2012, and were used by the Wine Institute to narrow the scenarios presented in their statewide LCA.

Goal 3. An outreach document on LCA was developed with National Center for Appropriate Technology (NCAT), and is currently available for use by stakeholders. This document was written over the course of 2011 and 2012. A collaborative planning meeting and numerous follow up meetings were conducted during this period. The article was revised repeatedly by authors and outside reviewers. The research and writing were conducted by Dr. Kerri Steenwerth, Rachel Greenhut, Rex Dufour (NCAT) and Emma Strong, while Dr. Alissa Kendall (expert in LCA) evaluated the correctness of this document for use by growers.

Other Partner contributions.
The vineyard managers contributed their time and resources ('in-kind') to maintain the vineyard sites where GHG emissions are monitored in the Lodi growing region. They provided feedback on management practices relevant to the LCA. The technician who works for Dr. Toby O'Geen provided technical support for sample analysis, as has a graduate student working with Dr. Louise Jackson. Partners have also contributed with regard to the quarterly meetings held for discussing updates on the project. The USDA/ARS currently contributes additional salary to cover assessment of greenhouse gas emissions and soil processes across the nine sites in Lodi in order to provide a robust, long-term dataset to USDA/ARS Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet) and Applied GeoSolutions LLC.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Goal/Outcome 1. *Provide a decision support system and GIS-based tool to: 1) help select farming practices that enhance C stocks, 2) assess C stocks on agricultural land, and 3) markets GHG-friendly farming to consumers.*

GHG emissions from three different soil types (9 sites total) have been completed (December 2012), and have been carefully monitored to ascertain total GHG emissions across the different vineyard systems. Certain management events like tillage and precipitation result in high GHG emissions. Therefore, simulated tillage and rainfall pulse events have been conducted to assess effects of soil type on GHG emissions. Data from these simulated pulse events and regular monitoring of emissions have been prepared for provision to Applied GeoSolutions, LLC, to aid in efforts to validate the DNDC model.

As the research developed, it became apparent that the interaction between soil type, vineyard management and GHG emissions must be assessed to accurately depict potential GHG emissions from vineyards in Lodi and Napa. The number of scenarios necessary to run in the DNDC model to determine GHG emission levels across the landscape was reduced due to the work performed by the graduate student researcher working on the LCA (LCA, Goal/Outcome 2). Due to the extensive and detailed nature of running these simulations, USDA/ARS has partnered with another project funded by CDFA, SCBGP ("Field Testing a Carbon Offset and Greenhouse Gas Emissions (GHG) Model for California Winegrape Growers to Drive Climate Protection and Innovation") in order to accomplish this work. Also, they are also working with Applied Geo Solutions. This other SCBGP funded study will run DNDC scenarios across 20,000 land area polygons, and it has been agreed that the scenarios from this study will be run first. The simulations for the current study (Project 7) have been completed and compiled for incorporation into the web tool for growers.

By coordinating with the Wine Institute project, this project was able to expand the modeling component beyond what had been proposed in the original project Scope of Work. This project will provide a tool looking at the interaction between soil type and management on regional emissions whereas the Wine

Institute's project focuses on a case by case basis, but will not provide regional effects on emissions from wine grape production. The link to the web tool is not yet available, but it is anticipated its availability will be in approximately 6-9 months. The delay resulted from the opportunity to expand the web tool for growers.

This project also addresses landscape scale effects of management and soil type on soil organic matter. Nearly one thousand soil samples from the field surveys conducted were processed for total C and N content, and particulate organic matter content. These data are in the process of being incorporated into this same web tool to convey relationships between vineyard management practices and soil type in Lodi and Napa. In order to create congruence with the other CDFA project funded to the Wine Institute and reduce confusion by the end user (i.e. growers), these two web tools will be released in partnership.

Final management outcomes from this portion of the study will be available in 2013. See section "Lessons Learned" for more explanation. Here are highlights from this portion of the project:

- Assessment of GHG emissions across the nine sites in Lodi and simulation of management events – completed
- Collaboration with Applied GeoSolutions, LLC on the webtool and coordination of this tool with the Wine Institute – in process
- Generate data to Applied GeoSolutions, LLC to accomplish validation of the DNDC model, in support of the Wine Institute's CDFA, SCBGP project – completed
- Generate data for GRACEnet to contribute to national database of greenhouse gas emissions from agricultural systems – completed

Goal/Outcome 2. *Quantify effects of vineyard floor management practices on GHGs. Life cycle assessment (LCA) will be used to identify which practices minimize direct emissions of GHGs. Data will also be used to calibrate and validate the DeNitrification/DeComposition model, a biogeochemical model that has been calibrated to assess GHG emissions from winegrape vineyards.*

The LCA of winegrape production and associated environmental impacts has been completed by the graduate student researcher. The scope of the LCA is from "cradle to gate", or from the raw extraction of materials used in production to the exit from the vineyard operation. By limiting the LCA in this fashion, the output will be applicable specifically to growers. The Wine Institute is conducting a statewide LCA of the overall California wine production from "cradle to grave", or from the source of the materials to the consumption of the wine, and thus, USDA/ARS has coordinated Project 7 with their LCA efforts. As stated above, the Wine Institute's project also is funded by CDFA, SCBGP ("California Wine Climate Protection Initiative: Calculating Scope Three Greenhouse Gas Emissions to Mitigate Climate Change, Reduce Costs, and Address International Market Demand"). USDA/ARS has continued to meet with members of this other project, which includes industry partners, the Wine Institute, California Sustainable Winegrowing Alliance (CSWA), and PE International.

Here, steps taken to complete the LCA are provided. To ensure fidelity of data, the biological science technician overseeing the acquisition of data for the LCA received additional training through coursework at University of California, Davis (UC Davis). Data from interviews with growers, experts in a given field, and suppliers and manufacturers (e.g. of fertilizers, pesticides, compost) were compiled and organized in preparation for running the LCA model. This is also called the LCI phase, and significant effort has been spent to ensure the high quality of the data. Over this same period of time, the graduate student who has been working with Dr. Alissa Kendall and Dr. Kerri Steenwerth designed the LCA model and associated decision tree describing the management scenarios that will be evaluated by the model. The LCA model is complete; it evaluates scenarios by region (i.e., Lodi vs. Napa). A Masters Thesis is in the process of being formatted for submission for scientific peer review. Once the peer review process has been completed, the paper will be released for public preview.

Three energy use and GHG emissions hotspots in the lifecycle were identified: pesticide manufacturing, on-farm truck use, and cover crop field nitrous oxide emissions. Regional management variability also influenced the environmental performance of the impact categories. Due to the typical management practices in Napa, the regions wine grapes had nearly twice the energy demands and associated emissions as compared to Lodi; however, whether a direct comparison can be made between products is unclear given regional variability in climate and soils. For example, regional climate and annual precipitation would affect the required hours and energy to pump irrigation water to the fields; soil variability would influence the water holding capacity and available water at the vineyard site. A number of alternative management practices for growers aiming to improve the energy use and air emissions of their vineyards were also discovered. Compost was demonstrated to be superior in the categories reviewed as compared to organic and conventional fertilizers, while various types of cover cropping regimes appear to have little impact on life cycle inputs and emissions considered in this study. The caveat must be addresses, however, that the model does not currently represent the cause and effect between soil and the environment. This facet, however, will be incorporated through coupling of the DeNitrification-DeComposition (DNDC) model with the LCA model.

Goal/Outcome 3. *With the National Center for Appropriate Technology (NCAT), we will create a publication to provide practical, grower-friendly information about LCA tools. It will convey how LCA serves as a means to identify best management practices to reduce GHG emissions and energy consumption from winegrape production, and provide economic and consumer marketing benefits.*

Biweekly meetings were conducted with NCAT in order to finish the outreach article. The outreach article has been completed. It will receive national distribution through the NCAT website, other national conferences regularly attended by NCAT, and weblinks on the USDA/ARS website.

Synergistic Outcomes.
The composition of soil organic matter (SOM) influences its overall long-term stability, but the complex nature of this is little understood. Long-term SOM stability is also influenced by management practice and soil type. In order to discern relationships among SOM and various landscape and management attributes, Dr. Francisco Calderón (USDA/ARS, Akron, CO) will analyze the soil samples and particulate organic matter samples for their chemical composition using Fourier Transform Infrared (FTIR) microscopy. His activities represent an 'in-kind' contribution.

The USDA/ARS continues to build on this study. The USDA/ARS Crops Pathology and Genetics Research Unit is now supporting a graduate student at U.C. Davis, who will discern effects of the soil landscape and vineyard management practices on soil microorganisms and the biological processes performed by soil microorganisms. Such processes include those pertinent to developing management practices to enhance soil nutrient retention and minimizing GHG emissions.

A second graduate student at U.C. Davis will extend the web-based tool presenting region, soil attributes, management and simulated GHG emissions across the landscape to develop a more nuanced understanding of how the landscape affects grower decisions.

Dr. Toby O'Geen will utilize the soils collected from Napa in this study to assess additional soil attributes important for phosphorus and potassium nutrition in grapevines. Further, USDA/ARS is applying for additional grant funding to extend the LCA tool to incorporate ecosystem services provided by vineyards and surrounding ecosystems like riparian and oak woodlands.

The delay in the distribution of the web tool was allowed in order to create the best environment for the end users, or the growers. The Wine Institute and the principal investigators and cooperators agreed to release the web tools in concert to minimize confusion regarding the utility of the two web tools: the current project's web tool identifies differences in processes in just Lodi and Napa, whereas the other focuses on larger scale changes at the state level.

Also, the release of the LCA manuscript documenting the environmental impacts of winegrape production in Lodi and Napa will be delayed due to the peer review process; the principal investigators of this project retain no control over the timeline of this process as it is conducted by the scientific journal to which USDA/ARS will submit the manuscript. The Masters of Science thesis of will be completed December 18, 2012, and will be publically available through the University of California in 2013.

Chemical analysis by combustion of soil carbon content, carbon content of particular organic matter, and organic matter chemical composition using FTIR spectroscopy represents a 'Synergistic Activity'. The samples have been sent to Dr. Francisco Calderón, chemical analysis has been completed, and findings are being synthesized for publication.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Beneficiaries of the project include winegrape growers, growers of other commodities working with Life Cycle Assessments, and USDA/ARS researchers who are part of GRACEnet.

Information from this project has been extended via:

- Presentations at Napa Viticulture Technology Group, May 2012
- International American Geophysical Union Meetings, December 2011
- Soil Science Society of America, October 2012
- Recent Advances in Viticulture and Enology, March 2011
- Washington Association of Winegrape Growers, February 2011
- National coverage through the National Center for Appropriate Technology and development of the Life Cycle Assessment outreach document

USDA/ARS expects that other end-users will be those who develop protocols for agricultural practices and their impacts on global warming potential, such as California Climate Action Registry.

Specific quantitative data will be gathered using website visitations when the online DNDC tool is released with the Wine Institute. Through this online tool, these deliverables will be provided: Calculation of C offsets potentially gained by reductions in N_2O emissions and increases in soil C content; a decision support system using a web-based GIS to enhance on-farm soil C stocks.

Consultants from Baine and Company have shown that the economic impact of research on the wine grape industry commonly manifests itself after almost 15 years after completion of the research. The study funded by SCB09042 (Project 7) was conducted in wine growing regions that represent a significant percentage of the California wine industry acreage total of 543,000 acres grown in 48 of 58 counties in California. It is anticipated that findings from this study will inform protocol development for payment for carbon storage in perennial agriculture, especially as current protocols addressing this concept for a California Carbon Market do not exist.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Unexpected Outcomes.
A difficulty encountered has been the selection of models to assess the GHG emissions. There is much debate in the scientific community regarding which model is appropriate. Additional time has been taken to evaluate the current findings using several models. An unexpected outcome of this project is that USDA/ARS will be able to evaluate several GHG emissions models. Due to this slight delay, publication of data related to the GHG emissions in peer-reviewed journals will now occur in 2013.

As indicated above, one unexpected outcome was found in the LCA. The most striking finding is that the impact of hand-harvesting in Napa was more energy intensive and had a greater global warming potential than machine harvesting in Lodi. This was attributed to the continued idling of tractors during hand-harvesting.

Lessons Learned.
An original goal was to measure GHG emissions from Lodi and Napa growing regions. This goal had to be reduced due to the intensive manual labor required to measure GHG emissions. Development of automated samplers for GHG emissions would have helped solve this problem or doubling the number of personnel (from four to eight) sampling in the field and running analyses in the laboratory.

Written documentation and database design were essential to maintain consistency among activities implemented by the project. Protocols in the laboratory and field were periodically reviewed for consistency. Periodic review of the database and documentation approach has greatly improved data collection and accuracy.

A gas chromatograph was purchased for this project. As many researchers know already, gas chromatographs are very sensitive and often break down. In order to avoid sample loss during periods when the gas chromatograph was broken, vacutainers were sealed with silicone to maintain their long-term fidelity.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Not applicable.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 8	**Project Title:** Coupling conservation tillage with overhead, low-pressure precision irrigation of vegetables: A new production paradigm for increased resource use efficiencies	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09011	**Date Submitted:** December 2012
Recipient Contact: Jeff Mitchell	**Telephone:** (559) 303-9689	**Email:** jpmitchell@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Vegetable production in California (CA) relies on irrigation and intensive tillage. Limited water availability and risks of irrigation-induced sediment, nutrient and pesticide runoff and drainage losses with surface irrigation, as well as dust and greenhouse gas (GHG) emissions with conventional intensive tillage systems for vegetable crop production require innovative management. Labor supplies and production costs are also problems for vegetable farmers. Subsurface drip irrigation, now commonly used in many vegetable production fields, has been shown to increase productivity and profitability, reduce subsurface drainage, and improve weed control. A recent survey of the University of California Cooperative Extension (UCCE) Advisors and San Joaquin Valley (SJV) West Side farmers indicated that over 85% of processing tomato acreage in the Central SJV is now produced using permanent bed subsurface drip irrigation.

When subsurface drip is used, however, farmers tend to be limited to tomatoes due to the placement, spacing and configuration of the buried tape. Rotating to other crops becomes more difficult and costly, and as a result, continuous monocultures often result with corresponding risks for pathogen build-up in the soil. Low-pressure, precision-application overhead irrigation systems that are widely used for agronomic crops in other regions, coupled with intensive conservation tillage (CT) practices may, however, be an innovative means for producing high quality crops more cheaply and efficiently. Such systems would overcome problems of surface irrigation across or through residues that tend to accumulate in CT fields, conserve water resources, and reduce drainage volumes. These systems may also reduce labor, fuel and equipment costs and GHG emissions. Stakeholder input indicates no solid research or experience, but growing interest in using these systems in CA for vegetable production. This CDFA project was conducted to evaluate the potential of overhead, mechanized irrigation coupled with CT as a more flexible, precision irrigation technology for SJV vegetable production systems, and as a means for increasing competitiveness and providing greater resource conservation. The synthesis or integration of these systems components, as reported here, is completely new and untested in CA.

The goal in this work was to develop more efficient, cheaper and resource-conserving vegetable production systems. Project objectives were:

1. To determine changes in profitability, resource use, and emissions from CT vegetable rotations under low-pressure, precision overhead irrigation due to increased water efficiency, reduced runoff, drainage, fuel use and labor,
2. To determine effects of reduced tillage and surface residues on soil evaporation , and
3. To extend information developed widely throughout CA's SJV

With this project, the University of California, Davis (UCD) created a close collaborative mechanism not only between the core research team, but also a larger group of farmers and private sector partners. This collaborative group took part in project planning and assessment meetings, frequently visited the study site, and worked together on extension education activities. Formation of the CA Overhead Irrigation Alliance (COIA) (now an integral part of UCD's Conservation Agriculture Systems Innovation workgroup) was also a significant outcome from this project. Members of COIA have worked together to hold two twilight field tour events to the site on overhead irrigation and conservation agriculture that have attracted over 250 participants in 2010 and 2011. A 2012 event will be held soon after the grant period ends in Five Points, CA. During the last year of this work, formalized weekly conference calls between members of the project team and private sector collaborators were held. These calls provided project updates and planning opportunities as well as course adjustments in irrigation management based on soil water sensor readings, crop growth, development assessments, and local evapotranspiration (ET_O) data.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Methodology

To address the questions and objectives of this project, a replicated crop rotation study using tomato, onions, and broccoli under drip and overhead irrigation in an 8-acre field of a Panoche clay loam soil at the UCD West Side Research and Extension Center in Five Points, CA. One acre plots of each irrigation system were replicated four times in a randomized complete block experimental design (Attachment 2). A single 5/8" 13 mil drip tape placed about 12" below the soil surface in the center of each 60" bed was used for the tomato and broccoli drip irrigated crops, and three 5'9" 10 mil tapes were installed at about 3" depth for the onions (Attachment 3a). Water applications were monitored using an in-line McCrometer 6" flow meter at the drip system pump. The overhead irrigation system was irrigated using a hose-fed, eight-span lateral-move irrigation system (Model 6000, Valmont Irrigation, Valley, NE). This system had a diesel-electric power plant with a CAMS control panel for speed control. Irrigation amounts for the overhead system were determined by various combinations of the (lateral-move system) movement speed and application nozzles. Application volumes were determined using an in-line Seametrics magnetic flow meter.
The field project was set up in 2009 and initiated with a processing tomato crop in 2010 that was followed by an onion crop harvested in June 2011, a broccoli crop harvested in November 2011, and a subsequent tomato crop in 2012. Growth was monitored for each crop by either harvesting and determining fresh or dry weights of representative plants, or by using a digital, band-ratioing infrared camera. Yields were determined using commercial, farmer-provided equipment. Irrigation applications for all crops closely matched ET_{crop} for both the drip and overhead systems indicating minimal drainage losses (Attachment 3b). The measured

Christiansen's Coefficient of Uniformity (CU) of the overhead irrigation system was determined to be 93% (Attachment 4).

Productivity

In terms of vegetable crop productivity, findings for single-season evaluations suggest similar or better yields can be achieved with overhead mechanized irrigation as those with drip irrigation using comparable applied water amounts for onions and broccoli, but that a better overhead irrigation management strategy is needed for tomatoes in order to match drip yields (Attachment 5). This finding in many ways is understandable, reasonable and perhaps even expected because not only is the season-long ET demand of tomatoes greater than that of cool-season produced onions and broccoli, but the balance between applied water and vegetative growth versus fruit yields, quality, and disease susceptibility is perhaps more subtle and difficult to manage for tomatoes. UCD is hopeful that whereas overhead tomato yields were only 58% of those of drip irrigated tomato in 2010, the early and mid-season crop growth that has been monitored in 2012 under overhead irrigation will be stronger (Attachments 6 and 7).

Soil water evaporation

Another significant finding from the work accomplished with this project is that surface crop residues significantly reduce soil water evaporation relative to bare soil systems. UCD estimates 0.89 and 0.97 inches more water is retained in the surface foot of soil under no-till than in tilled soil. In three field studies comparing residue effects on soil water evaporation, bare soil had about 0.56, 0.58 and 0.42 inches less water retained than under residues following 6-7 days of overhead sprinkler irrigation. Assuming a seasonal crop evapotranspiration demand of 30 inches, coupling no-tillage with practices preserving high residues could reduce summer soil evaporative losses by about 4 inches (13%). Reference is made to the following research article titled "No tillage and high residue practices reduce soil water evaporation" at the following website address: (http://californiaagriculture.ucanr.org/landingpage.cfm?article=ca.v066n02p55&fulltext=yes) (Mitchell et al., 2012; Singh et al., 2011). This is an important finding and is the first report of this phenomenon in California (Attachments 8 – 11).

Economic evaluation

To further evaluate the performance of tomato production systems that use conservation tillage, UCD compared the production costs of a bed-preserving minimum tillage system that is common in subsurface drip irrigated tomato fields, a generic no-till system, and the standard tillage approach that has been common for CA tomato fields for decades. Tomato was used as a model crop, however, the same general procedure and outcomes apply also to onions and broccoli. The minimum tillage system uses many standard tillage practices while protecting a buried drip irrigation tape by eliminating deep subsoil tillage. The standard tillage system represented practices used in the most recent UCCE cost study for processing tomatoes in the San Joaquin Valley (Valencia et al., 2002). Calendars of intercrop operations following harvesting to transplanting of tomatoes were generated for the standard and the minimum tillage system. The equipment and materials used and water applied were recorded. The cost of each operation for each system was estimated using a model of a hypothetical 1,000-acre farm under each of the four systems. The time required for each operation, including fuel, lube, and repairs, was generated using agricultural engineering equations. Input costs for fertilizer and pesticides were obtained from local input suppliers and entered into the model. The cost of production and resource use for each of the systems were then compared. In particular, the model summarizes the labor requirements for both tractor operators and irrigation labor as well as fuel use. From this, the economic feasibility of each system was estimated and the relative costs determined.

An overall comparison of the itemized costs is shown in Attachment 12 and a summary of the calendars and costs associated with each of the three systems is provided in Attachment 13. In these comparisons, a winter sprinkler pre-irrigation has been included with each of the four systems as is the convention through much of the SJV tomato-growing regions, primarily for salt management and to also provide about 6 inches of soil water ahead of transplanting. These cost comparisons indicate that the no-till system is the least expensive of the three systems - about $137 lower than the "standard" tillage systems, and $59 lower than the "minimum" tillage system. Savings are realized by no-tillage and the minimum tillage as a result of lower machinery-associated costs (Attachment 12).

The magnitude of savings achieved by no-tillage shown here is quite comparable to savings when other crops such as silage corn and cotton are compared in CA. It is important to point out that these savings, on the order of $140/acre, are not large relative to the overall production budget for vegetable crops. In the case of tomatoes, the savings represent about a two ton difference in yield assuming that a ton of tomatoes is currently valued at about $68/ton. Thus, reducing tillage alone may be seen as too risky in terms of potential yield loss due to the sheer difficulties of managing a crop such as tomatoes with no tillage. However, when the additional savings estimated for coupling overhead mechanized irrigation with conservation tillage, (rather than using drip irrigation), amounting to about an additional $100/acre are factored in, the potential benefits of merging these technologies become clearer. It is important to point out that adoption experience, in areas where CT is now common, often shows that it is because of perceived 'combined' or multiple benefits that people eventually change behaviors and practices (Mitchell et al., 2012), and not necessarily because of economics alone.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

This project has made good on its goals and has achieved a number of useful outcomes including:

a. The ability to produce onions and broccoli under overhead irrigation with yields similar to those with drip irrigation
b. The identification of a need for improved management strategies for tomatoes to increase productivity with overhead irrigation
c. A quantification of the efficiency and uniformity of overhead irrigation and the ability to precisely apply water volumes and thereby minimize drainage losses
d. The value of surface residues in terms of reducing soil water evaporation and increasing water use efficiency
e. Estimates of cost savings that may accrue by coupling conservation tillage with overhead irrigation
f. A coordinated extension education program that has successfully and very publicly extended the goals and findings of this work widely via press releases, major field days, and the hosting of numerous site visits, and

g. The publication of three articles stemming directly from this work, and at least two others are now being prepared

The project has enabled initial evaluations of the potential for merging overhead irrigation and conservation tillage technologies, and has identified areas such as management of tomatoes under overhead irrigation, where additional refinement is needed.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

As the findings from this work continue to be disseminated, a wider group of SJV farmers and consultants will directly benefit from this CDFA project. UCD has documented a number of direct inquiries from farmers regarding the work done in this project and the feasibility and desirability of their converting to pivot irrigation. Experience earned through this project bears directly on guiding and answering such inquiries. While UCD has demonstrated and documented an economic value of coupling overhead and conservation tillage technologies that could result in production cost savings theoretically approaching more than $250/acre per crop, UCD also appreciates and recognizes that wholesale conversion to these management systems is by no means a straightforward, simple process. The role these technologies play in the future will depend likely on risk assessments made by individual farmers, as well as how the 'combined' economic benefits as well as the services and resource conservation these new paradigms present.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

This work has provided highly visible documentation of the potential of overhead irrigation systems for vegetable irrigation, and has further identified tomato as a crop for which more management improvements will be needed in order to be economically viable. Following the first tomato season in 2010, UCD held a planning meeting on September 8, 2011 in which over twenty-five partners participated and provided strategies that are being implemented in 2012. While this current season's crop looks better than the 2010 effort, UCD does not believe a final set of recommendations has been fully developed. More work is needed. The cost and water savings shown here are important and may inevitably be useful in assessments of whether adoption is warranted.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

References

Mitchell, Jeffrey P., Gene Miyao, Karen M. Klonsky and Richard DeMoura. 2012. Cover cropping and conservation tillage in California processing tomatoes. University of California Agriculture and Natural Resources. Publication 8405. August 2012.

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Singh, P.N., J.P. Mitchell and W.W. Wallender. 2011. Parameter optimization for predicting soil water movement under crop residue cover. Transactions of the ASABE. 54(6):1-7.

Valencia, Jesus B., Donald M. May, Karen M. Klonsky and Richard L. De Moura. 2002. Sample costs to produce processing tomatoes transplanted San Joaquin Valley – South. TM-VS-0202 University of California Cooperative Extension.

USDA Project No.: 9	Project Title: Soil and Water Management to Reduce Water Losses, Energy Costs and Greenhouse Emissions in Tomato Rotations	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09002	**Date Submitted:** December 2012
Recipient Contact: Martin Burger	**Telephone:** 530-754-6497	**Email:** mburger@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

For California's specialty crops, management practices that decrease water losses from cropland and increase irrigation efficiency are needed to keep agricultural production sustainable in the face of surface water shortages, which can be expected to occur more frequently due to climate change. Furthermore, to achieve the goals of the California (CA) Global Warming Solutions Act of 2006, comprehensive strategies to reduce greenhouse gas (GHG) emissions must be developed. Nitrous oxide (N_2O) contributes about one third to the total GHG emissions from CA's agriculture sector. Therefore, management practices should be carefully evaluated in terms of their N_2O emissions. For a given farming system, energy consumption for irrigation and fuel use to power equipment, in addition to N_2O emissions from soil, affect the total GHG emissions or 'carbon footprint.' For example, increasing irrigation efficiency will reduce the overall GHG balance or global warming potential (GWP).

Processing tomatoes are grown on 300,000 acres of irrigated cropland during CA's hot, rainless summer months. Almost all the rainfall occurs in winter, during which much land is left fallow. During intense rainstorms, runoff from agricultural fields may take place. The runoff water ends up in rivers and in the ocean, and is thus lost (not stored in the soil). Cover crops (CCs) increase infiltration properties of soils and can decrease runoff. Other benefits of CCs are better soil structure, higher soil organic matter, and improved fertility. The benefits of including CCs in a rotation in terms of water storage and water availability to a subsequent crop have rarely been quantified. It has also been hypothesized that CCs increase uniformity of soil water content of irrigated land.

In recent years, the rate of adoption of subsurface-drip irrigation (SDI) by tomato growers has accelerated. It is generally assumed that less water is used with drip than with furrow irrigation (FI), but few data sets have shown this. Furthermore, soil compaction, which is detrimental to root growth, has been reported in SDI fields. The use of CCs could potentially alleviate this problem, but the effects of cover cropping on water distribution in the root zone have not been investigated. Information on GHG emissions, soil moisture distribution, water use, and possible improvements of SDI systems is, therefore, timely.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

In this 2-year experiment, comparisons were made of water inputs and losses, soil moisture, tomato crop performance, energy consumption, GHG emissions, and economics in winter-fallow and two cover cropped tomato rotations under FI and SDI. The experimental sites were the University of CA Davis Russell Ranch Sustainable Agriculture Facility (RR), where replicated (n=3) winter-fallow and cover cropped 1-acre plots have been in place since 1993, as well as 9 grower fields in Yolo County. At the RR, either a bell beans/vetch/oats mixture or Triticale were sown in late fall and grown during the rainy season; on cover cropped grower fields, bell beans or Triticale was grown. The Triticale CC was terminated with herbicide (glyphosate) in late February of each year, whereas the CC mixture was plowed in a month later. The objective of the research was to compare how the two contrasting CC management practices affected soil rainwater storage, groundwater recharge, irrigation water use, as well as agronomic outcomes and total GHG emissions.

The presence of CCs reduced runoff in 2010 by a relatively modest amount. In 2010, runoff was measured on 4 large grower fields (2 CC and 2 fallow) by automated water samplers. Runoff ranged from 0 (one of the CC fields) to 1 cm-centimeter (fallow field). In 2011 there was no runoff from any of the monitored fields. The runoff was not measured at the RR because the size of the individual plots is not suitable for runoff measurements. Based on the above runoff measurements, the additional amount of rain water stored in the profile due to CCs was very small (1 cm) compared to the irrigation needs of a tomato crop (about 45-75 cm, depending on irrigation method).

Water use was measured by inline flow meters in the water delivery lines. Water use was significantly lower under SDI than FI. In 2010, the applied water to the tomato crop by SDI in the winter CC systems was 75% (CC mixture) and 84% (Triticale CC) of the amount used in the FI systems. In 2011, the amounts of water used with SDI were 54%, 64%, and 72% of those used with FI in the CC mixture, Triticale, and winter-fallow systems, respectively. The exception was the winter-fallow system in 2010, where 28% more water was applied with SDI than with FI. The main reasons for the low water use in the FI winter-fallow system were poor infiltration characteristics of this soil, as explained below. For SDI, the water lost through evapotranspiration (ETc) was estimated based on measured canopy cover and reference evapotranspiration value (ETo) available from the California Irrigation Management Information System (CIMIS). For FI, soil moisture and experience served as guidance of irrigation scheduling.

A complete water budget, which allowed estimation of water lost below the root zone (i.e. leaching), was conducted each year. This calculation took into account the soil moisture in the profile to a depth of 3 meters (m) measured by neutron probes at 72 locations, water inputs, and ETc. To accurately measure soil moisture content in the SDI system, additional neutron probe access tubes had to be placed at two lateral positions in the bed and in the furrows. This is because soil moisture under SDI is typically much higher below the drip tape in the center of the bed than under the furrow. In 2010, 8 to 10 cm of water leached in the furrow-irrigated CC treatments below the root zone, but none in the other systems. In 2011, this drainage below the root zone under FI was 44, 48, and 65 cm in fallow, Triticale CC, and mixed CC, respectively. Under SDI, leaching was between 7 and 12 cm. These results indicate that the potential for leaching is lower under SDI than FI.

In 2010, tomato yields in the CC were higher than the winter-fallow systems, and did not differ between FI and SDI treatments. The FI winter-fallow system had the lowest yields, while SDI winter-fallow had intermediate yields. In 2011, yields were moderate to low in all treatments due to unfavorable weather conditions and related disease (bacterial speck) pressure. However, yields per unit applied water were higher under SDI than FI.

To test the hypothesis that the practice of cover cropping increases infiltration and uniformity of soil moisture in tomato beds, soil water potential was measured at multiple depths (20, 40, and 60 cm) and two lateral positions (15 and 30 cm from the plant line) by Watermark sensors. In 2010, these data indicated that near the plants in the upper two layers (20 – 40 cm) in the winter-fallow plots, the soil was getting drier as the season progressed, whereas in the CC plots, the soil responded to each irrigation and stayed moist in all the layers. This observation confirms that infiltration in the winter-fallow soil was slower, leading to lower water uptake than in the CC soils. This was the likely cause for the lower yields under winter-fallow than CC soils. The soil water potential measurements also showed that in 2011, soil moisture was adequate in all FI systems, whereas soil moisture in the uppermost layer (20 cm) of the SDI systems stayed dry. The latter finding indicates that there was no upward movement of water since the drip tape was placed at a 30 cm depth.

To test the hypotheses that a) lower water availability under FI than SDI (irrigation practice effect) and b) lower water availability in winter-fallow than winter-cover cropped soil (soil management effect) affected tomato crop performance, stomatal conductance was measured with a LICOR 1600 instrument as an indicator of plant water stress several times during the growing seasons. The results showed no difference in stomatal conductance between soil management treatments, but on average, stomatal conductance was higher under SDI than FI, indicating that the tomato plants experienced less water stress under SDI. These results were corroborated by carbon isotope (C^{13}) analyses of leaf tissue that showed the same results.

A large effort was expended for measuring direct emissions of GHG, namely N_2O. N_2O is a microbial process that utilizes inorganic forms of nitrogen (N) in soil. The production of N_2O is stimulated by N inputs (e.g. fertilizer), soil resources such as available carbon, and soil moisture. N_2O emissions were measured several times per week when soil moisture was elevated after irrigation or rainfall events, and less frequently under dry conditions. The measurements were made by placing a vented chamber on the soil surface and sampling headspace at regular, timed intervals. The air samples were analyzed by gas chromatography and the flux of N_2O was calculated from the change in N_2O concentration over time. Ninety flux measurements per year were carried out at 18 sites each by numerous (13) technicians and students who made an outstanding contribution to this project. The annual N_2O emissions were calculated by converting the measured fluxes to daily fluxes and interpolating between daily fluxes.

The results showed that the annual N_2O emissions in both years were significantly lower under SDI than FI. Averaged over the two years, under SDI the emissions were 77, 47, and 46% of those under FI in winter-fallow, Triticale CC, and Mixed CC, respectively. The emission factors (EF), defined as the percentage of the applied N fertilizer lost as N_2O-N, were, averaged over the two years, 0.3 to 0.9% for the SDI and 1.4 to 2.11% for the FI treatments. Under FI, the annual N_2O emissions were similar during the first year, but in the second year, the emissions in the CC were greater than those in the winter-fallow treatments. This difference in N_2O response was attributed to the large amounts of water applied in the FI CC treatments in year 2. Under SDI, the annual N_2O emissions were similar among soil management practices in both years. The majority of N_2O was lost during the summer growing season following the major fertilizer applications. The emissions outside the tomato growing season were between 10 to 25% of the annual total, and of those the emissions following the first rainfall in the fall after harvest were by far the greatest in one of the two years.

In addition to direct N_2O emissions, fuel consumption to power farm equipment and energy for irrigation were considered in the calculations of total GHG emissions. Fuel consumption for the different tillage passes used in tomato rotations, harvesting and transplanting, and for CC mowing and incorporation was measured on regular-size grower fields. Previous estimates of fuel consumption with different tractors had been based on measurements taken in the U.S. Midwest. The fuel units were calculated in carbon dioxide equivalents (CO_2eq.) according to U.S. Environmental Protection Agency conversion factors. The energy consumed for pumping irrigation water was calculated based on energy use by the pumps at the Russell Ranch, where ground water is at about 40 m. Assuming ground water use for both FI and SDI, the average annual energy savings were 725 and 227 kWh (kilowatt-hours) with SDI compared to FI in the CC and winter-fallow systems, respectively. A conversion factor of 0.575 lbs CO_2 eq./kWh (Pacific Gas & Electric) was assumed for the total GHG calculations. The initial intention had been to use typical pumping plant efficiency values in Yolo County, CA, and combine those with a range of values of total dynamic head, but pumping plant efficiency records are no longer available in this water district.

For the economic analysis, the costs of production (CP) for a 32-hectare (ha) field were determined for the three systems and two irrigation methods. The CP under FI were higher by 32 (2010) and 13% for the CC than the winter-fallow system. Under SDI the CP were higher by 18 (2010) and 10% (2011) for the CC systems. Differences in CP between the two CC management practices were ≤4%. The annual water costs, which were solely due to the energy costs for pumping groundwater, ranged from \$76 to \$637 ha^{-1} (one-tenth ha) and were always higher under FI (except in the winter-fallow treatment in 2010) than SDI because of the higher amounts of water applied with FI. Total CP ranged from \$3170 to \$4460 ha^{-1} in 2010, and from \$3660 to \$4770 ha^{-1} in 2011, and total revenue from \$4250 to \$8230 ha^{-1} in 2010, and \$5100 to \$6320 ha^{-1} in 2011. Yield differences were more important in determining the profitability of each system than differences of the CP.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The overall goal of the project was to evaluate the management practices in terms of water use, total GHG emissions, and economics. As discussed above, there were savings in water use with SDI compared to FI. The additional water used with FI was not lost because this water percolated below the root zone and, therefore, the groundwater balance was not affected by the irrigation technique. However, using SDI lowered total GHG emissions through savings in energy to pump ground water and lower direct N_2O emissions.

The emissions associated with N fertilizer production were included in the GHG emissions total. The analysis revealed that N_2O and fertilizer production-related emissions were >50% of total GHG emissions, which were greater under FI than SDI. The energy used for irrigation accounted for 7 (FI) and 9% (SDI) of total GHG emissions in 2010, and 15 (FI) and 12% (SDI) in 2011. Some additional tillage and in 2011 an initial sprinkler irrigation were required in the mixed CC system. However, these additional energy requirements did not significantly affect the total GHG budget. The major conclusion was the finding that in order to keep the carbon footprint of these tomato rotations as low as possible, N_2O emissions must be kept under control, and this is best achieved with SDI.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Tomato growers in California (about 490 farms) benefitted from this study because it demonstrated that N_2O emissions can be lowered with SDI. On January 10, 2012, the project manager presented the results of this study to 120 tomato growers as part of the Annual South Sacramento Valley Processing Tomato Production Meeting in Woodland, CA. An article entitled "Buried drip helps growers manage fertilizer" was published in the Trade journal 'AgAlert.' In the course of the project, three Field Days attended by 70 (2010), 122 (2011), and 160 (2012) people were held at the Russell Ranch site. The information presented at the Field Days is available at the websites of the Agricultural Sustainability Institute – ASI (http://asi.ucdavis.edu/) which as an umbrella organization that has subsumed the activities of the Sustainable Agriculture Research and Education Program, Sustainable Agriculture Farming Systems, and Russell Ranch. Participants at the Field Days, which at one of them included a workshop, were given surveys. Seventy-percent of the farmers who attended the Field Days (9 to 16) ranked the information presented as either good or excellent, but some commented that too much emphasis was placed on presenting measurement techniques rather than straightforward recommendations for best management practices. Some of the farmers who liked the information indicated that they want to keep abreast of the latest information on minimizing GHG emissions because the CA Global Warming Solutions Act may require farmers to take steps to reduce GHG emissions. Meetings with 6 collaborating growers, Principal Investigators, and staff to discuss preliminary results were held twice (2010, 2011).

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The original hypothesis, namely that a substantial amount of rain water can be retained by cover cropping, was only partially supported by the data collected in this study. Another hypothesis was that yields would be higher with SDI. This was not the case at the UC Davis Russell Ranch site. However, data collected on other grower fields did show higher yields under SDI than FI. Since the results varied from year to year, it was difficult to create a clear message to growers regarding cover crop and water management. For this reason, only one Trade journal article with a focus on SDI and N_2O emissions was released. A second Trade journal article and additional content for the ASI web sites will be released if the results from a third year of data collection will provide the data that support clear-cut farmer recommendations.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

None.

USDA Project No.: 10	**Project Title:** Multi Commodity Sustainability Practices Program	
Grant Recipient: Great Valley Center	**Grant Agreement No.:** SCB09026A	**Date Submitted:** December 2012
Recipient Contact: Linda Hoile, Program Manager Jami Westervelt, Senior Director of Programs and Operations	**Telephone:** (209) 522-5103 ext. 140 (209) 522-5103 ext. 122	**Email:** linda@greatvalley.org jami@greatvalley.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The public is increasingly demanding assurances about food safety and processes that ensure a healthier environment – including cleaner water, better air quality, and reduced carbon emissions and energy use. Changing consumer attitudes and preferences are manifesting themselves throughout the food production and distribution system. The agricultural industry is looking for ways to deal with environmental mandates to reduce carbon emissions and with consumer preferences for higher quality and safer food that can be tracked to reliable sources. Sustainable practice programs offer an opportunity to address myriad demands on specialty crop commodities. Sustainability programs can provide hard data with which to develop and tell a commodity's "story" through use of metrics to measure progress.

Through this grant, project partners SureHarvest, Sustainable Conservation and the Great Valley Center developed a Sustainability Strategic Plan for the Multi-Commodity Project and a Multi-Commodity Self-Assessment Template, laying the groundwork for increasing the number and strength of specialty crop sustainability programs in California. The project process involved outreach to commodity groups and stakeholders, sharing of information on sustainable practices and sustainable program models, and developing consensus and collaboration with a number of specialty crop groups.

The Strategic Plan and Self-Assessment Template provide commodity groups and growers with business management tools that can help improve the economic viability of farming operations, aiding them in gathering and using data to identify opportunities for increased efficiency, and providing an opportunity to differentiate their product in the marketplace based on the social and ecological values demonstrated through sustainable practices.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

The Multi-Commodity Sustainable Practices Project followed a collaborative and inclusive approach in the creation of a Sustainability Strategic Plan. This tool simplifies and reduces costs for an individual commodity group in establishing a sustainability program for their growers, and equips growers to work through the "5 P's model" in their farming operations. The 5 P's are: Principles, Processes, Practices, Performance, and Progress (Attachment #1). The Sustainability Strategic Plan provides a template that can be customized to meet each commodity group's specific needs.

The project Leadership Team also created a Multi-Commodity Self-Assessment Template tool for growers and crop associations to use in measuring current sustainability practices and processes and perform gap analysis in the areas of air quality, energy, finances, food safety, soil, ecosystem, pest management, social responsibility, waste and water management. Both tools encourage the 3E's of sustainability (economic viability, environmental soundness and social equity – responsibility).

Due to the technical nature of both the Strategic Plan and Self-Assessment templates, the project team engaged a cross section of commodity groups, stakeholders and topic area experts during the development of both of these tools. By engaging commodity groups and other stakeholders in the process of developing these two sustainability tools, there is now a broad foundation of buy-in and support for developing and implementing sustainability programs in the specialty crop industry.

The Multi-Commodity Sustainability Practices Project was a team effort stewarded by a Leadership Committee composed of the project partners – SureHarvest, Sustainable Conservation and Great Valley Center, and membership from crop commodity groups that included participants from California Specialty Crop Council, California Tomato Farmers, California Pepper Commission/Saticoy Foods, William Bolthouse Farms, California Pistachio Research Board, and Almond Board of California.

The Leadership Team also formed a Stakeholder Committee to draft the self-assessment template that covered the practice areas listed in the Multi-Commodity Project Strategic Plan. After an initial kick-off meeting, the Stakeholder Committee met via webinar. Stakeholder Committee members included: Bob Giampaoli, Live Oak Farms; Cliff Sadoian, peach grower; Mechel "Micki" Paggi, Center for Agricultural Business at California State University Fresno; Glen Fischer, Saticoy Foods/Pepper Commission; John Trumble, University of California Riverside; Terry Prichard, UC Davis Cooperative Extension; Pete Goodell, University of California Davis; Bill Peacock, Raisin Marketing Board; Troy Elliott, Bolthouse Farms; Joe Browde, California Association of Winegrape Growers, and Lauren Friedman, California Tree Fruit Agreement.

The stakeholders provided strategic input into the development of practice area language and the Multi-Commodity Self-Assessment Template. This was accomplished by hosting six webinars where the committee reviewed and edited the text drafted at previous meetings and received information from those who could not participate in the webinars via email.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The two primary objectives and outcomes achieved by the Multi-Commodity Sustainability Project were development of a Sustainability Strategic Plan and a Self-Assessment Template for commodity groups and growers to use to assess the sustainability of the farming practices used to produce their crops.

The economic impact and benefits that arise from the use of these tools could not be quantitatively measured during this project but will be realized during the next phase of the project, which entails fine tuning the Self-Assessment Template for specific specialty crops to create workbooks for each one. However, long-term measureable outcomes will be derived from a bench marking of sustainable practices by growers, using the self-assessment workbook, creation of action plans to improve their operations over time and a broad adoption of practices that enhance a farm's sustainable production of specialty crops.

Education and outreach were accomplished through the process of developing the two tools, with a number of specialty crop groups participating in meetings and webinars – both groups that had successfully implemented sustainable practice programs (wine grapes, almonds, avocados), as well as those groups that were just beginning to explore the benefits of a sustainability program for their industry. These groups benefited from the process of sharing information and developing their group's knowledge base. At the first project workshop SureHarvest gave a presentation on the "What and Why of the Sustainability Plan" which provided an overview on the important benefits of sustainability programs. In addition, the sustainable agriculture section of the Great Valley Center's website was enhanced through this project to provide a clearinghouse of links to sustainable agriculture information, examples and the two new tools developed through this grant.

Activities and steps taken in completing the Multi-Commodity Sustainable Practices Project included: conducting workshops with commodity groups to develop program objectives and next steps based on input provided; conducting a strategic meeting with the Leadership Team to establish areas of common interest to commodity groups and develop program objectives and next steps; assembling a broad stakeholder committee to gather input for development of practice area language; holding webinar stakeholder committee meetings; writing draft practice area language; conducting peer review of draft language, and obtaining approval from stakeholders to finalize language; writing drafts for the strategic plan for multi-commodity sustainable practices programs and sustainable practices assessment template and reviewing these tools with stakeholders, incorporating their feedback and obtaining their approval.

An exciting additional result of this project was SureHarvest secured another Specialty Crop Block Grant for 2011 – 2013 to sustain and continue the Multi-Commodity Sustainability Program. The Sustainability Strategic Plan developed by this grant has been used as the guiding document in Phase II for specialty crop groups participating in Phase I and as an introduction to the project for groups that were not involved in Phase I but were approached to participate in Phase II. The Self-Assessment Template created by this first grant has been used as the foundation document from which assessment workbooks specific to each participating specialty crop were derived under Phase II in order to aggregate data, benchmark practices, and initiate a cycle of continuous improvement.

Beneficiaries

- Provide a description of groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The Sustainability Strategic Plan and the Multi-Commodity Self-Assessment Template are valuable tools open to use by all specialty crop groups and individual growers to accomplish their own sustainability programs and reap benefits of greater profitability and ecological harmony. The Strategic Plan provides a group with a template for establishing a sustainability program for their industry, and the Self-Assessment Template provides an individual farm the opportunity to measure their sustainability practices and encourages continual improvement in their operation. Beneficiaries of this initiative include the following entities that gained knowledge and awareness of sustainable practices through their participation in the development of the tools, sharing of information and sustainable program models, and have either enhanced their existing sustainable practices program or are continuing towards development of a sustainability program through a Phase II grant to SureHarvest by CDFA. However, each of the statewide commodity organizations represents numerous individual specialty crop growers/farmers who are secondary beneficiaries as members of these organizations. This adds up to a potential for well over a 1,200 additional direct beneficiaries in the future as these specialty crop growers take advantage of the self-assessment template.

Almond Board of California
Bolthouse Farms
California Dried Plum Board
California Grape & Tree Fruit League
California Specialty Crop Council
California Garlic Onion Research Advisory Board
California Olive Council
California Pear Advisory Board
California Pepper Commission
California Pistachio Board
California Raisin Marketing Board
California Tomato Farmers
California Tree Fruit Agreement
California Walnut Board
Del Monte Foods
Sun Maid Growers

The economic impact of the Multi-Commodity Sustainability Practices grant cannot be measured until the sustainability programs for each specialty crop are fully developed (currently underway in a Phase II follow-up grant from CDFA that is being administered by SureHarvest) and those programs are subsequently implemented by the growers. The ultimate impact of the resulting sustainability programs is expected to be millions of dollars of operational savings and increased productivity, as growers implement sustainable practices that result in more efficient/reduced applications of irrigation water and pesticides; fuel and labor savings from conservation tillage; increased productivity through winter cover crops that increase soil carbon as well profits while reducing erosion, and many other practices that prove good for the environment and for growers' profits.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.
- If there is a remaining balance, explain why the project did not utilize all awarded grant funds.

There were a number of lessons learned through this project. The lessons and insights gained through this project include:

- Specialty crop growers and trade associations have concerns about how a sustainability program will affect their farming operations.
- Engaging stakeholders in the process of developing a sustainability strategic plan results in a broad buy-in and support for developing and implementing a sustainability program.
- Stakeholders recognized the 5P's of sustainability framework as a strong framework for a strategic plan that helped them understand sustainable farming.
- Stakeholder development of the self-assessment template gave them a feeling of ownership in the program.
- Specialty crop growers feel they have a good sustainability story to tell but lack the data to verify it. One of the drivers for their participation in the project was to use the self-assessment template to collect the data required to verify this story.

The project budget also provided a lesson in regard to finances. The budget for this project was initially compiled as part of a larger overall project and based upon an assumption that other grant funds would help supplement the funding and grant funding applications for this work were submitted to several public and private entities and feedback was positive at the time of submittal of this application. However, the economy took a turn for the worse and funding dollars dried up. Great Valley Center (GVC) was not able to secure the other funds upon which the proposal was based. During this time, many nonprofits had to close their doors but GVC remained operational. Through cooperation, the partners managed to follow through on all the commitments to the project even without the additional supporting dollars that had been expected.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attached is the additional information:

- Attachment #1 What is a Sustainabilty Plan – the 5 P's
- Attachment #2 Sustainability Strategic Plan for the Multi-Commodity Project
- Attachment #3 Multi-Commodity Self-Assessment Template
- Attachment #4 What and Why of the Sustainability Plan – Workshop Presentation

Great Valley Center Sustainable Agriculture page:
http://www.greatvalley.org/work/agricultural-programs/sustainable-agriculture

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 11	Project Title: Developing a Sustainable Practice Benchmark Tool For California Pears	
Grant Recipient: Pear Pest Management Research Fund	**Grant Agreement No.:** SCB09043	**Date Submitted:** December 2012
Recipient Contact: Bob McClain	**Telephone:** 916-441-0432	**Email:** bob@calpear.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Many large U.S. food distributors and retailers are requiring producer participation in sustainability programs. It should be noted that while a sustainability program encompasses some aspects of food safety, sustainability is not a food safety program.

The sustainability issue was first introduced to the California pear industry in 2007 when Sysco, a national food distributor, required private label pear processors to develop a sustainability program using Sysco guidelines. In 2009 the sustainability issue spread to our proprietary processor Del Monte Foods with their large customers Wal Mart and Costco questioning if Del Monte followed sustainable practices. Additionally, retailers were questioning grower-packer-shippers of fresh pears about their sustainability practices. Pear growers, pear canners and fresh pear shippers realized that and industry-wide effort to develop a California pear sustainability program would benefit the industry rather than having individuals within the supply chain impose differing sustainability standards on the pear industry.

The pear industry provided initial organizational direction and funding in early 2009 with staff meetings with pear processors, growers, shippers and the contractor SureHarvest and formed a Pear Sustainable Committee to flesh-out a direction and develop the initial sustainable pear industry questioner.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

The activities performed: Develop survey(s) to measure the baseline sustainability of the CA pear industry. Convey the results of these surveys to the industry as a whole as well as the individual results of each participant for their comparison to the industry. The survey results were reviewed each year in February at two grower research presentation meetings. Participation in these meetings comprises on

average 90% of CA pear growers. The positive results of these surveys were documented by providing the results to the supply chain partners and pear consumers through annual produce conventions i.e.: Produce Marketing Association and the CA Pear Advisory Board website.
Significant contributions to the project were made by SureHarvest personnel giving guidance in developing the survey questions, analyzing the responses, providing graphics of the individual sustainable practices and managing the presentations of results at pear research meetings. Additional contributions were made by the Pear Sustainable Committee which worked directly with SureHarvest at face to face meetings and through conference calls to refine survey questions and review results.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

In Early 2009, the contractor SureHarvest conducted a survey of 56 California pear growers on record regarding their best management practices related to several key areas of sustainability. The practices surveyed were identified over several meetings and conference calls by the Pear Sustainable Committee made-up of California Pear growers, pear handlers (packers and processors), pear crop consultants, UC Cooperative Extension, SureHarvest and representatives of the Pear Pest Management Research Fund (PPMRF). The practices included practices related to: General Farm Management, Integrated Pest Management, Soil and Nutrient Management, Water Management, Ecosystem Management and Employer Practices. At the initiation of the Grant in October 2009, SureHarvest compiled, analyzed and put into report form the survey results both for individual growers as well as the cumulative industry results. At two Pear Research Meetings in February of 2010 these survey results were presented to the growers and processors in attendance at the meetings. In addition, each grower was given an envelope containing the cumulative results as well as that grower's personal and confidential results for comparison. The response rate for this survey was 66% and the percent of adoption of most practices was quite high – well above a majority.

In conjunction with Marilyn Dolan from the Communications Department (CD), Sureharvest identified and examined comparison data from other Ag sustainability programs and generated a pear sustainability executive summary. This summary was used in a press release on the survey results. Additionally, a promotional slide was developed by SureHarvest and CD and used by Kathy Means of the Produce Marketing Assoc. at the Food Marketing Institute/Grocery Manufacturers Association Sustainability Summit highlighting the program as a good model for agriculture sustainability programs.

Still, many of the original survey answers to questions positive responses were lower than expected and indicated a lack of understanding of some of the questions – perhaps taking them too literally. For example, "Do you keep a yearly record of your fertilizer applications and relate these applications to soil and/or leaf analysis?" This question was revised to read: Do you, your Pest Control Advisor – Crop

Consultant, farm service company or someone on your staff keep a yearly record of your fertilizer applications and correlate your applications to soil and/or leaf analysis?"
SureHarvest staff worked with the industry Sustainable Committee to identify edits and additions to the second survey text for 2010 – 2011. Many of the questions were revised to provide clarity and the additional subjects of Air Quality Practices and Energy Efficiency Practices were added to the second survey. In addition, some quantitative metrics were incorporated into the survey by the Sustainable Committee. Later the metrics obtained from the fertilizer questions in this survey were used in a successful CDFA Fertilizer Research and Education Program (FREP) proposal by Kitren Gloser at UC Davis.

The statistics from the 2010-2011 survey representing 74% of industry acreage were compiled, analyzed, and put into report form for both individual growers and for the industry as a whole. SureHarvest staff analyzed the data, generated graphs and data points, and refined multiple report formats. SureHarvest reviewed the industry wide survey at two grower production research meetings in February 2011 and distributed individual grower surveys to those growers in attendance.
SureHarvest and PPMRF staff also worked with the CA Pear Advisory Board's (CPAB) marketing agencies, The Communications Department and MJR Creative Group, to help develop a strategy to incorporate sustainability as a key element of the California pear industry marketing activities. Marketing activities supported by the sustainability program included pear growers sharing their sustainability stories via web-based videos: Please see http://www.calpear.com/about-us/sustainability-report.aspx

In 2012 an outreach event was held where supply chain aspects of sustainability were discussed at a Sustainability Committee meeting and incorporated the sales/marketing staff from pear shipper companies into the Pear Sustainability Committee. This meeting resulted in conveying industry sustainable accomplishments through pear shipper's sales representatives to retail accounts.
In addition PPMRF and SureHarvest undertook to perform a historical pear production research sustainability analysis of all California pear research from 1984 through 2011. The analysis included 358 projects with a total funded value of $5,331,238. The analysis reviews each research project by the RESOURCES AFFECTED: Water, Air, Wildlife, Soil, Worker, Consumer and Energy and gauges the SUSTAINABILITY IMPACT on Economic, Environmental and Social influences. Further, each of these categories is scored with a value: 1 = Minimal; indirect focus or impact of project; 5 = Medium; secondary focus of project and 10 = Maximum; primary focus of project, significant potential for impact.

Example:

				Resource Affected								Sustainability Impact		
Project Name	Area	Year	$ Amt	Water	Air	Soil	Wildlife	Energy	Worker	Consumer		Economic	Environ	Social
Areawide Management of Codling Moth in Mendocino Orchards - Lucia Varela, UCCE Sonoma Co.	CDPR Grant Ento	2000	5,000											
Biologically Intensive Pest Management Program in Mendocino County Pear Orchards - Lucia Varela, UC IPM - North Coast IPM	CDPR Grant Ento	2001	25,000											

PPMRF has completed the rating project and will be using the results to further analyze the sustainability of their industry research program.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The groups benefiting directly from the pear sustainability project are 60 pear growers, 4 pear processors and 6 fresh pear shippers through the recognition by PPMRF's supply chain partners and consumers that the California pear industry considers sustainability an important part of industry performance.
The development of the sustainable surveys (actual give and take of the Sustainable Committee members) and the data derived from the surveys allowed for the development of materials for the CA pear industry to provide meaningful outreach to PPMRF's supply chain and pear consumers. In addition, California pears were one of the first (Lodi Wine Grapes are the first) California commodities to measure and document industry sustainability. The experience has been passed on through the pear industry to other California commodities who are in-turn developing their own sustainable programs. It also should be noted that the results of the industry survey compared to the individual grower surveys served to inform PPMRF's growers of areas where profitability and/or improvements could be made in their own operations.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Lessons Learned: Developing a meaningful survey and discovering that the CA pear industry has many sustainable practices it never realized were actually ongoing practices in the industry. The industry also learned there were some areas where short term practices could be implemented and also where long-term practice implementation would benefit in other areas.
There were some pear growers who refused to co-operate in the sustainable project and some still feel the same today. Their feeling is the information derived from the surveys is private information and may someday be used against them. There were also several growers that expressed negative attitudes at the beginning of the grant but ended-up understanding the importance of the results and feel sustainability is an important part of getting the story out about the industry as well as an internal review of their individual farming practices.
Unexpected outcomes: In the third year of the grant, 2012 the pear industry's major retail buyers of fresh pears (WalMart, Sam's Club; and Costco) required (through the fresh pear shippers) growers to undergo food safety audits. They specified the auditors and types of audits (Primus and/or Eurogap). There was a great hue and cry by the grower community about the costly and burdensome requirements and extensive documentation demanded. A sight inspection was required as well as a separate harvest inspection by the certifiers. Much of this food safety compliance preparation was not applicable to orchard operations and caused considerable consternation. This had a dampening effect on the

enthusiasm for and progress of the sustainability project. However, PPMRF feels the goals of the grant have been achieved.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

None.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 12	**Project Title:** Almond Sustainability Initiative: Integrated Water and Nutrient Resource Management	
Grant Recipient: Sure Harvest	**Grant Agreement No.:** SCB09035	**Date Submitted:** December 2012
Recipient Contact: Clifford P. Ohmart	**Telephone:** 530-601-0740	**Email:** cohmart@sureharvest.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Almonds have been a California Ag success story for the past decade with a farm gate value exceeding $1 billion. Challenges have occurred and continue, however. A rapid acreage increase coupled with the 2008 economic slowdown caused a 50% price drop. Drought and legal decisions restrict water supplies. The cost of fertilizer and other inputs has increased. Such challenges increase the need to optimize farming efficiencies and reach and educate 6000+ almond growers. Accordingly, Sure Harvest and the Almond Board of California (ABC) partnered to increase water and nutrient use efficiencies through an industry-wide integrated environmental performance outreach, self-assessment and data capture, benchmarking, and continuous improvement initiative. Key to the initiative, this project enabled growers to document practices, natural resource use efficiencies, and improvement opportunities. Individual grower reports identified strengths and opportunities in practices, and targeted education was provided in irrigation and nutrient management. An Almond Industry benchmark report, planned for December 2012, will identify industry-wide strengths and opportunities and establish baselines for subsequent phases of self-assessment, targeted education, and progress monitoring. Water and nutrient use markedly impact water, air, and soil resources. Among its achievements, this project finalized and applied self-assessment modules for Irrigation and Nutrient Management, which are key to the foundation of the rapidly expanding, world-class California Almond Sustainability Program (CASP), that will include seven modules by 4Q 2012.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

<u>Work Plan Activities:</u>
<u>Task:</u> Establish a project Leadership Team of growers; external stakeholders such as UC Cooperative Extension, Natural Resources Conservation Service (NRCS), and consultants; and Sure Harvest and ABC staff.
<u>Accomplished:</u> The Leadership Team has been established since Nov 1, 2009.

Task: Have Leadership Team review and approve the water and nutrient use efficiency self-assessment tool.
Accomplished: The tool was approved at the ABC Board Meeting on Dec 1, 2009.

Task: Announce and promote the almond self-assessment initiative.
Accomplished: Once the project was launched, it and CASP was promoted for the duration of the project via monthly newsletter articles, negotiations with almond handlers, press releases, trade publications, UC Cooperative Extension grower meetings, a sustainability section and associated videos of grower testimonials on the ABC website, and ABC conferences and trade shows. Moreover, written correspondence that highlighted the program and advertised self-assessment workshops was provided to 1000+ almond growers.

Task: Design workshops and an online system to collect self-assessments for practices and metrics related to water use, soil quality, and plant nutrition.
Accomplished: Workshops were successfully designed and then launched in December 2009. The online self-assessment system was launched in March 2012. All self-assessment data collected through termination of this grant has been entered into the online system. Growers increasingly are using the system for data entry and reporting, which is expected to increase markedly over the next year.

Task: Collect baseline assessment data (practices and metrics) from at least 300 growers, analyze results, and generate and distribute customized, confidential grower sustainability reports.
Accomplished: A total of 54 self-assessment workshops (exceeded grant target) were held during the life of the grant. A total of 781 growers attended self-assessment workshops, resulting in 480 submitted assessments (includes some reassessments) of 438 orchards constituting 68,351 acres (exceeded grant targets). Growers submitting assessments own and/or manage 270,128 acres. Despite an unexpected delay in development of the online system, assessment data were analyzed and customized grower reports comparing individual to statewide performance were produced and distributed in December 2010 (100 reports) and November 2011 (198 reports).

Goal 2: Conserve water and improve nutrient use efficiency.
Accomplished: Comprehensive efforts by the project partners to increase grower participation in self-assessment workshops and related activities continue. The lower-than-anticipated numbers involved in workshops and submitting data during the first year and a half were compensated by high levels thereafter (grant targets ultimately exceeded). However, the collection and analysis of substantial assessment data was essential before fully achieving tasks associated with improving water and nutrient use efficiency, i.e., quantification of "statistically representative" industry benchmarks, production of confidential grower benchmark reports comparing their water and nutrient use efficiency practices and metrics with industry averages, workshops providing prioritized education determined from data analyses (targeted education) to assist planning for improvements, and subsequent assessments and reporting to mark progress in adoption of pertinent practices and in efficiency metrics. Unfortunately, delays in achieving sufficient participation and in online system development impeded progress. Nevertheless, growers were encouraged to increase adoption of recommended practices by the design and distribution of the improvement plan template, distribution of the 2010 and 2011 interim comparison reports, and conduct of five educational workshops on irrigation and/or nutrition management for 443 growers during the project's final six months.

Albeit after grant termination, the completion of statistically representative industry benchmarking of water and nutrient practices and metrics via the online system will commence 4Q 2012, and will be used to compose an industry wide benchmark report and refine targeted education. Assessment activities to document progress are planned to start in 2013. ABC's commitment to the continuation and expansion of CASP ensures all original project goals and tasks will be achieved.

Contribution of project partners: The Almond Board of California was the key partner and contributed matching funds for printing the irrigation and nutrient modules; recruiting growers, coordinating logistics, and securing facilities, food, and supplies for workshops and Leadership Team meetings; developing the online system; and promoting and characterizing CASP via its website, newsletters, and email alerts. ABC's commitment to ensuring the continued success of CASP and its value for all California almond growers and handlers cannot be overstated. The accomplishments reported here constitute key components of CASP's foundation.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Goal I: Improve almond growers' capacity to measure and manage water and nutrient use efficiency.
Goal II: Conserve water and improve nutrient use efficiency.
A survey instrument, in the form of the integrated water use, soil quality, and plant nutrition self-assessment tool, will be used to evaluate performance measures for both goals.
Performance Measure I: Improvements in growers' capacity to measure and manage water and nutrient use efficiency. The self-assessment tool, as proposed, was to ask growers their level of awareness, planning, piloting and implementation of various management aspects related to water use and nutrient use efficiency. Improvement was to be as tracked by the percentage of participating growers moving from awareness to planning, planning to piloting, or piloting to awareness.
Target: 20% of participating growers to improve from the 2010 to the 2011 assessment.
Benchmark: Averages from the 2010 assessment to be the benchmark.
Activities completed: The self-assessment tool was created, along with an associated online system enabling growers to assess and generate reports online. Before the online system, Excel was used to capture assessment data, generate individual grower reports comparing their performance to peers, and identify initial areas for targeted education. Existing data has been entered into the online system and soon will be used to definitively benchmark and report industry wide performance, refine targeted education needs, and measure and track improvement.
Performance Measure II: Total gallons of water and units of nutrients conserved by 150 growers who complete the two-year cycle of assessing, planning, and reassessing.
Target: 10% conservation of total water and nutrients applied per acre or 10% improvement in respective use efficiencies (total water or nutrients applied per yield per acre) for the 150 growers.
Benchmark: Averages from the 2010 assessment to be the benchmark.
Activities completed: Due to delays in achieving substantial grower participation and in online system development, statistically representative benchmarking of water and nutrient use will begin 4Q 2012. Subsequent assessments for quantifying progress against improvement targets should begin 1Q 2013.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

California's almond growers and ABC continue to benefit from this project. Via collection of production information, both benefit from the shared "almond growing" story with public policy makers, almond buyers/food companies, and consumers. Growers will continue to benefit from better understandings about practices to improve resource use efficiencies by using CASP's iterative elements of self-assessment, performance interpretation, targeted education and action planning, and progress monitoring. By helping implement this project and CASP, ABC reinforces it reputation of providing value to its constituents and ensures continued and increased grower involvement in CASP.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

<u>Lessons Learned:</u>

1. Stakeholder input in developing a quality self-assessment tool for irrigation and nutrient management was critical to produce a quality product and program.
2. Stakeholder involvement improved when the program's importance was properly conveyed.
3. Successful outreach to growers on a complicated project involving self-assessment is challenging and most successful when using multiple ways to communicate the message.
4. Conveying to growers the value of participating in a self-assessment project is challenging.
5. Once growers participate in assessment and related program elements, most recognize the value for education, increasing efficiencies, and transparency in the marketplace and for public policy.

<u>Unexpected Outcomes:</u> Sure Harvest has extensive experience in designing and implementing sustainability programs involving self-assessment. This project had challenges similar to those previously experienced so no outcomes were unexpected.

<u>Goals not achieved:</u> Because of the significant long-term commitment by ABC and other partners, goals and outcomes not achieved during the grant period will be achieved.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

No additonal information.

USDA Project No.: 13	Project Title: Minimizing Water Use and Fertilizer Loss in California Container Nurseries by Precision Control	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09012	**Date Submitted:** December 2012
Recipient Contact: Leslie Lipman Michael Delwiche	**Telephone:** 530-752-1814 530-752-7023	**Email:** lalipman@ucdavis.edu mjdelwiche@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

California (CA) greenhouse/nursery/floriculture producers grow hundreds of species in a wide range of sizes. Conventional irrigation and fertilization systems control large areas of a nursery based on the plants with the highest water and nutrient needs, causing the other plants to be over-watered and over-fertilized, thus leading to runoff. This project developed a system for precision application of water and fertilizer with the goals of improving the efficiency of water use, reducing fertilizer and chemical runoff, and demonstrating feasibility of precision irrigation and fertigation in commercial container nurseries. Wireless sensor technology was used to measure container soil moisture and control water application. The University of CA, Davis collaborated directly with commercial nurseries to test the technology and establish a good relationship to foster outreach with the nursery industry.

This work could impact the majority of CA's approximately 3,000 major producers of nursery and floriculture crops. CA is the largest producer of these crops in the U.S., with a farm income exceeding $4 billion. Adoption of the precision control systems developed through this project would enable these growers to irrigate and fertilize their diverse crops more efficiently, reducing production costs and improving the quality of water leaving the farms.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

A commercially-available wireless sensor network for agriculture (eKo Pro, MEMSIC) was selected for use in this project since it uses the same core technology as previous work (Coates and Delwiche, 2009). Hardware and software were developed to allow operation of solenoid valves to control irrigation in nursery beds. Each "actuator" can operate up to 4 valves. Each wireless radio "node" can accommodate 4 sensors or 4 actuators (16 valves) per node. The actuator hardware was tested with thousands of valve actuation cycles and found to be reliable. A web-based interface allowed monitoring of sensor data and manual control of the valves. Automated control based on soil-moisture readings from container plants was implemented with a simple scheduling program.

Soil moisture sensors suitable for nursery environments were tested to determine which performed better in container nurseries. The selected sensor (EC-5, Decagon Devices) had relatively good immunity to container temperature fluctuations and yielded low measurement variability between individual sensors. A custom calibration between sensor output (volumetric water content) and gravimetric water content was created for a representative soil-less media.

Wireless sensor and control networks were installed at two commercial nurseries, each with 9 beds of 60 to 120 plants using drip irrigation with fan-spray stakes (Figures 1 and 2, attachment). Irrigation valves and water meters were installed to control and measure the water applied in each bed. Four soil moisture sensors were installed in containers in each bed. The sensor values were monitored during grower irrigation early in the irrigation season to determine the lowest (driest) water content reached before more water was applied. This water content value was used to set a threshold for automated irrigation. When 2 of 4 sensors reached this threshold in a single bed, water was applied for a fixed duration. These irrigation events could automatically occur as often as every 3 hours. There were 3 different plant varieties in each nursery. Beds were grouped by variety and randomly assigned one of 3 irrigation treatments (Table 1, attachment): A = long duration, B = short duration, C = manual control (grower practice). Treatments A and B were automated strategies with 2 different irrigation durations similar to or less than the irrigation duration use by the grower. The goal was to reduce overall water consumption and fertilizer runoff by applying water based on plant demand. It was expected that treatment B would irrigate more frequently than treatment A due to the shorter duration. Water consumption, plant growth, plant health, leachate (water and fertilizer) runoff, and water quality were monitored over several months to compare automated, variable-rate irrigation control with grower control.

In addition to variable-rate irrigation control with the wireless network, variable-rate fertigation was investigated. With a simple and inexpensive injection system, a separate injector could be installed at each bed to provide a unique fertilizer delivery rate. The system consisted of a venturi injector plumbed in parallel with a main-line (Figure 3, attachment). A small solenoid valve was connected to the fertilizer suction line of the venturi. An inline electrical conductivity (EC) sensor was connected to the outlet of the main-line and injector lines. By pulsing the valve on and off with varying duty cycle (a duty cycle of 0% means the valve is always off, and 100% means the valve is always on.), the amount of injected fertilizer was controlled. By monitoring the EC of water and injected fertilizer, the duty cycle of the suction valve was adjusted automatically by a small computer board to achieve a target fertilizer injection rate. The system did well at applying fertilizer at the target rate.

Nursery 1 Results: Nursery 1 consisted of 3 varieties of vines grown in #5 size pots. The plants were generally irrigated for longer durations by the grower than by automated control. Also, in 2 of 3 grower-controlled beds, the grower did not completely close the valves on several occasions, resulting in slow leaks that elevated the total water consumption for those beds. Figure 4 (attachment) shows water applied to each bed over several months and figure 5 (attachment) shows the water applied if the over-irrigation due to leaks was removed. A repeated measures analysis of variance and Tukey-Kramer multiple comparison test showed that the water applied (with over-irrigation removed) on a weekly basis by treatment B was less than that applied by treatments A and C, though treatments A and C were not significantly different. Overall, treatment B used 35% less water than treatment C (with over-irrigation removed). This shows that automated control has the potential to reduce water consumption compared to manual control by the grower, even after grower error is removed.

The volume of leachate from 5 pots in each of 3 beds was measured during several irrigation events to compare runoff differences between treatments (Figures 8 and 9, attachment). Irrigation efficiency, the percentage of applied water that did not run out of the container, was calculated for each container. An analysis of variance showed that treatment means were not equal. Treatments A and B with an average 64% and 73% efficiency, respectively, were more efficient than treatment C with 47% efficiency. The average volumes of leachate for treatments A and B were 23% and 74% less, respectively, than treatment C. Less water, applied more frequently, reduced overall runoff of water and fertilizer.

Plant growth, quantified as change in the length of the longest plant shoot, was measured on a weekly basis to determine whether there were differences between treatments. Analysis of variance of the weekly plant growth did not show differences between treatments. Though a statistical difference in weekly growth was not seen, a visual evaluation of the plants by the researchers and grower determined that within each plant variety, there was one bed with less total growth. In one variety, treatment B appeared to have slightly less growth, though the difference was small. This bed was along the southern edge of the nursery block and thus may have experienced slightly more sun exposure and air flow than other beds. For the other varieties, treatment C was noticeably smaller. This was likely due to the grower failing to irrigate for several days a few weeks before the end of the experiment. This caused shoot tips to die and stop growth until new shoots began to growth after irrigation resumed. The grower was not concerned to see the difference, but indicated that plants of same size should be shipped together for a more uniform appearance.

Nursery 2 Results: Nursery 2 consisted of 3 varieties of young citrus trees grown in #5 size pots. The grower used good water management practices and there were no slow leaks caused by the grower. However, on a single occasion, the valve on one automated valve failed to close after irrigation, resulting in over-irrigation for an extended duration before being detected. Automated alert messages were implemented to notify users more quickly if a similar event occurred. Figure 6 (attachment) shows water applied to each bed over several months and figure 7 (attachment) shows the water applied if over-irrigation was removed. A repeated measures analysis of variance and Tukey-Kramer multiple comparison test showed that the water applied (with over-irrigation removed) on a weekly basis by treatment C was less than that applied by treatments A and B ($P = 0.0233$) and treatments A and B were not significantly different. Total water use was less in treatment C since the grower irrigated less frequently, even though the water volume applied during each irrigation event tended to be greater than treatments A and B. Because of careful water management by the grower, less total water was applied than with the automated system. Overall, the grower applied about 24% less water than treatment A, which used the most water. This showed that the fixed water content threshold set at the beginning of the irrigation season needed to be lower, and in-season adjustment of the threshold may be needed to optimize water use.
The volume of leachate was measured for nursery 2 similar to nursery 1 (Figures 10 and 11, attachment). An analysis of variance of irrigation efficiency for each container showed no difference between treatment means, and treatments A, B, and C had irrigation efficiencies of 66, 69, and 63%, respectively. The average volumes of leachate for treatments A and B were 60% and 73% less, respectively, than treatment C. Though

there was no difference in the overall irrigation efficiency, the water applied per irrigation event in treatment C was higher and thus runoff was higher as well.

Plant growth was measured on a weekly basis. Analysis of variance of weekly plant growth did not show differences between treatments. A visual evaluation of all plants showed no substantial difference between beds. However, the grower was particularly interested in root growth in each container. Plants in treatment C tended to have drier soil and were more “rooted out” than plants in treatments A and B, meaning that the roots had more completely filled the container. When removed from the pots, the root balls in treatments A and B were more likely to break and leave a third of the potting media in the container. This was likely due to treatments A and B being irrigated too often and not allowing proper root development in the wettest portion of the container. Starting with lower sensor thresholds for irrigation, and allowing the grower to decrease the thresholds in small steps during the irrigation season, may have allowed the desired moisture content to be achieved and improved root growth in the automated treatments.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The measureable outcomes in this project had goals of reducing water use and fertilizer loss and promoting commercial adoption of wireless technology in container nurseries. Water use was reduced by 35% with automated irrigation in one nursery, which exceeds the goal of a 10% reduction. However, automated control resulted in increased water use in a second nursery. To achieve a 10% reduction in water use would require a modified control methodology, such as mid-season threshold adjustments by the grower. Measurements of leachate showed that automated control reduced fertilizer loss by 23% or more compared to grower controlled beds in nursery 1 and 60% or more in nursery 2. Both exceeded the goal of a 10% reduction. This was likely due to more frequent irrigation for shorter durations. Commercial adoption of this system was promoted by using a wireless platform that is already a commercial product. Valve control hardware and software are available for purchase.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project’s accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project’s accomplishments and/or the potential economic impact of the project.

The wireless control system used a commercial product as the basis for development. The valve control hardware and software are now available for purchase from the commercial collaborator on this project (Camalie Networks, Napa, CA). By working with a commercial product and vendor, the work on this project may be extended by growers and other researchers interested in improving water use efficiency and reducing runoff. It is expected that the vendor will continue to improve upon and market the system.

There are two primary barriers to grower adoption of this system: installation and cost. While a new nursery could design irrigation plumbing to best accommodate variable-rate control, most nurseries are already established. There are many different irrigation system designs being used. In one extreme case, individual beds of 100 plants are micro-irrigated manually by the grower. Using wireless control to automate each bed would likely be cost-prohibitive at this time. Nodes currently sell for about $600 each, though lower-cost systems are likely in the near future. Larger beds or a group of beds would make automated sensing and control more economically feasible. In another extreme case, overhead sprinklers supply water to 40,000 plants at once, though some growers are modifying their systems to provide irrigation control to smaller beds because they see the value in providing variable-rate control when different plant types are moved into the same irrigation zone. Improving irrigation efficiency to a large number of plants would likely make a wireless sensor and control network economically viable due to savings in water, fertilizer, and labor. The possibility of environmental regulations that would impose strict runoff monitoring or abatement practices could also be addressed through more frequent, shorter duration irrigation control with an automated system.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

A wireless sensor and control network was shown to be a viable solution for automated, variable-rate control in container nurseries. Having developed this system based on a commercial product should allow continued research and adoption by interested growers. One lesson learned was that automated control cannot completely replace the need for grower attention. Specifically, microirrigation tubes tend to pop out of sprayers and drip lines, a problem the growers already address with weekly maintenance checks. While sensors and automated detection techniques could be helpful, they would likely not replace the need for weekly maintenance checks. This wireless system was effective in improving water use efficiency and reducing runoff in one nursery, though its performance in a second nursery indicated that more refined control would be necessary to achieve water savings. Based on discussion with growers, the system would be most attractive for controlling irrigation in large blocks of plants with contrasting irrigation needs (e.g., one block that requires constantly moist soil versus one that must dry out between irrigation events).

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attachment (of Referenced Figures and Tables)

Coates, R.W., Delwiche, M.J., 2009. Wireless mesh network for irrigation control and sensing. Transactions of the ASABE 52(3), 971-981.

USDA Project No.: 14	**Project Title:** Implementing the partial root drying technique to increase water use efficiency for processing tomatoes	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No:** SCB09036	**Date Submitted:** December 2012
Recipient Contact: Louise Jackson, Professor/CE Specialist	**Telephone:** 530 754 9116	**Email:** lejackson@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

There is an urgent need to improve water use in California (CA) agriculture. Agricultural water consumption is about 70% of the water supply and urban water demands are increasing. At the onset of the study, California was entering a third consecutive dry year and was curtailing water deliveries. Since >50% of processing tomato fields are furrow irrigated, this project tested a simple change in irrigation methods using alternate furrow irrigation (AFI) vs. every furrow irrigation (EFI) to decrease water inputs with little expense or new equipment. AFI uses the concept of partial root zone drying (PRD) in which half of the root system encounters areas with low soil moisture, but remains physiologically active due to water availability on the other side of the plant. The project examined how AFI affects photosynthesis, water use efficiency (WUE), yield of processing tomatoes, and related environmental benefits such as nitrate leaching and soil greenhouse gas (GHG) emissions. The main purpose of the project was to understand how and when AFI could increase tomato WUE without a yield decrease. It examined how soil types and cultivars might cause different responses from AFI. Field studies involved collaboration with growers, industry, the University of California Cooperative Extension (UCCE) and other organizations for sustainable agriculture. In addition to agronomic aspects, the physiological mechanisms associated with PRD were studied intensively, in order that yield responses could be explained in terms of stress tolerance.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

<u>2010 Field Trial at the Research Facility of Campbell's Soup Company</u>

A field trial was conducted at a 1-acre field at Campbell Research and Development Station in Davis, CA. This study evaluated two widely planted cultivars under AFI and EFI, with all other practices similar to commercial processing of tomato fields. The soil was mapped as a Reiff very fine sandy loam. The field was initially sprinkler-irrigated, then furrow irrigated every 1.5 weeks for a total of 10 irrigations. For each irrigation, the AFI strips received water on every other furrow, i.e., the 'dry' furrow was irrigated. The EFI strips had all furrows irrigated at each irrigation event. Furrow inflow was measured in all irrigations. Estimates of the total water applied were calculated based on the duration of each irrigation event. The design was a randomized complete block with a split block structure.

Frequent measurements were made of gravimetric soil moisture, plant stress [photosynthetic rates, stomatal conductance, and physiological WUE (photosynthetic rate/transpiration rate)], the canopy cover with an infrared digital camera, and of soil GHG emissions (nitrous oxide and carbon dioxide after every irrigation). Leaves were analyzed for Carbon-13 ($\Delta^{13}C$) as an indirect measure of WUE. Biomass and allocation to fruit was measured two times. Seasonal changes in the nitrate and ammonium in the soil were tracked, and anion exchange resin bags were used to trap leached nitrate. Fruit quality measurements were conducted by Campbell's.

Overall, the Campbell's research station trial demonstrated that AFI substantially reduced water inputs without a significant decrease in yield, photosynthesis, or quality, but with higher yield per amount of water applied, and no change in soil GHG emissions, compared to the typical EFI practice. The summarized results were:

- AFI received 25% less applied water than EFI (AFI: 31.6 ± 1.2 centimeters (cm); EFI: 42.4 ± 1.3 cm; mean ± Standard Error (SE)).
- Mean tomato yields were not significantly different for AFI and EFI (111 and 115 t ha^{-1}, respectively). No significant cultivar irrigation interaction indicates that cultivars responded similarly to AFI.
- Shoot and fruit dry biomass was similar in both irrigation treatments and cultivars, as was canopy cover.
- The agronomic WUE was calculated as the yield produced per cm of water applied to the crop as irrigation. It was 29% higher for AFI than EFI.
- Under AFI, water depletion in different layers of soil suggest that tomato roots utilized deeper water than EFI, even though moisture was lower in the top 12 inches of soil.
- Photosynthetic rates, stomatal conductance and intrinsic WUE (calculated as the photosynthetic rate divided by the leaf water loss by stomatal conductance) averaged across all dates, were not different between irrigation treatments. Shoot Carbon-13 discrimination (an indirect measure of intrinsic WUE) was not different between AFI and EFI and corroborated the results from the leaf gas exchange measurements.
- Fruit quality was not affected by the irrigation treatments. Fruit pH, soluble solids (°Brix) and color were similar between irrigation treatments.
- Soil nitrous oxide emissions (averaged across all dates) were similar between treatments. Data analysis on inorganic nitrogen (N) in soil and nitrate accumulation in the resin bags at depth is still in progress.

<u>2011 On-Farm Trials on Different Soil Types</u>

In 2011, four on-farm trials were conducted in furrow irrigated, single row tomato fields in 1.52 meter (m) wide beds in Yolo County, CA. The different fields had different soil textures. The same cultivar (cv. Shasta) and transplanting dates (within one week) minimized other environmental effects on crop response, such as temperature and precipitation. Two field trials were conducted on a Reiff very fine sandy loam soil because of the low water holding capacity and potential for water stress to affect yield. The other two trials were on a Yolo silt loam soil and a Sycamore silty clay loam. The trials included 36 beds divided in three blocks of 12 beds each (two 6-bed irrigation strips). The irrigation decisions on amount and timing were made by the grower and the irrigation foreman. Irrigation was monitored for furrow inflow, duration of each irrigation event, and correct alternation of furrow in the AFI treatment. Irrigation treatments were started with the first furrow irrigation at one month after planting and continued on average every 12 days for a total of 6 irrigations. Measurements of crop development and plant performance included: canopy cover, leaf gas exchange, leaflet $\Delta^{13}C$ and N content, soil moisture, and the biomass of shoots and fruit separated, sorted and processed for fruit quality parameters.

The on-farm trials demonstrated very similar results as the research station trial. AFI again reduced water inputs without a significant decrease in yield, photosynthesis, or quality, but with higher yield per amount of water applied, and no change in GHG emissions, compared to the typical EFI practice. The summarized results were:

- All on-farm trials had at least a 28% reduction in applied water and an average decrease of 38% (AFI: 31.4 ± 1.6 and EFI: 51.3 ± 3.5 cm). More water was applied on soils with higher clay (e.g., mean ± SE for AFI: 38.3 ± 1.0 cm and EFI: 66.6 ± 1.7 cm) than in sandy soils (e.g., AFI: 27.0 ± 0.5 cm and EFI: 38.0 ± 1.0 cm).
- The yield averages for all fields were not significantly different between AFI (84 t ha^{-1} on average) and EFI (86 t ha^{-1} on average). Yields were highest on the Sycamore soil and lowest in one of the Reiff soil trials.
- The agronomic WUE of AFI was 26% higher on average compared to EFI indicating that AFI can be very useful especially in dry years.
- Soil moisture content (0-255 cm depth) tended to be lower in AFI, especially at depths between 75 and 120 cm where AFI had 13% less gravimetric soil moisture by harvest, across all fields. This difference was more pronounced in soils with higher water holding capacity (e.g., Yolo silt loam), and might be due to deeper root growth in AFI. Sandy soils had very low soil moisture at all depths suggesting deep roots in both treatments were a response to low water holding capacity of soil.
- Photosynthetic rates were similar in AFI and EFI, but stomatal conductance was reduced by 9%. Thus, the intrinsic WUE of AFI tomatoes increased by 8% compared to EFI tomatoes. This pattern was consistent across all soil types.
- The leaf $\Delta^{13}C$ values were similar in the two irrigation treatments within each trial. When data was analyzed with 'trial' as a factor, leaf $\Delta^{13}C$ values showed a very slight difference between irrigation treatments at 80 and 104 days after planting.
- Fruit quality was slightly different across fields. AFI had higher total soluble solids, total solids, and color. Other fruit quality parameters were similar between irrigation treatments (e.g., fruit pH).
- Data analysis on soil nitrate concentration is still in progress and should be completed later this year, and will be reported in forthcoming scientific and extension publications.
- A fifth trial was conducted in Dixon (Solano County) on tomatoes that were grown as two rows per bed. The same set of measurements was begun, but the irrigation on this trial was not carefully carried out by the grower, and after a few weeks, it was impossible to salvage the trial.

<u>Additional Research Activities:</u>
Several other activities were conducted to provide support and context for the project.

- A great deal of preparatory effort was made to develop the procedures for the leaf gas exchange measurements taken with a field portable open flow infra-red gas analyzer.
- The Geographic Information System (GIS) layers proposed to examine the distribution of tomato production on different soil types have been collated for the Sacramento Valley. The intent was to use GIS to show where soil types were most conducive to AFI.
- A template was created for a grower survey on interest regarding AFI, but due to delayed receipt of funding and further setbacks in the plan to do this with Campbell's growers, a written survey was substituted with interviews of relevant players in processing tomato production to understand more about the uses and constraints of AFI (e.g., Managing Director, California Tomato Research Institute; processing tomato UCCE farm advisors; non-governmental organizations).

Outreach:

- March 2010: Several meetings held with growers, cooperative extension, field managers, students and the University of California, Davis (UCD) faculty. The Purpose was to discuss irrigation management, present the AFI project and receive feedback.
- May 22, 2010: Russell Ranch Field Day. Presented project to 50 participants: growers, farm advisors, students and general public.
- July 1, 2010: Field day at Campbell's Research Station to give details about the AFI trial being conducted on site. Participants were field managers, Campbell's researchers and program directors.
- September 17, 2010: Field day with representatives from NGOs working in sustainability (e.g., Sustainable Conservation) and the Tomato Growers Association.
- January-February 2011: Presentation of results to growers, farm advisors, Campbell's researchers and field managers. Discussion for taking AFI to grower's fields to conduct the 2011 on-farm trials.
- June 2, 2011: Field day with collaborators to visit trials and discuss on-farm response of crop to AFI.
- July 18, 2011: Field day with researchers, farm advisor, field managers, UCD students and researchers. Evaluation of potential yield and potential tradeoffs of AFI treatment vs. EFI.
- Project described in several other presentations: e.g., Governor's Climate Change Conference at UCD in November 2010, Yolo County Climate Change and Agriculture Conference at UCD, February 2012. When data analysis is complete, summaries will be circulated for articles in UC farm advisor newsletters, the CA Farm Bureau's Ag Alert newspaper, to non-governmental organizations such as Sustainable Conservation, who has been following the project for developing AFI in their Best Management Practices program.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Performance Monitoring Goal 1. Understand processing tomato responses to AFI via PRD in California. Instead of a written questionnaire, the survey was conducted by discussion with many stakeholders, especially with collaboration with Campbell's research staff. Instead of one on-farm trial that focused only on the water budget and yields with the two irrigation types, four trials were conducted that dealt with many more types of plant, water and soil data.

Performance Monitoring Goal 2. Recognize cultivar traits that improve AFI and increase WUE. This goal was achieved at the Campbell's research facility trial, where management closely followed growers' practices, and was far better than the planned on-campus trial. The trial was expanded to also include N fates and losses, generating a very unique data set that combined physiology, agronomy and environmental outcomes. Differences between cultivars did exist (mainly related to physiological WUE), but the main outcome was that tomatoes appear to be able to adjust their transpiration efficiency, rooting depth and deep extraction of water to compensate for drying on one side of the plant.

Performance Monitoring Goal 3. Increase technical and economic feasibility of AFI via PRD management. In the on-farm trials in 2011, the emphasis was on verifying AFI's large increase in WUE found at the research station. Nitrogen analysis is still in progress for leaching, but the project did not have the staff to perform the soil GHG emission analysis on the four farm trials. The cost and energy savings of AFI are currently being calculated. As an estimate, the UCCE cost and return studies of transplanted, furrow-irrigated tomatoes in Yolo County (*coststudies.ucdavis.edu/files/tomatoessv1_2008.pdf)*, show water costs of $31.92 per acre-foot, with 3.3 acre-feet at $106/acre. If AFI reduces water applied by 25%, then water costs decrease to $80/acre due to application of only 2.47acre-feet per acre with no additional labor, materials or equipment. Other issues will be considered, however, such as the need for irrigators who have experience and capacity to fine tune furrow irrigation appropriately for each field.

Expected Measureable Outcome 1: Decrease water use by 30% without yield reduction for furrow-irrigated tomatoes. Data were expected to show for tomatoes that yields under alternate furrow irrigation can be similar to conventional irrigation, with reduction in 30-50% of water consumption with partial root zone drying as for other crops. The target for the project was a reduction of ≈30% of water applied, which typically averages 20% more than actual evapotranspiration of processing tomatoes in the Central Valley. This outcome was met, based on the results described above for the five field trials.

Expected Measureable Outcome 2: Increase adoption of alternate furrow irrigation by 30% of tomato growers in the Sacramento Valley. This outcome is a long-term outcome and is more likely to occur in years when the water supply is limited. In fact, 2012 is the first 'drought' year of the study, so the study's end date of June 30, 2012 is too early to find out how many growers actually used AFI. The participatory research approach with growers, UCCE and Campbell's Soup Research Division has directly conveyed results to end users, and the outcome will be enhanced by the positive experiences of these end users. The adoption process will increase statewide after the study results are released via newsletters, UCCE websites, and podcasts, especially if water shortages remain. The intention is ask the tomato grower associations to survey growers in the spring of 2013, after these publications are finished.

Expected Measureable Outcome 3: Show positive synergies between decreased water use, and small changes (5-15%) in fuel and energy use, nitrate leaching, runoff, sediment loss, and GHG emissions. Positive synergies seem very likely, although this is the last part of the project to be completed. The reduction in water will translate to decreased pumping or transport costs of water, and those will be estimated based on different sources of irrigation water. In all of the study sites, water was managed to avoid runoff and sediment loss by blocking furrows at the end of the rows. Soil GHG emissions did not increase with AFI in the research station trial. The data on nitrate leaching will be available in the near future. These synergies have and will continue to be explained to agricultural and public audiences through outreach activities.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

In the long term, this project is expected to benefit ≥30% of the ≈200 tomato growers in California (~275,000 acres and >$900 million in crop value) by demonstrating techniques to improve water use efficiency, reduce irrigation costs, and improve environmental quality with furrow irrigation. During the last few years, many tomato growers have switched to drip irrigation to increase yields and to reduce water application, but not all tomato growers can afford to install drip irrigation, and in addition, some rotations preclude drip irrigation. The beneficiaries of the study are mainly those growers that need a strategy for such situations in which water inputs can be reduced without a decrease in tomato yield, and without the costs of drip irrigation. It should be noted that the costs of drip irrigation go beyond installation, for example, for the disposal of plastic tape in a land fill. Over the long-term, the benefits of the project can be considered to extend to the wider specialty crop industry, due to the fact that reducing irrigation inputs via AFI occurs without increases in costs or labor, uses less energy for pumping and water transfers, and provides some synergies for environmental quality.

In addition to the beneficiaries involved in California tomato production, the project's wider distribution of the results to agricultural scientists and extension personnel nationwide will likely lead to testing of AFI and partial root zone drying for other crops, with potential to increase the set of beneficiaries over the long-term.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

AFI is a viable irrigation method for processing tomatoes especially in dry years when water availability for agriculture decreases. Water inputs can be substantially reduced without a decrease in yield, or additional labor or equipment. The fine-tuning of furrow irrigation, however, requires knowledgeable irrigators and careful attention to inflow rates.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Jackson L.E., Barrios-Masias, F.H., Miyao, G. Using AFI to increase crop water use efficiency for processing tomato: benefits and tradeoffs. Brochure in preparation to be posted on various websites for UCCE and printed for various distribution channels.

USDA Project No.: 15	Project Title: California Roundtable on Food Supply and Water	
Grant Recipient: Ag Innovations Network	**Grant Agreement No:** SCB09037	**Date Submitted:** December 2012
Recipient Contact: Dan Schurman	**Telephone:** 707-823-6111	**Email:** dan@aginnovations.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The California Roundtable on Food Supply and Water (CRFSW) was created to benefit California specialty crop producers by providing a forum for influential stakeholders in agriculture and water systems to uncover core obstacles, identify win-win solutions, and create recommendations to address California's ongoing water crisis. The Roundtable format has been a proven strategy for reducing polarization between specialty crop and environmental interests. This project was created to craft and promote a consensus strategy to ensure a long-term sustainable supply of water to agriculture while satisfying other public demands. The California specialty crop sector has been severely impacted by diminishing water security resulting from supply shortages and increasing competition from environmental interests and urban/recreational users. The Roundtable was launched on the heels of a 3-year period of drought in the state—a time when stakeholders on all sides were highly motivated to come together to identify mutually beneficial solutions. Member organizations of the California Roundtable on Agriculture and the Environment (CRAE), an 8-year old consensus process, unanimously recommended the launch of the CRFSW. Initial objectives included: (a) a new unified voice on water issues that includes producers, environmental and urban interests, and that has the breadth and influence to shift opinion and policy on water; and (b) a set of water recommendations that address the long-term issues in a comprehensive way that can be used at local, state, and federal levels to educate and inform change.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Roundtable Development

- ✓ Conducted preliminary interviews to inform development of Roundtable
- ✓ Developed guiding documents for Roundtable, including concept, process approach, Charter, etc.
- ✓ Established multi-stakeholder launch committee to help vet process, scope, and members.
- ✓ Conducted stakeholder analysis and identified list of invitees to participate in Roundtable.
- ✓ Created process approach and worked with launch committee on agenda for launch meeting.
- ✓ Conducted launch meeting.

Roundtable Implementation

- ✓ Conducted at least 8 Roundtable meetings per year, guiding members through a process to create consensus framing of issues and develop consensus recommendations.
- ✓ Provided ongoing convening and facilitation services, project support, research, writing, editing and graphic design services.

Outreach and Communications

- ✓ Developed and maintained website for the Roundtable.
- ✓ Designed and printed copies of two Roundtable recommendations reports.
- ✓ Partnered with Roundtable members to deliver recommendations to target audiences and implement communications plan to widely disseminate framing and recommendations. Directly reached 64,000 experts and practitioners with key recommendations and new ways of thinking about agricultural water challenges.

Evaluation and Review

- ✓ Conducted frequent check-ins with Roundtable members to ensure needs were being met.
- ✓ Conducted semi-annual oral reviews and anonymous annual evaluation surveys.
- ✓ Incorporated recommendations from evaluation processes into management of Roundtable on ongoing basis.

Other (above and beyond deliverables)

- ✓ Assisted Roundtable in taking over the management of the California Agricultural Water Stewardship Initiative (CAWSI). Developed governance structure and charter for CAWSI.
- ✓ Re-vamped and expanded the CAWSI online water stewardship resource center. The center has had nearly 9,000 unique visitors since the re-launch in December 2011 and almost 1,000 return visits.
- ✓ Created and convened a 7-person multi-stakeholder Editorial Board to review and recommend new content regularly.
- ✓ Launched, in partnership with Pacific Institute, an interactive case study database of on-farm water management practices on the CAWSI website.
- ✓ Planned an educational bus tour of Delta water issues (to take place September 25, 2012) for Roundtable members.

Project Partners

A full list of current and past Roundtable members is available at http://aginnovations.org/roundtables/crwfs/members/.

Ag Innovations Network (AIN) has had consistent participation among almost all Roundtable members. Members participated thoroughly in the process of developing the reports and recommendations, and collaborated in implementing communications plans for the reports. This strategy was very effective because AIN was able to leverage communications of the findings by the Roundtable members who were most influential to each of the targets.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The following progress was made on project objectives:

Objective 1: Development of a set of policy and action recommendations that have unified support between specialty crop and environmental interests. Creation of a website and outreach tools to increase uptake of recommendations.
Two sets of policy recommendations were created in this project—one focused on agricultural water stewardship and the other focused on water storage solutions to enhance water supply reliability for specialty crop producers. A website was created and routinely updated to communicate developments, and collaborative communications plans were developed and implemented in the course of the project. Furthermore, the Roundtable's launch of the online agricultural water stewardship resource center and interactive map of case studies has further communicated recommended practices to practitioners and the technical support community. The findings were communicated to key policy bodies including the State Water Resources Control Board (SWRCB), the California Water Commission, and the State Board of Food and Agriculture, as well as key conferences such as the California Water Policy Conference.

Objective 2: Enhance relationships between specialty crop representatives and environmental/public interests to reduce polarization and increase support for sound water management on specialty crop farms.
Participants in the process have consistently reported—verbally and in evaluation surveys—that the facilitated Roundtable dialogues have helped them develop invaluable relationships that they can draw on and benefit from outside of the project. The project has given participants and their broader constituents new, shared language and goals from which to work.

In addition to these measurable outcomes, AIN also initially proposed that the project would create a) a new unified voice on water issues that includes producers, environmental, and urban interests, and that has the breadth and influence to shift opinion and policy on water; and b) a set of water recommendations that address the long-term issues in a comprehensive way that can be used at local, state, and federal levels to educate and inform change. These were both achieved to a high degree.

No federal funding was used during the grant period to fund lobbying activities or unallowable political activities of any kind. The Roundtable did not engage in any electoral activity or endorsements, nor state or federal legislative activity.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

AIN anticipated that this project would benefit all irrigated specialty crop operations in the state—as well as the general public—by reducing polarization, identifying broadly-accepted solutions, and securing greater water supply reliability through policy change and program implementation. AIN is beginning to see a very broad impact that the first (Roundtable recommendations) report has had in not only the agricultural community, but in the environmental community, among state agencies, even philanthropic institutions. The project resulted in consensus statements on agricultural water stewardship and water storage. The first of these had wide influence among state policymakers and stakeholder groups in shifting the focus from water conservation to the more effective and practical concept of ag water stewardship. The second report will be released after the grant period so no data on impacts has yet been collected. A few anecdotal highlights:

- ✓ The Roundtable's water stewardship report formed a key focus on the State Water Resources Control Board hearing on agricultural water conservation held on July 20, 2011, and consequently was integrated into the Board's activities. At the hearing, Dr. Peter Gleick hailed the report as "evidence of great advances in the conversation" between agricultural and environmental communities.
- ✓ The report's core messages were reflected in the California State University, Fresno publication of *Agricultural Water Use in California: A 2011 Update*, an update of the milestone 1982 Davenport and Hagan report.
- ✓ The Bechtel Foundation reported to AIN that they based their philanthropic strategy for water in California on the report's framing and recommendations.
- ✓ The water supply community, the agricultural community, the environmental community, and state agencies all benefited from the framework advanced by the Roundtable. Coverage of the report was made in a large variety of key publications among these stakeholder groups.

The Agricultural Water Stewardship recommendations were delivered or presented to at least:

- 29 California government officials, including the Governor's office and state legislators
- 55 California delegates to the US Congress
- 423 state agency officials
- 5178 members of water quality control boards, irrigation districts and water associations
- 51 regional water management groups
- 92 members of relevant councils and committees
- 51 senior agricultural leaders
- 59 members of the educational and research community
- 17 philanthropic foundations with a water focus
- 41,312 people within AIN's own constituencies
- 112 media outlets

Presentations were made to:

- Ag Water Management Council
- California Farm Bureau Federation Board
- California Water Commission
- California Water Quality Conference
- State Board of Food and Agriculture
- State Water Board Ag Conservation Workshop
- Water Plan Public Advisory Committee

The recommendations were also posted on a variety of websites, list-serves, and newsletters. In sum, over 64,000 people were reached directly through these efforts, with many more likely to have been reached indirectly.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Some of the key lessons learned through this project include:

- ✓ Experts on water and agriculture are highly soloed. The Roundtable had a bigger-than-expected impact in terms of helping different parts of the system talk to each other.
- ✓ There are great benefits (and interest) in taking a step back from urgent water-related decisions and taking a big picture perspective.
- ✓ Water conservation is not an effective descriptor for either agricultural or environmental goals. Water stewardship was advanced as a more appropriate framing.
- ✓ Collectively leveraging the members' networks was a powerful way of disseminating new ideas and recommendations.
- ✓ Roundtable of individuals not organizations helps push the envelope where they might not be comfortable speaking for the whole.
- ✓ Having continuity is important—in dialogues that take place over several meetings, it's important that participants are kept involved throughout.

Unexpected outcomes:

AIN did not originally anticipate an iterative process where several water-related topics would be taken up in sequence. As such, the unexpected outcome was two sets of policy recommendations instead of one. AIN also took on an additional piece of work, taking over the governance of the California Agricultural Water Stewardship Initiative and its online resource center. This led to several unexpected outcomes: a more robust online water stewardship resource center, an interactive database of case studies, and a set of additional resources to support farmers in implementing helpful water management practices.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

California Roundtable on Water and Food Supply website: http://aginnovations.org/roundtables/crwfs/
California Ag Water Stewardship online resource center: http://agwaterstewards.org
Agricultural Water Stewardship report:
http://aginnovations.org/images/uploads/CRWFS_Water_Stewardship_Recs_electronic.pdf

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 16	**Project Title:** Tree Phenology Models for Climate Change Projection and Improved Water and Nutrient Management	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09044	**Date Submitted:** December 2012
Recipient Contact: Patrick Brown	**Telephone:** 530-752-0929	**Email:** phbrown@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The impetus for this project was the lack of phenological models for tree crops in California. Phenology is the study of the timing of biological events such as flowering in the spring, and the environmental factors, such as accumulation of cold temperatures in the preceding months, that cause that timing. Phenology models to predict timing of flowering have been developed for crops in Europe, Australia and Chile, but prior to this project none had been tested or developed in California for California cultivars. Growers need such models for on-the-ground management decisions such as when to order pollinators or supplementary labor, when to schedule field activities, as well as to track developmental needs of the crop so that fertilization and irrigation decisions can be made based on the needs of the crop and avoid wastage. From a climate change perspective, regional, state and national agencies need these models to plan research and funding to ensure long-term viability of agriculture in California. Almonds, pistachios and walnuts combined are a $6.1 billion industry in California, with 1.1 million bearing acres. A sound understanding of the effects of climate change on crop phenology is essential for the long term viability of these industries. This project builds on CDFA's 2007 project #6 which found that winter chill is likely to decrease dramatically over the 21st century, potentially leading to severe problems for many fruit and nut growers.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Temperature observations from 4293 global weather stations were gathered and used to project future chill accumulation under low, middle or high emissions for the middle and end of the century. These projections have now been published (Attachment #1) and are available through an online interactive web resource (http://treephenology.ucdavis.edu). The models predict that winter chill in many major growing regions of fruits and nuts will be reduced and will likely be insufficient for many of tree crops in the future.

Bloom timing data from University of California (UC) breeding programs and temperature data from state weather stations was gathered for model development and testing. This consisted of ten years of almond data

(1995-2005) for three locations in the UC Regional Almond Variety Trial, (with thanks to Joe Connell, Butte County Extension), up to six years of pistachio data (2005-2011) at four locations (Craig Kallsen, Kern County Extension), and up to 60 years of walnut data (1953-2012) at six locations (Chuck Leslie and Gale McGranahan, UC Walnut Breeding Program). These data were used to test existing spring phenology models, 10 for almond, 14 for pistachio and 9 for walnut, for flaws and strengths in California (in cooperation with Ted DeJong and David da Silva, UC Davis Dept. Plant Sciences and the Zhang lab, Dept. Air, Land & Water Resources). None of the models predicted bloom timing better than the average date of bloom, largely due to over-fitting of models and the use of calendar dates for many parameters (Attachment #5). A Beta (draft) website (http://fruitsandnuts.ucdavis.edu/Weather_Services/Bloom_Cast/) was built (cooperation: UC Agricultural and Natural Resources, UC Fruit & Nut Resource Information Center, Pistachio Research Board) with the best pistachio model, integrating temperature data from state weather stations to allow growers to track the progress towards bloom thresholds. The almond dataset was analyzed in collaboration with Dr. Neil Willits, UC Davis Dept. of Statistics to identify when chill and heat accumulation began in almonds. Chill accumulation begins earlier and heat accumulation later than previous believed. This work was presented at the IXth International Symposium on Modelling in Fruit Research and accepted for publication (Attachment #3). The walnut dataset was used to test whether the timing of flowering and leaf-out in walnuts has already shifted because of climate change. Walnut male buds are shedding pollen earlier than over the last 60 years, whereas the leaf buds were opening earlier until about 1994, when they began opening later, indicating vegetative buds for the cultivar ‘Payne’ are no longer getting optimal chill (Attachment #4).

State and county yield data was gathered and compared with temperature data to determine whether almonds, pistachios or walnuts have, in the last thirty to fifty years encountered low enough chilling to negatively affect yield. Almond data from 1960 to 2008 statewide, and Kern County data from 1980 to 2008, pistachio data from 1979 to 2008 statewide and Kern County 1980 to 2008, and walnut data from 1970 to 2008 statewide and Tulare County 1980 to 2008, is being used. The counties chosen are the warmest counties where the crop is cultivated over large acreages. No significant linear relationship was found between chill accumulation and yield for any of the records, indicating that chilling requirements are lower than currently thought and current cultivars are not as threatened by climate change as previously expected (Attachment # 6).

Three years of data on the timing of bloom and leaf-out for prominent cultivars of almonds, pistachios and walnuts at six locations per crop in distinct climate zones in the Central Valley has been collected. Sites were visited two times per week over the course of bloom and leaf-out, which for all three crops spanned from February through May, tracking the progress from 5% bloom and leaf-out to 95% bloom and leaf-out. Temperature and relative humidity was recorded every half hour for the three years of the project. Radiation was recorded at six sites in the Valley. In addition, shoot samples were collected during the winters of 2010-2011 and 2011-2012 and forced in growth chambers to test dormancy requirements. Response of buds was examined visually and by monitoring their respiration and metabolism through calorimetry (results in preparation). To complement the summer phenology modeling with state and county yield data, hourly temperature records and yield and harvest date data from project growers has been recorded to generate temperature-based development and maturity models.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The two primary goals of this project were 1) to establish crop phenology models for almonds, pistachios and walnuts and make them available to growers via the internet and 2) to project changes to phenology as a result of climate change, particularly phenology in California and global scale winter chill.

In order to create crop phenology models for almonds, pistachios and walnuts, existing phenological models were tested with California bloom and weather data. Through this process, inappropriate model approaches such as using calendar dates as model parameters and using sequential chill-heat models were identified. It was determined that fitting phenological models to datasets without strictly limiting the potential chill and heat requirement values of the species would lead to severe model over-fitting, resulting in a model that would explain the data used to build it, but would not be applicable to future years and other settings, particularly with future changing climate conditions. Non-parametric regression was used with the almond dataset to establish an approximate chill optimum. Bayesian analysis has been used with the walnut dataset to estimate an approximate chill optimum for the cultivar 'Payne'. This work has confirmed that there is significant variation in the chill optimums and requirements for different cultivars within a species, and thus similar analyses with other cultivars will be conducted. The parameterization of the models has also been progressed by work with shoots collected from the field and forced to bloom under spring-like conditions in growth chambers. All the data for this parameterization has been collected, and is under analysis. Additionally, field data has been collected from three springs to validate the models developed using historic data, and for testing whether relative humidity or radiation affects the timing of phenology, in addition to temperature. The internet platform for making the final phenological models available to growers has been established and a Beta version is live (http://fruitsandnuts.ucdavis.edu/Weather_Services/Bloom_Cast/).

This work has led to the conclusion that the scientific and modeling communities have confused how much chilling is necessary to get bloom at a certain time and how much chill is necessary to have an economically viable number of flower and vegetative buds open. The bloom timing work with the breeding program data and field data is directed at measuring how temperature affects the timing of bloom, leaf-out and maturation. To truly address the impact of climate change on agriculture in California, how warmer temperatures will affect yield needs to be addressed. To this end, project staff has been examining yield records at the state and county level in comparison with winter chill records. The analysis of the data is nearing completion and publication.

To establish phenology projections, records were gathered from more than 4,000 weather stations globally and under scenarios of different levels of greenhouse gas emissions and timeframes. The results were made available through a website (http://treephenology.ucdavis.edu) that allows for all the resulting data to be downloaded, or for users to interact with the data using a map that can zoom into locations of interest with a drop-down list to show different emissions scenarios and timeframes. For the phenology projections for California, the findings indicate that by mid-Century almonds and pistachios should get enough chill on average, even under the highest emissions scenario to yield adequately. Walnut chilling may however be inadequate without breeding improvement, and pistachio cultivation will likely be endangered with current cultivars after mid-Century. Once the phenological models are complete, project staff will be able to say more exactly in what regions and under what emissions scenarios warmer winters could threaten these crops. More work is still needed to make similar conclusions regarding summer development and yield, however all the necessary data for these analyses have been gathered.

In addition to the online tools that have been established to share the results of this project and make them useful to growers, this work has so far been presented at the Governors' Global Climate Summit, the IXth International Symposium on Modelling in Fruit Research, meetings of the California Pistachio Research Board, California Walnut Board and the UC Pomology Extension Continuing Conference, and published in PLoS ONE and Scientia Horticulturae (Attachment #2), approved for publication in *Acta Horticulturae* and submitted for publication to Global Change Biology.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The growers of almonds, pistachios and walnuts in California have benefitted from the findings of this project. Finding that almond and pistachio cultivation are not threatened in the near future in California allows for growers to invest in these crops in warmer parts of the Valley. Finding that walnuts bloom behavior has already changed in response to warmer winters benefits walnut growers in warm regions, who can now plan for low chill cultivars or transition into lower-chill crops like almonds. These findings are also useful for breeders and other researchers to guide research for climate adaptation for nut crops in California. Investors, commodity boards and regional and state planners benefit from the projections of how climate change could affect chilling on a global scale, particularly in competing markets. Upon completion of the phenological models, growers and the rest of the agricultural industry will benefit by being able to better anticipate the management needs at phenological stages.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

It was found that by making the experimental procedures highly replicable and clearly articulated (especially regarding bloom assessment) cross-year and cross-staff consistency was ensured and has established a standard for other researchers. Sensor redundancy is essential in field experimentation however excessive data collection should be avoided and data should be gathered to the level of detail necessary for the analysis, not to the maximum capacity of the sensors. Collaboration across disciplines, departments and agencies has been invaluable to this project. By presenting this work to a wide audience – growers, commodity boards, ecologists, extension agents, Geographic Information Systems specialists, breeders, and other researchers –

unexpected advice, extra data and useful connections was received. Perhaps the number one lesson from this project, though, was that plant behavior cannot be modeled in a vacuum and the inputs of growers, extension advisors and the projects own in-field observations has greatly enhanced the utility of the results. Flaws in many existing models and potential problems with the projects own model building could not have been reconciled without the field work aspect of project.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attachment 1: Luedeling, E., E. H. Girvetz, et al. (2011). "Climate Change Affects Winter Chill for Temperate Fruit and Nut Trees." PLoS ONE 6(5).

Attachment 2: Luedeling, E. (2012). "Climate change impacts on winter chill for temperate fruit and nut production: A review." Scientia Horticulturae 144: 218–229.

Attachment 3: Jarvis-Shean, K., Da Silva, D., Willits, N., DeJong, T.M (unpublished). "Using non-parametric regression to model dormancy requirements in almonds." Acta Horticulturae.

Attachment 4: Pope, K. S., Dose, V., Da Silva, D., Brown, P., Leslie, C., DeJong, T.M. (unpublished). "Detecting non-linear response of spring phenology to climate change by Bayesian analysis."

Attachment 5: Figures from Pope, K. S., Da Silva, D., Brown, P., DeJong, T.M. (unpublished). "Phenological models fail to predict behavior better than average dates in California."

Attachment 6: Figures from Pope, K. S., Dose, V., Brown, P., DeJong, T.M. (unpublished). "Examining chilling requirements through historic yield records of California nut crops."

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

SPECIALTY CROP BLOCK GRANT PROGRAM

FINAL PERFORMANCE REPORT

USDA Project No.: 17	Project Title: Determining the Potential Impact of Vegetable Food Safety Regulations on Wildlife and the Environment	
Grant Recipient: Western Growers	**Grant Agreement No.:** SCB09003	**Date Submitted:** December 2012
Recipient Contact: Hank Giclas	**Telephone:** 949-885-2205	**Email:** hgiclas@wga.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

In 2007, commodity specific food safety guidelines for lettuce and leafy greens were adopted by the California Leafy Green Products Handler Marketing Agreement (LGMA). The guidelines contain guidance for reducing potential crop contamination from intrusion of wildlife into cropland. Environmental organizations and others (Wild Farm Alliance, 2008; RCD Monterey Bay, 2009); however, have expressed concern that some growers' practices addressing potential contamination from wildlife could have adverse impacts on wildlife and environmental quality. The purpose of this project was to determine where those impacts might exist, to convene an expert panel to address those issues, and then to publish recommendations to reduce or eliminate conflicts.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activities and tasks completed during the grant period were:

1. *Develop questionnaire for interviewing growers regarding potential problem areas.* An in-depth survey instrument, consisting of 84 questions (questions were skipped if not applicable to a grower), was developed and reviewed with industry members and conservation experts. The survey was designed to identify current co-management practices associated with food safety guidelines and whether those practices adversely affect wildlife and/or the environment.

2. *Interview growers using the developed questionnaire.* The survey was accessible through the Internet and available to leafy green growers for completion from August 2010 through January 2011. Email requests asking leafy green growers to complete the survey were sent by various associations and groups while the survey was open.

3. *Tabulate and summarize results from growers' interviews.* The target group for the survey was the estimated 197 leafy green growers in California. More than 26% of the California leafy green growers completed questionnaires. (A summary of the survey findings is attached to this document.)

4. *Review and summarize existing scientifically-based literature*. A study of the available peer-reviewed scientific literature relating to co-management issues related to leafy green food safety and conservation practices was completed in April 2010. Fifty-eight studies were included in the review and report. (The scientific review is attached.)

5. *Convene a food safety and environmental Expert panel for the purposes of reviewing the study findings.* Eight Expert Panel members were selected to represent small, medium, and large growers, wildlife NGOs, wildlife academics, shippers, processors and food safety academics. Government representatives from the USDA and the FDA participated as observers. (The list of Expert Panel members is included in supporting documents.)

6. *Make arrangements for and host the Expert Panel committee meeting.* The introductory Expert Panel meeting was held via phone on August 12, 2011. A face-to-face meeting was held in Salinas, California on October 26, 2011.

7. *Review the study findings.* Study findings were initially reviewed at the October 26th meeting. After the meeting, Expert Panel members requested additional analysis and provided comments on the survey summary document. A revised survey summary was finalized in November 2011.

8. *Write a report of the expert panel meeting summarizing all relevant discussions and conclusions.* The expert panel recommendations were summarized along with the rationale and justification and provided in spreadsheet and word documents to the LGMA technical committee in April 2012 and the Grower-Shipper Association (GSA) in May 2012. A revised summary including GSA comments was submitted to the LGMA technical committee prior to the July 2012 technical committee meeting. (copies of the summary recommendations and rationale are attached.)

In completing the above activities, Western Growers was the Project lead; Intertox was a project partner. Western Growers managed the survey development, facilitated the Expert Panel meetings, revised the proposed recommendations document after each meeting and developed recommendations documents for presentation to the LGMA technical committee. Intertox managed the survey and results analysis, completed the scientific literature review, prepared minutes from the meetings and assisted with the preparation of the above mentioned documents and a paper for publication.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

1. *Identification of problem areas in current recommended best practices or in practices used by growers.* Three deliverables and the associated findings contributed to the successful completion of this goal. The first deliverable was the completion of the grower survey and tabulation of the survey results. The survey results characterize current co-management practices and potential issues. The second deliverable was the scientific literature review and it was used to classify co-management issues related to food safety and conservation practices. The third deliverable was a review of the leafy green guidelines. The review served the purpose of identifying guideline language relating to wildlife and the environment. The results from the three deliverables were provided to the Expert Panel and for their use in developing and proposing solutions/recommendations.

2. *Develop and propose solutions/recommendations addressing co-management issues*. Between November 16, 2011 and March 26, 2012, the Expert Panel members participated in twelve webinar meetings developing solutions/recommendations to address potential co-management issues. Using the leafy green guidelines document, the Expert Panel worked through and addressed all language relating to co-management. After the GSA reviewed the document, additional changes were made to incorporate GSA suggestions. (A copy of the proposed changes to the LGMA guidelines provided to the LGMA technical committee for the July 2012 meeting is attached.)

3. *Publish a paper that describes the results of the research and provides recommendations for ameliorating any issues*. A paper describing the current co-management practices, survey research, scientific literature review, Expert Panel recommendations and recommendations adopted by the LGMA is currently under development. As noted in the last biannual report, submittal to an environmental or food safety journal is scheduled for fourth quarter 2012. Completion of this goal is expected December 2012. (A Draft paper that will be proposed for publication is attached)

4. *Tabulation of the inclusion of expert panel recommendations in the LGMA*. The Expert Panel proposed forty-three modifications to the LGMA guidelines document. When the GSA reviewed the proposed changes, they recommended additional modifications/changes for a total of forty-eight modifications. During the LGMA technical committee, committee members voted on and approved twenty-five proposed changes (approval of 55% of the forty-five proposed recommendations). While some of the remaining twenty recommendations were discussed, the technical committee did not vote on them. The remaining twenty recommendations will be reviewed with individual committee members and other Grower-Shipper Associations in advance of the next LGMA technical committee (September or October 2012). Western Growers will present the remaining twenty items for voting consideration during that meeting. To achieve the goal of having 75% of the Expert Panel proposed changes accepted by the LGMA will require the adoption of

nine additional recommendations out of twenty (total 45 recommendations). Completion of this goal is expected prior to December 2012.

5. *Follow-up with growers to see if they changed their practices based on findings.* As noted in the last biannual report, Western Growers will follow-up with growers in late 2012. While many of recommended changes to the LGMA guidelines were adopted in July, the remainder of the changes will be reviewed in the fourth quarter 2012. Once the LGMA technical committee agrees to changes, the LGMA board then will need to also accept the changes. An assessment of changes to grower practices may not be feasible until 2013 depending on when the changes are finally adopted. However, Western Growers plans to field a grower survey in late 2012 to determine if grower practices have changed based on the Expert Panel related LGMA changes that have already been adopted.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The results of this project benefit California specialty crop producers by clarifying best practices for managing these conflicting priorities and reducing costs from food safety guidelines that are determined to be unnecessary or overprotective. Removal of unnecessary or overprotective measures could also prove beneficial for wildlife and wildlife habitats.

The September 2006 E. coli outbreak eroded consumer confidence and cost the leafy green industry millions of dollars: processors alone lost an estimated \$50-\$100 million (CSSRC, 2007). In 2007 cash receipts from California-grown vegetables and melons totaled \$7.97 billion and represented 21.8 percent of California's gross cash receipts (CDFA,2009). According to the USDA, California specialty crop growers harvested over 223,000 acres of lettuce worth 1.6 billion in 2008 (USDA, 2009). The results of this project will: 1) assist lettuce and leafy green in implementing cost-effective Good Agriculture Practices (GAPs) that both meet food safety guidelines and decrease impacts to environmental quality, and 2) provide valuable information to environmental regulators and industry experts that influence food safety guidelines. It is difficult to estimate the economic impact of reducing the conflicts between food safety and environmental protection, but there is some evidence of the type of costs related to food safety programs. The average leafy green grower in California spent \$604,000 on food safety programs (Drotlef,2009). Even a smaller reduction in these costs to growers from more cost-effective practices would lead to substantial industry wide savings.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Modifying the existing commodity specific food safety guidelines for lettuce and leafy greens was more problematic than expected. Even though the Expert Panel recommendations are an update to and are more protective from a food safety perspective than the 2007 guidelines, the concern is that buyers might not accept the science-based revisions and their focus on fecal contamination and crop damage as a replacement for the current emphasis on animal intrusion.

The Expert Panel consisting of industry members, conservation experts, government observers and academics was a powerful, positive demonstration of the ability of diverse groups to cooperate to achieve a common objective. The Expert Panel recommendations submitted to the LGMA were all unanimously approved. As of July 2012, 55% of the recommendations have been approved. Outside of the grant, Western Growers will continue working with the LGMA until 75% of the recommendations (the project goal) are adopted.

For others planning similar projects, the shared learning is that when agreement among diverse groups is required for making changes with significant economic consequences, Expert Panels, or similar groups can be critical for obtaining buy-in from a wide array of stakeholders.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Additional information attached to this final performance is referenced in the text above and includes: a summary of survey findings, scientific review, proposed changes to the LGMA guidelines and accompanying rationale and a draft paper for publication.

Project 18 - Agriculture and Land-Based Training Association (ALBA)

Final Performance Report

Project Title
Specialty Crop Solutions for Health Distressed Communities

Project Summary
The purpose of this project was to address public health and market access issues with ethnically valued specialty crops (SC) that can be grown by beginning and immigrant farmers in the central coast region. Many in this region, particularly Hispanics, suffer high incidences of nutrition related illness and obesity. More than 70 percent of men and 52 percent of women in Monterey County are overweight or obese, higher percentages than state averages. In the meantime, beginning and immigrant farmers are uniquely geared to address the issue through direct marketing. Many of these growers rely on farmers' markets where they offer very competitive prices. With objectives focused on local foods promotion, grower education, unique SC field trials and greater public access to nutrition program Electronic Benefits Transfer (EBT) and benefits at farmers markets, this project will increase the competitiveness of California grown SC while enhancing public health and creating resilient local markets.

Project Approach
1) Leveraged and expanded partnerships with health agencies and businesses seeking to increase consumption of healthful foods among low-income residents.

The ALBA worked with current and new partners to coordinate efforts for increased effectiveness of initiatives such as the FUNDamentally FRESH campaign in 11 farmers' markets located in low-income communities, both through the Access to Healthy Foods Committee and outside of the committee. The Healthy Food Access Committee updated its shared goal that was adopted by all members, along with activities and meeting schedule. Existing partners include the Second Harvest Food Bank for Santa Cruz County, the Food Bank for Monterey County, Network for a Healthy California/Monterey County Health Department, Community Alliance with Family Famers (CAFF), University of California Cooperative Extension, Radio Bilingue and Univision Spanish News. New partners include Catholic Charities, Food Bank for San Benito County, Central Coast Hunger Coalition, California Department of Social Services (CDSS) of Monterey County (in King City, Salinas and Seaside), CDSS of Santa Cruz County, and CDSS of San Benito County. Primary partners on FUNDamentally FRESH worked with ALBA to fulfill reporting plans on a monthly basis for evaluation purposes. ALBA was more successful in coordinating with such partners by informing one another of specific information and unique perspectives on best practices in reaching low-income residents. For example, because one of the members of the Healthy Food Access Committee was an EBT client herself, she was able to shed light on the vacuum of information that she experienced when she enrolled in EBT at the CDSS. This is when the idea was born to start with outreach within the CDSS offices. Now, all of the CDSS offices in the tri-county region have a poster promoting the FUNDamentally FRESH bonus incentive and all of the farmers' markets that offer it, so the folks just enrolling in Cal Fresh/EBT will know about this.

2) Built upon a nascent 'Buy Fresh, Buy Local / Compre lo Fresco de Nuestra Región local foods promotion campaign.

The ALBA made great progress in developing campaign materials to promote more than 40 farmers to over 50 customers and succeeded in further developing the ALBA Organics branding that is now printed on its produce boxes, strawberry and raspberry plastic clamshells packaging. ALBA Organics partnered with CAFF in promoting Buy Fresh Buy Local through the distribution of Harvest of the Month kits to hundreds of classrooms in Monterey and Santa Cruz counties. Thousands of school children have tasted and learned about local fruits and vegetables grown locally, their history, nutritional benefits and culinary uses. Six new Farmer Profiles that describe the individual farmers' experiences, achievements and resulting positive impacts in the community were produced. These profiles are posted on ALBA's website and printed/laminated as promotional material that farmers can use as outreach tools within their own markets. ALBA Organics customers are also regularly informed of the individual farmers that grew each crop ALBA distributes, as each of the 50 plus farms sourced are featured on Produce Availability Lists. Farmer profiles, photos and logos have been posted through ALBA's newsletters and social media outlets. Since the start of this grant, ALBA has hosted four You Pick events, when the public is invited to learn about local farms and SCs that the public can pick and purchase to take home. Over 1,000 local residents have attended these events and learned about Buy Fresh Buy Local.

3) Worked with schools and faith communities to establish five church or school-based farm stands that offer SCs specifically to low-income families.

The ALBA established three new farm stands where farmers can offer SCs for sale to the public. In April of 2010, ALBA established a new partnership with St. Mary's By the Sea Episcopal Church in Pacific Grove, California, led by farmer Rigo Bucio, with sales averaging $250. In June of 2011, ALBA established a new partnership with a company called Language Line Services in Monterey, California, initiated by the Garcia Brothers Farm. Their sales averaged $200 per week. In August of 2011, ALBA established a new partnership with the Watsonville YMCA, where farmer Maria Elena Padilla is selling on a weekly basis with $50 average per week. Although ALBA projected sales to be higher, both Mr. Bucio and Ms. Padilla are dedicated to continuing. Mr. Bucio will continue to sell through the winter season. Ms. Padilla will possibly end for the season and start again next year. One participant, the Garcia Brothers, were unable to continue, as after a three month stint they determined that although sales were decent considering this was their first few months, they did not have the time and resources to be off the farm on a weekly basis. After developing criteria for selecting institutions, ALBA determined that it would be useful to have a Memoranda of Understanding between the farmer, the hosting agency and ALBA.

4) Provided agronomic education, field demonstration and market research on culturally valued crops and innovative SC food products.

ALBA surveyed (15) farmers on prospective ethnic specialty crops to be considered for trials, which were narrowed down to watercress (berro), vegetable pear (chayote) and a few others. ALBA then executed trials with these crops: Cilantro, Oaxacan chilies, jalapeno chilies, ethnic sweet peppers, radishes, pie pumpkins, paste tomatoes and watermelons. The ALBA sold habaneros, serranos, and jalapeno chilies, cilantro, bok choy, red radishes, magda squash (gray Mexican squash) and spigarelo kale.

The ALBA offered the following workshops: "Ethnic Crops I," "Ethnic Crops II," "Getting Started: Seed or Transplant?," "Succession Planting for Big Money," "Equipment Innovations for Small Farmers," "Food Safety – What you Must Know," "Tractor and Equipment Safety," "Labor Law," "Advanced Weed Control in Diverse Cropping Systems" and several others.

ALBA partnered with Fare Resources to conduct market research of potential crops and pickled jalapenos as a processed crop. ALBA also surveyed over 15 customers about ethnic crops that they would like to purchase.

5) Partner with health groups and farmers' markets to create incentives for EBT enrollment and use by 2,000 people buying SCs directly from growers.

The ALBA developed FUNDamentally FRESH, which provides a $5 bonus to EBT clients after spending $10 with their EBT card. This incentive is available at 11 different farmers' market locations in Monterey, San Benito and Santa Cruz counties and is the successful result of diverse partnerships with a multitude of agencies. The EBT spending increased by an average of 400 percent between 2009 (without the incentive) and 2010 (with the incentive), and although it is a little early to tally the exact increase for this season, the results will be significantly higher for 2011. The bonus dollar incentives were provided by private donations, and grant funds were used to disburse the incentives to consumers. The primary measures of assurance for specialty crops included: 1) farmers' markets managers training the market vendors as to who can accept the tokens among vendors (fresh produce farmers only), 2) the tokens have a message printed on them that says "Fresh Produce Only" and 3) if a non-specialty crop vendor tried to redeem the token with the market manager, its redemption would be denied.

The ALBA produced a Spring/Summer Edition 2011 of the bilingual_Farming for the Future newsletter which reaches 600 Spanish-speaking growers and more than 1,000 partners. One of the feature articles provided information about how farmers can "get in" and successfully sell in farmers' markets. ALBA produced a 2010 Spring/Summer Edition including an article that described Assembly Bill 537 – *EBT in Farmers' Markets*, and the 2010 Fall Newsletter covered FUNDamentally FRESH. The campaign was also shared with local media including the Salinas Californian, El Sol, the Monterey Herald, and the Monterey County Weekly, all of which covered this. The ALBA shared the results of FUNDamentally FRESH with over 20 organizations and led a presentation of the results at the Healthy Food Access Committee meeting in September 2011.

6) Establish program monitoring and evaluation (M&E) protocols, and report project performance in a timely manner.

During the summer of 2011, ALBA conducted a consumer survey in 10 farmers markets to better understand the impacts of FUNDamentally FRESH. Sixty-five surveys were completed and tallied and shared with the California Farmers' Market Consortium and Roots of Change. ALBA conducted a survey among farm visitors to learn how to improve its Buy Fresh Buy Local harvest events. One key outcome of the survey is that people enjoy the experience of picking and harvesting their own produce, and ALBA has continued to offer this activity at events. In March, ALBA worked with students from the Monterey Institute for International Studies who conducted an evaluation of ALBA's Food Systems Program. The results were shared with staff and presented as a document with some key findings and recommendations.

Key contributors to the project included:

- Everyone's Harvest Farmers' Market Association, Santa Cruz Community Farmers' Market Association, Natividad Medical Center Farmers' Market, King City Chamber of Commerce, Hollister Downtown Association, Soledad Farmers' Market, Watsonville Farmers' Market, and Greenfield Farmers' Market, all contributed to the success of FUNDamentally FRESH by offering it in their markets and assisting with M&E.
- Fare Resources – Conducted market research on prospective ethnic crops and processed food options.
- Food Bank for Monterey County, Second Harvest Food Bank, Food Bank for San Benito County all assisted with outreach of campaign in community and in farmers' markets and did Cal Fresh prescreening local farmers' markets.
- Healthy Food Access Committee, Central Coast Hunger Coalition, Monterey County Health Department all supported outreach efforts and strategy on best practices.
- CDSS Monterey, San Benito and Santa Cruz counties all agreed to put up campaign posters specially developed for CDSS.
- Radio Bilingue hosted a live radio show to talk about FUNDamentally FRESH and Cal Fresh.
- Univision Spanish News covered the incentive campaign of the newly opened Natividad Medical Center farmers' market.

Goals and Outcomes Achieved

New marketing opportunities were established in the community and farmers' markets engaged more low-income EBT clients than ever before. The farmers' profits increased through the incentive dollars and increased EBT clientele and education and information about ethnic crops was brought to light for both farmers and ALBA Organics marketing team.

Based on monitoring and evaluation of FUNDamentally FRESH, EBT spending in the farmer's markets increased by 400 percent to 600 percent. Baseline sales data was collected in 2009 and compared to sales in 2010 and 2011 when the incentive was offered. Consumers that were surveyed indicated that the campaign succeeded in helping them access more fresh fruits and vegetables and helped to make it possible for them to shop in the farmers markets.

The next outcome measure that is more long term will be to better understand the impact of the incentive on farmers. Although there is more profit because of this, measuring it to result in quantitative evidence will be important. As a result of new and stronger partnerships, all involved are more successful as coordinated and focused information sharing allows for informed decisions.

Beneficiaries
Participating agencies mentioned above benefited from this project, along with small farmers in ALBA's incubator, farmers selling specialty crops in farmers' markets and low-income EBT clients.

Beginning farmer beneficiaries earned an average of $200 more per week through farm stands. Farmers' market SC vendors earned more money in farmers' markets through increased EBT spending markets (400 percent through 600 percent) and incentive dollars.

The project benefited 102 specialty crop producers in eight farmers markets with increased EBT sales of approximately $27,000 – which includes nearly $9,000 in EBT incentive funds disbursed and utilized by consumers. The project was leveraged by continuing into 2011 in partnership with Roots of Change for another $6,000 in EBT incentives used toward a total of $18,000 in EBT sales among the same markets and specialty crop producers in 2011.

Lessons Learned
The EBT incentive was more successful than expected with the sharp increase in EBT spending. However, more research should be done to understand the long-term behavioral changes that may result from farmers' market/incentive outreach. The farm stand initiative's success depends on the capacity of farmers to service the farm stand and stick it out until profits increase. The marketing opportunities for ethnic crops are significant depending on the particular clientele and market trends.

The extensive support of local agencies and food banks to improve enrollment and participation of Cal Fresh/Supplemental Nutrition Assistance Program and usage in farmers' markets was unprecedented, as several agencies this year began providing the service of enrollment for the first time.

The Buy Fresh Buy Local licensing was not achieved, as ALBA learned early on that local store owners were not ready and unwilling to purchase and promote local foods. Before a campaign can be successful, the store owners and its clientele must have a certain amount of buy in.

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 19	**Project Title:** Upgrade and Expansion of the California Stone Fruit Trade and Regulatory Database	
Grant Recipient: California Grape and Tree Fruit League	**Grant Agreement No.:** SCB09013	**Date Submitted:** December 2012
Recipient Contact: Marcy L. Martin	**Telephone:** 559-226-6330	**Email:** mmartin@cgtfl.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The purpose of this project was to expand and update the California Grape and Tree Fruit League's (CGTFL) on-line trade and regulatory database. That database covers global trade regulations for peaches, plums, nectarines, and apricots (collectively "stone fruit"). Prior to the project, the database contained regulatory and trade information on 15 countries. This project entailed expanding the system to cover 25 export markets around the world, and updates to it through the length of the grant cycle.

The need for this project was outlined in CGTFL's original concept paper. Stone fruit exports continue to expand. In 2008, California exported $229 million in apricots, peaches, nectarines, and plums, a 24% increase over 2007 and a 53% increase since 1999. Though exports fell back from that level in 2009 due to the economic downturn, global shipments are recovering. Moreover, the CGTFL is on the cusp of opening new markets, including Australia which has proven sizable for other California produce.

As exports grow, California stone fruit exporters need accurate trade and regulatory information that applies to their products in export markets. Such information helps avoid detentions at a foreign port.

Foreign country import policies and regulatory standards are constantly changing. In the time since this project was initiated, there have been numerous developments that have affected (or could have) California stone fruit export opportunities. Some recent examples include Indonesia's decision earlier this year to close numerous ports, including the Port of Jakarta to imported fruits and vegetables. The Port of Jakarta has been the principle port of entry for U.S. produce. There have also been three free trade agreements completed (two implemented) since this project was initiated. These agreements changed tariffs applied to imports from the U.S. In Hong Kong, the government announced its decision to develop its own list of pesticide maximum residues. That announcement was made in 2007 and warranted monitoring on an ongoing basis. Last month, Hong Kong released its final list. Stone fruit growers and exporters must be aware of these regulations to avoid shipping disruption in that market. These are just a handful of examples justifying the need and timeliness of the project.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Tasks associated with this project can generally be summarized as follows:

- Database expansion – the CGTFL database was expanded from 15 to 25 countries.
- Research/Monitoring – trade regulations and developments were monitored on an ongoing basis. Monitoring and updates were made to eight sections including (Summary, Pest & Disease Lists, Phytosantiary Requirements, Sanitary Requirements, Labeling and Documentation, Contacts, Tariffs and Taxes, and Additional Requirements).
- Surveying – Hard copies and online surveys were developed and circulated in an attempt to obtain industry feedback on the database. Survey responses were admittedly limited.
- Usage tracking – use of the database was tracked each year. In 2009 there were 51 unique IP addresses that visited the database in the course of the fiscal year. In 2010, this number increased to 100 unique IP addresses, which represented a 96% increase. In 2011, the number increased 11% to 111 unique IP addresses. For the year ending June 2012, the number had grown to 121. Growth has exceeded the 5% per year goal.

The database project has met the expectations of CGTFL. Trade and regulatory developments have been monitored and reported to CGTFL and industry members. This has helped ensure uninterrupted trade to many markets and the avoidance of expensive violations and product loss; though it is difficult to quantify such success (it is a challenge to speculate on what might otherwise have occurred).

The survey process for industry feedback could be improved upon. Survey responses were very limited. This is not necessarily a negative. Industry members would surely notify CGTFL about problems or inaccuracies encountered in the database or with questions they might have. Nevertheless, other mechanisms could be used to obtain feedback from industry such as through board meeting or other meeting materials or even by including the database as a discussion on meeting agendas. Email communication could also include survey links or other means to connect more frequently with industry.

Though industry feedback was limited, CGTFL fully believes in the importance of the database and the information it makes available to industry. As a result, it was recommended that CGTFL continue to fund database monitoring updates despite the conclusion of SCBGP funding. That has occurred, with funding extended for another 12 months.

CGTFL did not rely on many partners for this project. Bryant Christie Inc. was the principle partner as they handled the responsibility or monitoring trade developments and updating and expanding the database accordingly. However, it is also important to acknowledge the contributions of CDFA and USDA personnel that negotiate and clarify changes to foreign trade standards and policies. For example, there have been numerous changes in quarantine status for various pests of concern. This information must be communicated effectively and promptly by state and federal regulatory officials. Similarly, changes in foreign countries may require translation. USDA international posts are very helpful providing translations of pertinent legislation.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

CGTFL followed its workplan for this project. The order of activities for completing the project included:

- Soliciting proposals from contractors to assist with database monitoring and expansion.
- Contractor selection\
- Research and expansion with 10 new countries
- Ongoing research, monitoring and updating
- Surveys and database usage tracking

CGTFL included eight measurable outcomes in its original proposal for this project. Those outcomes are listed below with a result for each in italics.

1. Adding ten new countries to the database. *10 new countries added in year 1.*
2. Expanding information on country packaging and labeling information in the database. *Packaging and labeling information has been expanded. Labeling information now includes requirements for packaged foods and those that might be in place or in discussion for fresh products (for example Japan's proposed labeling for post-harvest fungicides).*
3. Expanding documentation requirements in the database. *The database has been expanded with additional documentation requirements including links where possible to sample documents that can provide guidance to exporters.*
4. Adding trade flow data to the database including export data on global competitors. *Trade flow data was not added to the database. Obtaining data, particularly on competitor country exports went beyond the scope of the monitoring and expansion agreement in place for this project. Moreover, CGTFL has access to such trade flow data through the Global Trade Atlas under an agreement with USDA.*
5. Creating a system that allows for easier updates of and access to information within the database. *Contractor updated the look of the CGTFL database to mirror CGTFL's website design, thereby making for a better end-user experience. Components of the database (maximum residue levels, for example) were linked to an independent database which permitted automatic updates when MRL levels changed. This improved accuracy and timeliness of updates.*
6. Increasing the numbers of annual visitors to the database. *Database visitors increased from 51 in year 1 to over 120 in year 3.*
7. Increased exports of California stone fruit. *California stone fruit exports are again on the rise though exports dropped after 2008 following the financial crisis and economic recession.*
8. Fewer export problems reported by the California stone fruit industry. *Anecdotally, the CGTFL has been made aware of fewer trade disruptions over the last few years.*

The following goals were also established for this project.

	(Benchmark) 2009	2010	(Result) 2011	2012
% reduction in number of shipments detained or delayed *	TBD	NA	NA	NA
# of exporters using database*	51	100	111	121
# of exporters using database who find it useful in helping expand exports*	1	3	4	5

* Exporter response to CGTFL surveys was minimal. As a result, it was not possible to determine a true figure of the number of exporters making use of the database or of specific reductions in detentions. However, the database was discussed regularly as part of CGTFL marketing committee meetings and anecdotal reports of the effectiveness of the database were received annually by CGTFL staff. CGTFL estimates at least 12 positive discussions with stone fruit shippers pertaining to their use of the database. This input forms the foundation of the results listed above. It should also be noted that usage can still be gauged by examining visits to the system. Data included for this measure above, reflects database visits.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The CGTFL database is a reference tool for stone fruit growers in the State of California. It is designed to give producers and shippers a resource where they can obtain information needed to assess export opportunities and to avoid trade disruption. Through industry surveys, it has been difficult to determine a true sense of the number of companies making use of the database. However, usage of the system can be inferred from database visitation statistics which have been tracked annually. From those statistics, usage has increased by over 137% since the project began.

CGTFL itself and staff from the California Tree Fruit Agreement (a separate marketing order for promotion of California tree fruit – but which no longer exists) also benefitted from the database. The database provided insight and details on issues that could potentially affect exports. This helped staff prepare comments for U.S. trade policy officials or for submission directly to the World Trade Organization or foreign governments as appropriate. The Indonesia port closure issue cited earlier in this report is an example of how the database was used for this purpose. Similarly, MRL data was used to prepare comments on Japanese and Hong Kong policies.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

A key lesson learned from this project has been that industry surveys are a difficult mechanism through which to obtain feedback. Growers and shippers are busy with their day-to-day operations. Obtaining feedback from these contacts on the CGTFL's website or the database has been difficult. Moreover, many may be reluctant to disclose trade issues they have encountered for fear that such information in the public domain may put them at a competitive disadvantage. Whatever the reason, survey responses have been minimal, making it difficult to assess certain quantifiable measures. Fortunately, CGTFL believes that sufficient data is available through other means (website tracking, general export data, anecdotal evidence of reported trade disruptions) to determine the need and utility of this resource. Moreover, the fact that the CGTFL board committed to continued funding for the resource beyond the SCBGP grant speaks volumes about the usefulness of the resource.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

See website – www.cgtfl.com.

Project 20 – California Canning Peach Association (CCPA)

Final Performance Report

Project Title
California Canned Peaches to India

Project Summary
Global exports of California canned peaches have been relatively flat in recent years. Exports declined in 2008 to reach 31,869 metric ton according to United States Department of Agriculture statistics. The lack of export growth is primarily due to competition from other global suppliers who can employ cheap labor and sometimes benefit from domestic government assistance to produce canned peaches at a lower cost than California processors. The loss of foreign market share has contributed to the decline in profitability in the California canning peach industry. To reverse this trend, the CCPA sought to identify and pursue a new export market for California canned peaches through the California Department of Food and Agriculture Specialty Crop Block Grant Program.

The goal of this project was to expand exports of California canned peaches by investigating market opportunities in India. The Indian market, while relatively untapped, is expanding. Global exports to India have grown from zero in 2002 to $92,000 in 2007. The market is not dominated by any one supplier and Greece and China have yet to enter the market. In addition, demand for imported processed food items is increasing among both consumers and retailers. For these reasons, CCPA identified India as a potential growth market and conducted market research and a trade mission to further explore opportunities.

Project Approach
The CCPA completed all activities and tasks outlined in the Workplan.

In the first stage, CCPA solicited bids for a research company to act as a project partner for this project. CCPA retained Bryant Christie Incorporated (BCI), an international affairs management firm based in the United States (U.S.) that specializes in international marketing, research and trade policy. On behalf of CCPA, BCI conducted market research, which included information regarding market access requirements and restrictions, market access for competitors, competitive products and suppliers and trade contacts. A formal draft of the report was presented to CCPA in April 2010. The report concluded that opportunities to increase exports of California canned peaches exist in India and recommended that CCPA conduct a trade mission in May 2010 to further identify trade leads and better understand the distribution channels and retail sector of India.

Based on the positive results of the research report, CCPA moved on to the second stage of the project and organized a delegation of key California canning peach industry members to travel to India. Representatives from CCPA, BCI, Otis McAllister, Incorporated (a major global distributor of U.S. processed food products), and a major cling peach growing operation in Northern California participated in the trip. The trade mission took place during the period of May 2 through 8, 2010 and included visits with Del Monte, Wal-Mart and various Indian processed food importers among others. As a result of these meetings, the delegation was able to establish relationships with the Indian trade and further explore actionable export opportunities.

Upon completion of the trade mission, BCI submitted a final research report to CCPA on June 14, 2010. The report provided favorable conclusions and recommendations to CCPA, including a potential market entry strategy, marketing opportunities, and a list of target importers and retailers. A copy of the report is available upon request.

<u>Goals and Outcomes Achieved</u>

The following activities were completed in order to achieve the performance goals and measurable outcomes for the project:

- The CCPA hired a qualified research firm to conduct market research. CCPA retained BCI for this project.
- The BCI conducted market research, which included information regarding market access requirements and restrictions, market access for competitors, competitive products and suppliers and trade contacts.
- The BCI reviewed the research and drafted a preliminary report.
- Upon favorable results in the research report, CCPA recruited participates for the trade mission to India.
- Meanwhile, BCI developed an itinerary for the trip and contacted Indian importers and retailers to set up meetings. BCI also arranged all travel-related logistics for the delegation.
- The BCI prepared briefing materials for the delegation, including maps of the areas visited and information about the trade.
- On May 2 through 8, 2010, the CCPA conducted the trade mission to India.
- On June 14, 2010, the BCI submitted a final report to CCPA outlining conclusions and recommendations.

As a result of these activities, CCPA was able to achieve its first two performance measure goals. First, CCPA successfully completed an initial market research report. Second, CCPA organized a delegation of California canning peach industry members to participate in a trade mission to India.

These initial accomplishments are expected to achieve the project's ultimate goal of increasing exports of California canned peaches to India. Based on the favorable results of this project, the California canning peach industry plans to maintain communication with Indian importers and establish actionable trade opportunities. Initial contact and communication established in 2010 will likely result in export growth through 2015. The CCPA expects exports to India will increase annually over the next five years.

<u>Beneficiaries</u>

This project directly benefited the members of the California canning peach industry. The CCPA operates as a nonprofit farm cooperative, owned by its member-growers. CCPA's mission is to safeguard the profitability and success of California's processing peach industry. The research and trade mission to India conducted through this project will impact California's top seven canned peach processors and growers, which represent approximately 24,500 acres of California cling peaches.

According to CCPA statistics, the California canning peach industry produced 420,000 metric tons of cling peaches worth US$ 134.8 million in 2008. The price of California cling peaches has continued to increase since 2005, which has made them a high-value specialty crop in California. With the increasing value of cling peaches, the exploration of new export opportunities in India is pertinent to the continued growth of the canning peach industry. The final research report produced for this project provided the industry an extensive background and analysis of the current processed food market and retail sector in India. The trade mission allowed key California canning peach industry members to further explore potential export opportunities and establish relationships with the Indian trade. As a result, an initial market entry strategy has been created.

The economic impact of this project will be the initial export of California canned peaches to India and annual five percent increases thereafter over the next five years.

<u>Lessoned Learned</u>
This project enabled CCPA to accomplish all performance measures outlined in the initial proposal and determine India's potential as a new export market for California canned peach products. The completion of an initial market research report identified specific opportunities, challenges and key points of contact in the Indian market for California canned peaches. The subsequent trade mission allowed representatives of California peach processors, CCPA members, and cling peach growers to further evaluate the current market situation and identify obstacles and advantages for the industry.

Initial obstacles to increasing California canned peach exports to India include high transportation costs and logistical difficulties. The geographic distance between the U.S. and India presents a challenge for U.S. suppliers as global food suppliers in closer proximity to India have cost and time advantages over the U.S. Adding to these obstacles is that many U.S. products have to be transshipped through regional trading hubs. Once U.S. products arrive in India, they are further inhibited by limited infrastructure. The country's network of roadways is underdeveloped, impeding access to some markets. This adds the challenge of finding trustworthy importers and distributors to assure products arrive to their destinations as safely and efficiently as possible.

Indian consumer preferences can also present challenges to U.S. processed food products. Indian consumers traditionally have had diverse food habits and often prefer fresh and familiar products compared to international products with which consumers may not be as familiar, such as canned fruit. This plays to the benefit of local producers and food processors because they are able to cater to these local preferences while operating on a smaller and less expensive scale and end up selling at lower prices.

In addition to the limited market size for canned fruit due to traditional preferences for fresh produce, California canned peaches must contend with canned peaches from South Africa, which already exist in the market, imported by Del Monte. Del Monte appears to have gained substantial reach in terms of distribution for its canned peaches and other processed products. Meanwhile its partnership with Bharti, India's leading business group, provides it with several advantages that other suppliers lack: access to retail distribution, a knowledge base to navigate market regulations, and now with the expansion of a production plant within India, Del Monte may soon be able to compete even more effectively in terms of pricing thanks to new efficiencies gained by its local manufacturing site. During the trade mission, the CCPA delegation met with Del Monte representatives to explore potential sales opportunities.

Despite the number of obstacles facing food products entering India, this project helped CCPA identify several advantages and incentives for California canned peaches in the market.

The Indian food retail sector is growing and changing, which presents more favorable conditions for new products entering the market. India's already large middle class is expanding and the retail food sector in urban areas is transforming to accommodate its demands. Aided by the expansion of large Indian grocery conglomerates and fast food franchises, Indian consumers are becoming increasingly exposed to American products and lifestyles. Changing demographics and patterns in produce consumption indicate that these consumers are beginning to expect a wider selection of products to satisfy their broadening tastes. New products are becoming routine buys and processed food consumption continues to rise as shoppers demand higher quality, greater convenience and more choices. New imported food products are especially popular and have been most successful when they are introduced between October and December due to the major cultural holidays that are celebrated during this season.

The CCPA also found encouraging results for American producers shipping to India in the examples of California grapes and Washington State apples. Both products entered India at a time when the market for such products was essentially nonexistent, but grew to multi-million dollar sales marks within three to four years. The success of these American products further emphasizes Indian consumer interest in new products.

California canned peach producers can also use India's lack of infrastructure to their advantage. India critically lacks cold storage facilities and transportation. Reportedly thirty percent of the perishable produce traveling throughout the country is discarded because of this lack of cold chain infrastructure, and efforts to improve the system have been slow in coming. Canned peaches would have immediate access to markets across the country by not requiring refrigerated shipping. Canned peach producers would also be able to bypass the extra legwork of dealing with logistics companies to work around the problem of cold chain transportation.

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The following photographs were taken during the trade mission:

CCPA delegation meeting with importer FieldFresh and Del Monte in New Delhi.

CCPA delegation observing canned food products at SPAR Hypermarket in Bangalore.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 21	**Project Title:** The Impacts of Changes in the Agricultural Transportation Sector on the Competitiveness of the California Specialty Crop Industry	
Grant Recipient: Cal Poly Corporation	**Grant Agreement No.:** SCB09021	**Date Submitted:** December 2012
Recipient Contact: Dr. Jay E. Noel	**Telephone:** (Tel) 805-756-5014	**Email:** jnoel@calpoly.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The movement of California (CA) fruits, vegetables, and nuts to distant domestic and international markets requires movement by a multimodal system of truck, rail cars, intermodal rail, ocean ports and air transport. The services provided, the prices charged, and the competitive/complementary interactions among modes, directly affects the competitive success of CA specialty crop (CSC) shippers in reaching and serving these markets.

Increasingly a major future challenge facing CSC producers, affiliated firms, and CA public officials will be related to issues of maintaining a logistically efficient and competitive CA agricultural transportation system.

The basic problem addressed in this study is how current conditions and changes in agricultural transportation technology, infrastructure, transportation costs, and environmental and climate change mandates on the transportation sector affect CSC regional and international competiveness. There are current as well as anticipated changes occurring in the transportation sector that can affect CSC competitiveness.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

1. The demand for transportation services was assessed by estimating the quantity of CSCs that must be moved each year.
   a. Reported statistics from the CA Department of Food and Agriculture (CDFA), National Agricultural Statistics Service (NASS), and Agricultural Marketing Service (AMS) were compiled showing increasing production trends for most of the top 20 CSCs over the last three years, with a large percentage of production going to exports to other states in the U.S. or internationally (61.5% for raspberries/blackberries for example).

   b. Based upon production regions, volumes, and the most recent AMS data, trucking is the dominant transportation mode accounting for 95% of *domestic* specialty crop shipments with the other 5% split between rail and air.
2. An overview of rail, air, and port transportation issues was developed based upon findings from the CDFA, NASS, and AMS secondary data for rail and air. Interviews were conducted with representatives of the CA ports of Long Beach, Oakland, and Stockton. Interviews were also conducted with Railex LLC officials, a national intermodal service provider, in 2010-2011. Based upon these interviews it can be concluded that:
   a. Rail is still not a competitive alternative to trucking produce across country.
   b. Intermodal transport has advantages but limited capacity.
   c. Air has a very small percent of total agricultural transport.
   d. Exports to Asia through CA ports are on the rise with no foreseeable issues other than lack of infrastructure in foreign countries.
3. Two surveys and in-depth interviews of agricultural shippers and transportation service providers were conducted. Eighty-six CSC trucker/carriers and 42 CSC shippers responded to a 38 question and 34 question survey respectively that included questions regarding firm size/makeup, raising fuel costs, service availability, and CA transportation policy. Respondents were also solicited for their general perspectives/concerns regarding shipping produce in CA and within the continental U.S. Two major findings of the surveys were:
   a. Both shippers and truckers are concerned about the future regulatory environment and what that will mean for their gross margin. Trucker/carriers indicated a potential increase of the price of services to increase between 19 and 29% due to recent and proposed legislation. Over 80% of CSC shippers responding indicated that the same regulation was at least "Problematic" to being a "Serious Problem."
   b. Effective wages of truckers and the return on transportation capital has been on the decline due to congestion, drive time limits, and especially wait time for loading and unloading produce. Truckers indicated experiencing congestion on major CA interstates over 25% of the time. Respondents indicated over 16 hours are spent waiting to load, loading, waiting to unload, and unloading. Particularly, truckers spend approximately forty-percent of the loading and unloading time waiting to load the product.
4. Based upon data made available by the trade publication *The Packer*, and AMS, ten representative California produced crops were identified to illustrate the effects that transportation might have on competitiveness. The crops chosen were: celery, cherries, table grapes, head lettuce, oranges, peaches, strawberries, watermelon, sweet corn, and fresh tomatoes. Following major competing regions were identified: Arizona, Florida, Michigan and Texas, based upon overlapping production during CA growing seasons.
5. A spatial analysis of transporting fresh fruit and vegetables with no production capacity constraints was performed. A graphical information system, ArcGIS, was used to integrate mileage between U.S. production areas and 15 metropolitan statistical areas (MSA), shipping point prices, and transportation costs to produce maps for the visual analysis provided in the attached report. Findings from the spatial analysis include:
   a. Based on a pure mileage standpoint, CSC producers easily compete for the major markets on the U.S. West coast.
   b. When transportation costs were factored in, the competitive border for CA producers moved westward by a couple hundred miles.

   c. When production costs were factored in, in certain quarters for certain crops, the competitive boundary moved significantly to the east when CA had the production advantage, such as strawberries in the winter quarter.
6. A model of regional competitiveness constrained by states' production capabilities and transportation costs was performed.
   a. There are trade-offs between shipping point prices, per-unit transportation costs, and production capacity to their impact on CSC competiveness.
      i. The most significant factor is its production capacity. In the case of celery, even if the rest of the U.S. had a competitive advantage on production and transportation they do not have enough supply to fulfill the 30-35% of truck-transported demand represented in the 15 MSAs modeled.
      ii. The next significant factor is shipping point prices. For example, in the third quarter CA has an $11.33 per-unit shipping point price advantage over Florida, negating transportation costs as a factor in CA competitiveness for strawberry production. Holding transportation costs constant in the rest of the U.S., CA transportation costs would have to increase by nearly 500% in order to have a marginal effect on CSC production.
      iii. Finally, per-unit transportation costs had the smallest effect. For strawberries in the first quarter both CA and Florida have the potential to supply the 15 MSAs, however the difference between shipping point prices is only $0.06 resulting in an allocation of strawberries throughout the MSAs based solely upon per-unit transportation costs.
7. An analysis of the impact of greenhouse gas emissions (GHG) on CSC refrigerated truck movement was performed.
   a. The added cost accounting for GHG emissions is extremely small for CA produced commodities. For example, if customers in Boston wanted to pay to offset the carbon emission generated from transporting celery from CA, it would cost roughly $0.01 per pound.

The primary limitation of this study as it progressed was the availability of secondary data. There is extremely limited public information available for total shipments of fresh fruit and vegetables into specific cities/markets and from designated locations. The USDA/AMS last produced an annual report of Fresh Fruit and Vegetable Arrival Totals for 20 Cities in 1998. In addition, the arrival data that was once published was based on information obtained from various terminal markets, which, given the rise of retail distribution centers, have an increasingly smaller role in the distribution of fresh fruit and vegetables. While this report greatly benefited from industry collaboration and confirmation, in order to make unbiased policy decisions in the future, more detailed shipment data including quantities, prices, and destinations will need to be gathered.

The project partners at the Center for Agricultural Business (CAB), CA State University, Fresno provided the demand for transportation services, provided assistance on developing the characteristics of truck services, did the work on characteristics of rail and air, and assisted on the characteristics of the ocean ports. The CAB did initial work on the state competitiveness model and did the analysis on the environmental concern associated with CSC truck transport. The CAB also shared in the writing of the final report (referenced at end of this report) and did five presentations to CA agricultural transportation stakeholder organizations.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The specific objectives of the study were to:

- Gather primary and secondary data on the various modes of transportation. This data would include product market and transportation market information by region and specialty crop sector.
- Identify those transportation modes (truck, rail, air, ports) where the CSC grower, shippers, and transportation industry firms are experiencing or may experience changes in their regional and international competitiveness due to logistical and cost issues associated with current and projected changes in transportation technology, infrastructure, and agricultural transportation markets. The importance to be identified by specialty crop category and CA region.
- Evaluate the impact that changes in agricultural transport technology, infrastructure, and agricultural transportation markets will have on the future competitiveness of CSC producers in the regional and international marketplace.
- Provide policy makers and other stakeholders involved with agricultural transportation issues with suggestions on maintaining or improving the regional and international competitiveness of CSC industries through changes and improvements in existing transportation mode services.

There are two key findings from this study that were arrived at through the completion of the various activities that address the specific study objectives. The first relates to the results of the empirical analysis of CA regional competitiveness. The findings of the competitive spatial analysis and the CSC competitive model analysis indicate that transportation costs, shipping point prices, and product availability all have an effect on CSC competitiveness but the effects of each are not uniform. Product availability appears to be the leading factor in determining an individual state's specialty crop competitiveness.

Thus, there are trade-offs between shipping point prices, per-unit transportation costs, and production capacity on their impact of CSC competiveness. However, the most significant factor affecting CSC competitiveness is its production capacity. The next most important factor is shipping point prices. The least important factor of the three is per-unit transportation costs. Higher per-unit transportation cost can shift the CA competitiveness boundary slightly to the west, but changes in shipping point prices and production capacity are the major drivers of CSC competitiveness.

The second set of study findings are based on the results of the CSC shipper and trucker surveys. The competitive issues highlighted by those surveys are highway infrastructure with emphasis on congestion, logistical inefficiencies, and the CA regulatory environment.

The logistical inefficiency issue combined with the congestion lead to a major concern of both specialty crop shippers and truckers. That concern is the future supply of truck drivers; 80.7% of specialty crop shippers indicated that shortage of drivers was a serious or problematic concern over the next five to ten years. Truck drivers are paid for miles driven. The impact of the hours spent loading and unloading a truck combined with highway congestion issues reduces the effective wage a truck driver can earn. Those issues also lead to fatigue and time spent away from home.

The two issues of highway congestion and wait times also lead to a concern about future truck supply. Both congestion and wait time reduce the return on investment by trucking firms creating an environment of increased risk and uncertainty on the part of truck firms relative to their investments, and to CSC producers and shipper domestic market competitiveness.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Approximately half of the fruits and vegetables consumed in the U.S. come from CA, and a significant amount of CSCs go into international markets. Very little research has been done on CSC transportation issues. Transportation has always been a high priority for CSC industries. Addressing transportation issues is important for the current and long-run sustainability of CSC industries.

This study provides valuable insight into how the CSC industries, specialty crop producer organizations and their umbrella organizations, government, and transportation companies can adapt to changing transportation issues.
Meetings and Presentations Given:

- *Food Distribution Research Society in Portland, Oregon October 18, 2011*
- *Railex Meeting Delano, CA December 2, 2011*
- *Agricultural Transportation Coalition Meeting in Fresno, CA February 2, 2012*
- *Southern Agricultural Economics Association Meeting in Birmingham, Alabama February 4, 2012*
- *National Green Industry Research Consortium, March 5, 2012*
- *Grower-Shipper Association of Central CA, June 8, 2012*
- *Agricultural and Applied Economics Association Meeting in Seattle, Washington August 13, 2012*

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

This project was about how transportation affects the competitiveness of CSCs. This directed the research team to delineate the difference between competitiveness and profitability. It was found that it is possible to be competitive but not make a profit in the short-run. This resulted in a greater understanding about how CA's competitiveness in the specialty crop arena is about more than transportation costs. Two components that were found to be more important to competitiveness were productive ability of producers and availability of product.

There is a need for better public data in order to conduct a more thorough and rigorous analysis of how transportation affects competitiveness. Available public data sources are out of date in relationship to today's movement of specialty crops. They do not take into account the current marketing chain of fresh fruits and vegetables.

A third major discovery was that the three dominant factors concerning shippers and/or truckers of CSCs are: the inadequacies of the CA highway infrastructure with emphasis on congestion, logistical inefficiencies of loading and unloading the crops from trucks, and the uncertainties that the CA regulatory environment brings.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

The Impacts of Changes in Agricultural Transportation Sector on the Competitiveness of the California Specialty Crop Industry – Report (Attachment 1 – Part 1; Attachment 2 – Part 2)

USDA Project No.: 22	**Project Title:** Use of 1-MCP after Harvest to Improve Fruit Quality after Long-distance Shipment and Storage	
Grant Recipient: California Pear Advisory Board	**Grant Agreement No.:** SCB09014	**Date Submitted:** December 2012
Recipient Contact: Bob McClain	**Telephone:** 916-441-0432	**Email:** bob@calpear.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

1-methyl-cyclopropane (1-MCP) is an ethylene action inhibitor that delays ripening of pear fruit. 1-MCP is registered in California as SmartFresh™ for postharvest gas application in sealed rooms or tents.

The California Pear Advisory Board (CPAB) has been funding programs that would increase their export markets. One of the many issues with long distance shipment of Bartlett pears is maintaining the pears green appearance and preventing ripening before arriving at distant markets. Beth Mitcham, the contractor from UC Davis has been experimenting with the use of SmartFresh (postharvest application of 1-MCP) for Bartlett pears for several years to improve post-storage quality and allow Bartlett pears to be shipped to distant markets such as Brazil and India. While results were promising, a continued challenge was the balance between storage benefits and eventual ripening of the fruit for marketing. In some cases, the pears do not ripen when exposed to ripening conditions and in others the SmartFresh does not prevent ripening for the desired period of time. The response of the fruit was quite variable in these experiments and in many cases fruit did not respond or a much higher concentration of SmartFresh was required to see an effect. It was not at all clear the reason for these treatment failures at the time, but Beth Mitcham's research in 2009 indicated that ethylene concentration during Smartfresh treatment, time between harvest and treatment, fruit temperatures before and after treatment, and the density of the fruit load in the treatment room all can play a role in fruit response to SmartFresh.

The motivation for this project was to increase distant foreign markets by being able to ship Bartlett pears long distances without ripening and upon successful arrival of these shipments have the pears ripen properly at the retail outlet.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activities in grant year 1:

1. Determine the influence of pre and post-treatment temperature exposure on Bartlett pear response to SmartFresh.
2. Determine the effect of the presence of ethylene gas during SmartFresh treatment on pear fruit response.
3. Explore the influence of exposure to ethylene gas after harvest on the response of Bartlett pears to SmartFresh.
4. Establish the relationship between fruit maturity and the accumulation of ethylene in treatment chambers.
5. Determine the influence of ethylene concentrations during SmartFresh exposure on the capacity of 1-MCP to delay ripening of fruit of different harvest maturity.

This year 1 research showed that fine tuning the ethylene concentration and temperature during treatment together with fruit temperature during storage or transport to final markets after treatment is important to assure beneficial effects. Additional findings highlighted the competitive nature of 1-MCP and ethylene for regulating ripening of Bartlett pears and underscore the importance of monitoring ethylene concentrations in treatment rooms before applying SmartFresh. Trials indicated that a relatively high ratio of 1-MCP to ethylene (50:1) is required to provide maximum ripening inhibition.

Activities in grant year 2:

1. Determine the relationship between harvest maturity and ethylene production rates to identify fruit at risk of not responded to SmartFresh.
2. Determine the relationship between fruit ethylene production and/or internal ethylene concentration at harvest with ripening capacity.
3. Identify and analyze the most promising candidate genes as markers of fruit ripening capacity.

Early-, mid- and late season Bartlett fruit ripened rapidly and uniformly in response to a 24-hour exposure to 100ppm ethylene after harvest, reaching a eating firmness of 3 lbs. in six days a 68° F. Pre-treatment with 600 ppb 1-MCP for 24 hours at 32° F, the current recommended dose for European pears, reduced the sensitivity of the fruit to ethylene to varying degrees depending on the harvest maturity and harvest date. For pears sourced from the Sacramento River packinghouse, pre-treatment with 600 ppb 1-MCP extended the shelf-life (time to eating firmness) of fruit by 15 days for all three harvest maturity stages. For fruit obtained from the Lake County packinghouse, 1-MCP treatment extended the shelf life for early-, mid-, and late-season pears by 18, 15, and 12 days. Increasing the 1-MCP concentration from 600 ppb to 2000 ppb did not confer additional benefits for the fruit and indicates that 600ppb 1-MCP was a saturating dose. Findings indicate that ripening capacity in Bartlett pears develops gradually from 1-2 weeks before first commercial harvest. While there was a general association between several standard harvest maturity indices (e.g. flesh firmness, soluble solids, and internal ethylene concentration) and ripening capacity, it is not clear if these indicators could be used to consistently predict ripening behavior. Using an alternative approach employing modern molecular tools, 9,085 cDNA sequence fragments were isolated that increased during the induction of ripening capacity.

Activities in year 3:

1. Determine the potential to predict ethylene competition and identify optimal SmartFresh™ treatments to reliably extend the shelf life of 'Bartlett' pears.
2. Identify promising candidate genes as markers of fruit ripening capacity.
3. Determine the relative changes in gene expression to help select the best candidates to predict ripening capacity.
4. Determine the reliability of candidate genes to predict ripening capacity in fruit from different districts and in response to postharvest treatments.

These Year 3 activities are in progress at the time of this writing. The California Bartlett harvest was just completed the week ending August 31, 2012. For example, the late harvested Bartletts from Lake County were brought into the lab at the beginning of last week.

There was interaction with the Research Director of CPAB and the contractor on a frequent basis, especially during the summer and fall months when the experiments were taking place. The CPAB Research Committee met twice per year to review progress, make suggestions and to recommend funding the following year's matching contribution from the Board. Each year a Pear Postharvest Review meeting was held to inform pear grower packer-shippers and their sales desks of this project's progress.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
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Activities: Contractor designed a laboratory research program that maximized the range of experiments needed to identify a successful 1-MCP treatment under varying California conditions. Pears were collected from a shipper in the Sacrament River district and a shipper in the Lake County district. Early, mid and late season Bartletts were collected from each growing district representing three samples each year. The experiments took place under controlled conditions in the pomology lab at UC Davis. Fruit for each sample were arranged in a randomized block design during treatment, storage and shelf life evaluation. Four replicate boxes containing fruit were used for each treatment. Six fruit were removed at random from every box at each sampling time for firmness and color evaluation.

In year two, successful shipments of 1-MCP treated Bartletts were actually made to Brazil, Eastern Russia and India. This is a year in advance of the predicted grant third year shipment to these markets. Personal on-site follow through by the shippers indicated the buyers were happy with the condition of the pears on arrival and the pears ripened properly.

Baseline data example:

Table 4. Ethylene concentrations (ppm) inside treatment chambers at the beginning and end of 24-hour 1-MCP (SmartFresh) and ethylene combination treatments at 32 °F. Chambers contained fruit obtained at different maturity stages from a packinghouse near Lakeport, CA.

Treatment	Early-season		Mid-season		Late-season	
	Beginning	End	Beginning	End	Beginning	End
Control	0.000	0.084	0.000	0.072	0.009	0.256
SF alone	0.000	0.038	0.000	0.071	0.009	0.418
50 SF:1C_2H_4	0.011	0.082	0.013	0.101	0.020	0.727
20 SF:1C_2H_4	0.028	0.148	0.034	0.090	0.037	0.175
10 SF:1C_2H_4	0.057	0.101	0.058	0.180	0.068	0.649
1 SF:1C_2H_4	0.489	0.800	0.621	1.095	0.632	1.135

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

California pear growers and shippers benefited from the completion of this project's accomplishments. Being able to ship to distant markets provides the pear industry with additional markets that would otherwise be unavailable due to distance and the ability of the fruit to remain firm during transportation and arrival. Also, these distant markets lack adequate port and refrigeration facilities, which without 1-MCP treatment as experience have shown, would contribute to 'bad arrivals'. Given the pear industry's fresh market inelasticity (domestic market saturation), these new markets will contribute to the pear industry's profitability.

The quantitative data that concerns the beneficiaries was developed by the contractor. Specifically, the effects of ethylene concentration at different stages of harvest in different pear growing locations as it relates to the effectiveness of 1-MCP treatment.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Lessons learned are that pear shippers, through the results of this project, were able to gain the confidence to ship valuable produce (pears) long distances to new markets with reasonable certainty of good arrivals that would progress through the supply chain to retailers and ultimately consumers.

Unexpected outcome:
Given the understanding that ethylene is a ripening enhancer and 1-MCP is an ethylene inhibitor, it is somewhat of a surprise that such a small amount (parts per billion) of ethylene present in the pear can negate the effects of 1-MCP.

CPAB believes the goals of the project have been achieved and will be able to provide pear shippers with a protocol for 1-MCP pear treatment under different seasonal conditions.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

None.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 23	**Project Title:** Export Training for Specialty Crops	
Grant Recipient: Center for International Trade Development, State Center Community College District	**Grant Agreement No:** SCB09015	**Date Submitted:** December 2012
Recipient Contact: Candy Hansen-Gage	**Telephone:** (559) 324-6401	**Email:** candy.hansen-gage@scccd.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The future of California specialty crop producers depends largely on a well-trained workforce that can compete internationally. Currently, 25% to 30% of California's agricultural output is sold overseas; in some cases (like almonds) more than 60% of the crop is exported. As a result of State budget issues, two State entities of the California Department of Food and Agriculture (CDFA) that assisted California companies in export endeavors were closed, leaving a void at the State level, i.e. no comprehensive agricultural training program exists. As incomes rise in developing countries, demand for high-valued specialty crops also rises. But without the "human capital" to take advantage of these opportunities, California specialty crops will suffer internationally. This project increased the supply of well-trained personnel who are able to market, sell and ship high-valued California specialty crops internationally, through statewide training that focuses on the specific requirements of specialty crops: maintaining freshness, quality, cold chain, phytosanitary regulations, etc.

The Fresno Center for International Trade Development (CITD), working together with its numerous partners, addressed the following identified needs of California's specialty crop industries through customized training and counseling: 1) small business export training, counseling and assistance for specialty crop producers; 2) greater export readiness and increased trade awareness; 3) breaking down barriers facing future export markets and the high cost of developing these markets; and 4) the inability to locate buyers, distributors and importers. Utilizing its experience in training new exporters, combined with its connections throughout both California's educational system and agricultural industry, CITD conducted a program that developed new exporters of specialty crops, while increasing the skill level of both current and new to export companies, along with activities designed to introduce these new exporters to foreign buyers through outbound and inbound trade missions.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Year 1 Activities and Tasks Performed:

- Developed a 6 Session export training program for CA specialty crop producers called the CalAgX (Oct – Dec 2009);
- Conducted marketing and recruitment for CalAgX training statewide (Jan – Mar 2010);
- Secured host training sites and trainers (Jan – Feb 2010);
- Hosted CalAgX training in Sacramento, Clovis and San Luis Obispo, CA (Apr – Jun 2010) with 26 companies completed training;
- Developed 8 customized market entry plans for specialty crop companies (May-Jul 2010);
- Assembled Advisory group and developed strategic plan to accomplish project goals and review progress (Apr 2010);
- CITD hosted an Ag Trade Roundtable in Monterey (Apr 2010) and 2 Focus Groups in San Francisco and Fresno (June 2010);
- Hosted Branded Program Seminars in Los Angeles and San Francisco (Jul 2010) for 24 companies

Year 2 Activities and Tasks Performed:

- Hosted 4 inbound buying missions to California that focused on Specialty Crops – China Produce Buying Mission (Oct 11-13, 2010), Taiwan Produce Buying Mission (Oct 19-22, 2010), European Specialty Crop Trade Mission (Feb 8-12, 2011), and Longos Canadian Retail Buying Mission (Jul 11-14, 2011).
- Conducted marketing and recruitment for CalAgX training statewide (Nov 2010 – Feb 2011);
- Secured host training sites and trainers (Oct – Dec 2010);
- Hosted CalAgX training in Napa and Clovis, CA (Mar – May 2011) with 33 companies completed training;
- Developed 11 customized market entry plans for specialty crop companies (May-Jul 2011);
- Hosted Branded Program Seminars in Los Angeles and San Francisco (Jul 2011) for 31 companies;
- CITD participated in Ag Roundtable in Sacramento (Aug 18, 2011) U.S. Trade Representatives Ambassador Kirk and Ambassador Siddiqui (Special Invitation)

Year 3 Activities and Tasks Performed:

- Hosted 1 inbound buying missions and 1 outbound buying mission focused on Specialty Crops – Taiwan Produce Buying Mission (Oct 17-21, 2011), and Agricultural Trade Mission to China and Korea (Jun 10-16, 2012).
- Conducted marketing and recruitment for CalAgX training statewide (Oct 2011 – Feb 2012);
- Secured host training sites and trainers (Oct – Dec 2011);
- Hosted CalAgX training in Oakland, Clovis and Camarillo, CA (Mar – May 2012) with 39 companies completed training;
- Developed 15 customized market entry plans for specialty crop companies (May-Jul 2011) and an additional 26 customized market research reports for specialty crop companies participating in CITD trade missions (Apr – Jun 2012);
- Hosted Branded Program Seminars in Los Angeles and San Francisco (Jul 2011) for 31 companies

Contribution/Role:

- **Outreach:** Partners from CDFA, USDA Foreign Ag Service, Agricultural Trade Offices, California Agricultural Export Council (CAEC), Ports of Oakland and Los Angeles, and several Commodity Groups provided significant outreach to overseas buyers and California exporters for trade missions and recruitment for CalAgX.
- **Training:** Partners from CDFA, CAEC, Ports of Oakland and Los Angeles, and several Commodity Groups provided input into training curriculum.
- **2010-12 Host Sites:** Sacramento CITD, San Luis Obispo County Farm Bureau, Napa County Farm Bureau, and the Ports of Oakland and Los Angeles.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Activities completed in order to achieve performance goals and measurable outcomes for the project are summarized under the Project Approach section. Baseline for all Goals was 0.

Goal 1: *The export training of specialty crop growers, processors and marketers.*

GOALS	Year 1	Year 2	Year 3
Target	25	35	40
Actual	26	33	39

Goal 2: *Working with participating companies to develop and implement 75 market-entry plans.*

GOALS	Year 1	Year 2	Year 3
Target	19	26	30
Actual	8	11	41

GOAL 3: *Enroll 75 qualified companies in WUSATA Branded Program.*

GOALS	Year 1	Year 2	Year 3
Target	25	25	25
Actual	24	31	45

Goal 4: *Increase overall export sales of participants by $4.5 million over 3 years.*

GOALS	Year 1	Year 2	Year 3
Target	$750,000	$1.5 million	$2.25 million
Direct Sales	$959,888	$214,500	$1,965,000
Indirect Sales	$11,052,000	$14,500,00	$7,617,940

Direct sales result from missions/promotions CITD facilitated; indirect sales resulted from specialty crop companies that completed CITD export training, and CITD mentored and marketed these companies to participate in additional trade shows/missions that the CITD supports through its partnerships.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The eligibility criteria for the program favored those companies that are "new-to-export," that is those that either previously did not export, or had limited export experience with the goal of turning them into exporters. Thus, this project brought new sales to the California specialty crop industry through the efforts of the 100+ qualified companies participating in this program as sales expand into new markets (rather than merely gaining market share at the expense of other California producers). Indirectly the project benefitted a much larger share of California's specialty crop industries, as new markets developed overseas, the increase in overall demand raised the general price received by all producers.

Using the Fresno CITD's past 20 years of experience and success as a baseline indicator, expected outcome for participants was the generation of a minimum of $4.5 million in new export sales of specialty crops over the term of the project, which is a 900% return on investment for the specialty crop industry and California. As reported by the U.S. Department of Commerce, for every $1 billion in export sales, 22,000 jobs are created and/or sustained. According to this model, our target goal of $4.5 million in new export sales will correspond to 99 jobs created and/or sustained.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

- **Partner Selection:** When it comes to recruitment of participants for training or trade missions, partnering with organizations that have a vested interest in target group increases success. For example, a CITD or Farm Bureau that doesn't specialize in working with potential ag exporters will give minimal effort, but organizations like Specialty Crop Trade Council or the Ports, have a vested interest in seeing their members succeed or more exports flow through their Port, so they dedicate time to this endeavor.
- **Compound Sales:** During this project, a lot of its success is measured by the export sales generated. Most companies that participated in the export training programs don't immediately jump into exporting, with exceptions. They generally take an additional year or two to slowly "test the water" and build confidence. Once companies do start participating in the CITD or other sponsored trade missions and activities, CITD documents initial sales and follow-ups with participants typically up to 6 months to record developed sales. One thing CITD does not take into consideration is the additional sales contracts that are developed over the subsequent years as a business relationship is formed between buyer and seller. The initial return on investment for this project reported here does not reflect the long-term exponential growth in sales that will take place solely due to the company's initial participation in this project.

- **Company Synergy:** CITD witnessed a lot of synergy develop between experienced and newer exporters. Many attendees developed business arrangements and partnerships. For example, Koos Foods now represents Gold River in Korea.

The CITD had the following unexpected outcomes:

- **75 Market-entry Plans:** Most companies chose not to participate in the development of market-entry plans; the most common reason was that they did not have time to work with CITD staff in that it was their busiest time of year. To overcome this challenge, the CITD gave the companies the option to have customized market research done for 1 product to 1 country. This change increased the plans/research done in year 2, but still significantly below projected. In year 3, CITD added the option for companies participating in specialty crop trade missions to have customized market research done prior to the mission, and this significantly increased the amount of research performed.
- **Branded Program:** An additional benefit to marketing efforts and hosting of the Branded Program, in partnership with the Western United States Agricultural Trade Association, is the number of California companies that actually apply for Market Access Program (MAP) funding through the Branded Program. CITD targeted 25 companies per year to participate in the Branded workshops, but learned that companies did not have to attend the workshops to be eligible to apply for these funds. During year 2, CITD began tracking the number of California companies that applied for MAP funding. Year 2 had 51 California Specialty Crop companies apply, and Year 3 has 52 California Specialty Crop companies apply so far.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

- Attachent A – Copy of the www.fresnocitd.org website, specifically the CalAgX home page.
- Attachment B – Copy of the CalAgX 2012 brochure, application questions (it is an online application), and Commitment Letter.
- Attachment C – Copy of a participate Authorization Statement and a Customized Market Research Report.
- Attachment D – Copy of the e-blast marketing the WUSATA Branded Program Seminars, and a copy of the Los Angeles Branded flyer.
- Attachment E – Copy of the Specialty Crop Trade Mission to China & South Korea flyer, and Mission Evaluation and Contribution form.

Project 24 - Buy California Marketing Agreement (BCMA)

Final Performance Report

Project Title
California Grown Marketing in Japan

Project Summary
The purpose of the project was to continue to increase awareness levels and decrease concerns about food safety of California specialty crops in Japan. Despite Japan being California's third largest market for agricultural goods ($957 million in 2007), California specialty crops face many marketing constraints in Japan, specifically the all-too frequent negative media coverage of the quality and safety of United States agricultural products. As a result, in 2006, the BCMA developed a "California Grown" marketing and Public Relations (PR) campaign designed to create an umbrella program to address these constraints through funding from the United States Department of Agriculture's Market Access Program Global Broad-based Initiative. This program was built on the excitement generated by Governor Schwarzenegger's visit to Japan in 2004. After successfully conducting an array of media and consumer outreach activities, the program ended in 2008, limited to three years of funding.

By continuing to build on this momentum, this Specialty Crop Block Grant Program (SCBGP) project helped continue to increase California specialty crops exports to Japan by increasing awareness levels and decreasing in concerns about food safety of California products.

Project Approach
The following major activities were performed during the grant period:

Public Relations Activities
Point of Sales (POS) Materials and Merchandising Manual: Governor Schwarzenegger remains a popular figure in Japan; therefore, a merchandising manual and POS materials with the Governor's likeness were designed and produced for this project. The materials were used for in-store promotions and PR activities.

Press Releases and Trade Interview
The BCMA distributed six press releases announcing the inauguration of the campaign and activity/event results throughout the project. While not part of the initial project plan, BCMA took advantage of Secretary A.G. Kawamura's, California Department of Food and Agriculture (CDFA) visit to Japan for some additional exposure highlighting California agricultural products. As a result, BCMA secured two press interviews in Tokyo.

Press Tasting Event at MLB Cafe Tokyo
A press tasting event was held in June 2010 to increase media awareness of the California Grown campaign and introduce products from California. A group of Vegetable Sommeliers, fruit and vegetable specialists endorsed by the Japan Vegetable and Fruit Meister Association, was also invited to help promote the high quality and freshness of California grown products. A total of 48 people participated in the event.

Joint Cooking Class with California Travel and Tourism Commission (CTTC)
For further exposure, BCMA worked with the CTTC to jointly promote California food and tourism. This included BCMA's online recipe contest and cooking lesson with Chef Ema Koeda. Chef Ema developed three recipes for the cooking class and provided a demonstration on how to prepare these dishes. A total of 39 participants were invited to cook alongside Chef Ema.

Recipe Contest
The BCMA along with Recipe Blog (a major portal recipe site) and CTTC, co-hosted a recipe contest to encourage consumers to develop their own recipes using California grown products. The contest required participants to create an appetizer, main dish or dessert inspired by the "Ten Travel Themes" or "District and City Information" presented by the CTTC. BCMA received a total of 220 recipes, surpassing the target of 200 recipes. The grand prize winner received a "California Food and Wine Gourmet Tour" sponsored by Hankyu Travel Agency.

Media Tie-in
The BCMA placed an advertorial on recipes using California grown products in Ryori Tsushin, a monthly gourmet magazine with a circulation of 50,000. The objective was to further increase exposure of California grown products and California food culture. BCMA partnered with Chef Kikuchi to develop recipes using California grown products. Given that Chef Kikuchi previously lived in California, he was able to develop recipes that incorporated California cuisine into the Japanese culture.

In-store Promotions
The BCMA produced merchandising manuals and POS materials with Governor Schwarzenegger's image for use during the in-store promotions. While the goal was to conduct at least two large in-store promotions, BCMA was able to secure a total of three in-store promotions in 2010. Total sales during the promotions reached approximately ¥320,567,000 (US$3.93 million).

Daiei - Number of outlets: 150 stores (national) Period: May 17 through June 27 Items: cherry, orange, prune, walnut and almond Total sales: $3.04 million	Tokyu Store - Number of outlets: 96 stores (Tokyo and Kanagawa prefecture) Period: May 29 through June 1 Items: cherry, orange, lemon, asparagus, broccoli, raisin, prune, walnut, almond and wine Total sales: $891,343	Kansai Supermarket - Number of outlets: 20 stores (Hyogo and Osaka prefecture) Period: November 30 Items: table grapes, strawberries and pomegranates Total sales: $8,487

Bryant Christie, Incorporated (BCI) provided overall management of activities and events associated with this project. Specifically, BCI managed Uniflex Marketing, BCMA's in-country representative, and coordinated all program communications between BCMA, Uniflex Marketing, CDFA and participating groups.

Goals and Outcomes Achieved
All goals according to the work plan for this project were met. Please see Project Approach section for details of the actual accomplishments.

The first consumer survey was carried out at the beginning of the project to set benchmarks and ensure BCMA's strategic marketing plan and activities were appropriate. The second consumer survey was carried out at the end of the project to measure the effectiveness of the project. Based on the results of the survey, BCMA achieved its goal of increasing consumer awareness and positive perception of California specialty crops. Benchmarks and results were as follows:

Performance Measure	**Baseline**	**Target**	**Actual Results**
Percent of respondents knew that California produce is imported into Japan	60%	65%	65%
Percent of respondents showed intention to purchase California produce	31%	35%	36%
Percent of respondents indicated a positive perception (high quality, nutritious, freshness) of produce from California	30%	35%	42%

Source: Online survey targeting the Tokyo metropolitan and Osaka areas; n = 200

Beneficiaries
The following California specialty crops benefited from the completion of this project's accomplishments: cherry, citrus, prune, walnut, almond, lemon, asparagus, broccoli, raisin, table grapes, strawberries and pomegranate. Total sales of the specialty crop products listed above during the California Grown in-store promotions reached approximately $3.93 million. This would not have been achieved without the funding from the SCBGP.

Lessons Learned
The major challenge the project initially faced was the limited availability of the California products carried by the specific targeted retailers in Japan. However, with the use of the SCBGP funds, BCMA was able to provide support to the retailers to carry out "California Grown" promotions. In addition to promoting California products, some retailers actually increased the number of California products to sell during the promotions.

Contact Person
Name the Contact Person for the Project: Maile Shanahan Geis
Telephone Number: (916) 441-5302
Email Address: maile@californiagrown.org

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 25	**Project Title:** Improving Long-Term Sales and Competitiveness of Monterey Area Winegrape Growers	
Grant Recipient: Monterey County Vintners and Growers Association	**Grant Agreement No:** SCB09022	**Date Submitted:** December 2012
Recipient Contact: Rhonda Motil	**Telephone:** 831.375.9400	**Email:** rmotil@montereywines.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The concept of this project evolved when documented research shows a lack of awareness of Monterey's fine AVA (American Viticultural Area) labeled wines. Contributing data showed that as a result, about 70% of the region's winegrapes were being sold as low-margin bulk grapes or juice to commercial out-of-area wineries. Those low margin markets challenge the sustainability of Monterey County's independent grower-vintners' operations. In addition, a 2006 feasibility study also showed that there was an opportunity of a 15+% premium to growers for Monterey grapes, when used in AVA-labeled wines.

The Monterey County Vintners and Growers Association (MCVGA) knew that by demonstrating and promoting Monterey wines' unique qualities to key stakeholders, which included media, targeted buyers, and consumers, the Association would be able to increase the sales of high-margin AVA labeled wines and increase name recognition of Monterey County as a winegrowing region. The project was timely, as vineyards were being established throughout the region by both existing and new grower-vintner operations that saw the potential of the region, the proliferation of new technology tools to access information via web based outlets was on the rise, and the competitiveness for shelf space among international brands continued to increase.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

A detailed workplan was developed and followed in order to guarantee success for the project. The stages within the workplan were outlined under nine major activity categories:

(1) **Planning –** Grower-vintner members were contacted and recommendations were finalized for firms to be solicited for bids on all elements of the project. All vendors/partners were selected within the expected timelines.

(2) **Design, proofing and printing of an American Viticultural Area (AVA) Map –** A thorough AVA map was produced that included the vineyards within Monterey County's nine AVAs and the new branding/copy points as identified in the above planning stage. The map was posted online and developed as a print piece. All deadlines were met. Over 250 media and trade professionals received the map in a targeted PR (public relations) campaign. Sales representatives at a variety of winery-vintner operations began to use the map as a sales tool within their portfolio presentations to wine buyers and distributors.

(3) **Grape sourcing from the 2010 Monterey County harvest for specialty crop grapes to be used in the Monterey County Signature Series Wine Collection –** Three vineyards within each of the four selected Monterey County AVAs were chosen to provide grapes for the ultimate blending of the Signature Series Wine Collection. It was collaboratively determined that the two varietals that represent over half of the acreage in Monterey, Chardonnay and Pinot Noir, would be used for this unique Signature Series Wine Collection. Vintners who would produce the wine were also selected.

(4) **Video filming, production, and posting of new Monterey County viticulture videos –** The video firm who was selected filmed the workplan specified events and viticulture footage, and then distributed the videos to relevant content partners with high Internet traffic. Due to this extensive reach, the videos led to over 210,000 impressions.

(5) **Winemaking, bottling, and labeling of the Signature Series Wine Collection –** The labels for the Collection were designed and printed, and all supporting materials such as bottles, corks, and foils were procured. Participating winemakers collaborated on the blending, bottling, transportation, and storage elements for the production of the wine. In regards to "unusual developments" this is the area where the most "lessons learned" were acquired. While the wines were not conceived as a product "for sale" and were for educational purposes, federal and state requirements pertaining to bottling (acquiring a dba – doing business as), getting labels approved, paying taxes, etc. were still industry requirements that needed to be, and were, adhered to. This contributed to additional time and costs associated with the product. However, the delivery of 440 cases of high quality wine was achieved.

(6) **Material design to compliment the release of the Signature Series Wine Collection –** Graphics, photography and text that describe the region and the wines were developed to engage the audience in a better understanding of the specialty crop, the region, and the Signature Series Wine Collection.

(7) **Promotion and distribution of a comprehensive public relations campaign to launch the new tools and Signature Series Wines –** Public relations press releases, media contacts, and promotions were executed to announce the deliverables and wines.

(8) **Wine launch of the Signature Series Wine Collection –** 440 cases were labeled and packaged.

(9) **Program evaluation –** Metric analysis was completed on name recognition, acreage and grape value statistics, increases in web traffic and volume of media references.

Contributions/Roles of Project Partners: The 14 elected Board of Director members had an active role at monthly Monterey County Vintners & Growers Association meetings to review progress and provide input and direction on the project. The Grape Grower Chair facilitated logistics for the Signature Series Wine Collection. Key vendors, such as Kelly Bobbitt, Moosepoint, Zumablue, Parker Sanpei & Associates, VESTRA, Earley & Earley, and Innovative Solutions delivered on time and according to specifications. In-kind consulting and service guidance was provided by professional experts Paul Novak, Michael Marcus, and Kevin Cahill. Local stakeholder groups including the Agriculture Commissioner's Office, the Visitors Bureau, and the Business Council provided independent study data for performance evaluation. Vintner members actively shared sales data.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

GOAL 1: *Increase sales of Monterey AVA wines. The benchmark was that approximately 30% of Monterey winegrapes were going to AVA bottles, per a commissioned study. The target was that growers-vintners within the region would experience a collective 10% increase in Monterey AVA wines.*

A sampling of over 20% of the winery membership indicated that all members experienced or exceeded this growth. Such examples included:

- Brand 1: Case sales of 67,236 (January 2009 through August 2009) increased to 124,294 from (January 2012 through August 2012).
- Brand 2: Monterey Cabernet grew 28% to 25,500 cases and Pinot Noir grew 9% to 35,000.
- Brand 3: Over 12% growth, year over year, since 2009.
- Brand 4: Chardonnay grew by 365%, Pinot Noir by 87% and Sauvignon Blanc grew by 208%. As a result of this success across varietals and tiers, another label was launched, with a Monterey AVA, that is distributed nationwide and in such major outlets as BevMo.
- Brand 5: Leading varietal of Monterey Chardonnay increased from 159,868 cases in 2009 to 328,724 cases in 2011. In 2012, this brand is on track to sell approximately 350,000 cases of Monterey AVA Chardonnay.

GOAL 2: *Increase consumer awareness. The benchmark was that consumer recognition was at a mere 3% for recognizing Monterey as a wine region or wine destination. The target was an increase to 6% name recognition.*

This was easily surpassed in two independent studies. According to recent Monterey County Convention & Visitors Bureau (CVB) Research, 170 out of every 1000 Monterey visitors were aware of, and participated in wine tasting in 2009. In 2011, this increased to 210 out of every 1000 visitors. This is an increase of 23%, or 40 visitors for every 1000. That same report indicated that wine was a 46.5% influence in their decision to visit Monterey.

In a second independent survey conducted in 2012, 33.8% of the respondents recognized Monterey as an area for winegrowing. This was a survey with 185 respondents, across the U.S., with the only demographic requirement that they were over the age of 21.

GOAL 3: *Increased media coverage. The benchmark was to begin to track media references and value through the length of the grant. A key target was to have the Signature Series wines release referenced in at least 25 media outlets. The performance measure was through the BurrellesLuce clipping service.*

Burrelles and PR Newswire reported that over 280 outlets picked up the story and reported on the Signature Series Wine Collection. In another metric, utilizing an independent comparison via BurrellsLuce, the MCVGA more than tripled the number of impressions in media outlets. In 2010, MCVGA acquired 277,228,390 impressions. In 2011, this number jumped to 857,896,236. Media value of the referenced articles in 2011 was tracked at $1.89M, a new metric for future measurements.

GOAL 4: *Increased traffic to the website. The benchmark was that there was an average of 9,250 visits per month. The target by the end of the project was to increase unique visitors by 25%. This would be measured by web hits.*

The methods for how people obtained information that they were seeking changed considerably from when the grant was proposed. This resulted in favorable results for the project, as more and more people utilized the web, channels such as Facebook, and mobile applications to acquire information. The independent data figures of webhosting company, Bluehost, shows that unique visitors to the MontereyWines.org website increased by 220% and the total number of visitors increased 238% from December 2010 to July 2012. Utilizing Google figures, there has been an overall increase in all top level categories, as well as new visitors (at an average rate of 75%) from July 2011 to July 2012.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Over 80 vintner-grower operations within Monterey County, as well as additional brands who procure grapes from Monterey County, and who opt to label as such, reaped the benefits from this project. In addition, according to the Monterey County Agriculture Commissioner's Office, a cooperating entity for the project, the newly developed 2012 Economic Report showed that the overall economic impact of Monterey grapes to the County is over $632M. This is a new metric to be monitored and evaluated.

The volume of Monterey County tasting rooms also increased by 40% over the past two years, leading to increased economic opportunities for complimentary establishments who attract guests who are visiting and purchasing Monterey wines. This is particularly impactful for the 3.3 million guests who visited Monterey County in 2011 and were seeking sources of entertainment during their stay.

While the Monterey County viticulture industry was not immune to the economic downturn impacting most businesses throughout this grant period, the June 2012 Monterey County Agriculture Crop Report release, utilizing data from the 2011 crop, showed healthy average price per ton gains across varietals within Monterey County. Of the top five red varietals from Monterey County, all five experienced an increase in the price per ton of Monterey County specialty crop grapes. The most aggressive gain was in the area of Pinot Noir, also one of the Monterey County Signature Series Wine varietals, which showed an increase of $283/ton from 2010 to 2011. Of the top five white varietals from Monterey County, four of the five experienced an increase in the price per ton of Monterey County specialty crop grapes. Chardonnay, the second Monterey County Signature Series Wine varietal and the varietal with the most acreage in Monterey County had an increase of $166/ton from 2010 to 2011.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The MCVGA and the members clearly learned the value of collaborative efforts, high quality tools, the usage of technology and social medium, and the importance of building brand identity in order to grow the awareness of the region and increase the value of Monterey County AVA labeled wines.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Not Applicable

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM

FINAL PERFORMANCE REPORT

USDA Project No.: 26	**Project Title:** California First: Spotlight on California Wine Regions	
Grant Recipient: Wine Institute	**Grant Agreement No.:** SCB09027	**Date Submitted:** December 2012
Recipient Contact: Nancy Light	**Telephone:** 415-356-7520	**Email:** nlight@wineinstitute.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The California (CA) First project, initiated by Wine Institute (WI) and its grower counterpart, the California Association of Winegrape Growers (CAWG), was intended to enhance the ability of CA's vintners and growers to maintain and grow trade and consumer awareness and sales in a highly competitive U.S. wine market. California produces 90% of U.S. wine but has been experiencing a declining share of an expanding U.S. market, which became the world's largest wine market by volume in 2010. California producers face growing competition here from traditional (France, Italy, Spain) and emerging (Australia, Chile, Argentina) winegrowing countries around the world, most receiving significant government subsidies to market to U.S. consumers. For example, Bordeaux, just one of many wine-producing regions of France, announced plans to spend $4 million in 2012 to market to U.S. consumers. Additionally, research continues to show that the incoming generation of wine consumers, "millennials," has less loyalty to California-produced wines than previous generations.

CA First created a statewide "umbrella" promotional campaign for California wine that communicates the diversity of the state's wine regions to create a compelling and differentiating message for California wine. The campaign leveraged the efforts of regional winery and grower organizations around the state and those of individual wineries and growers to create coordinated statewide marketing events, such as California Wine Month in September, publicity programs and tools (brochures, websites, social media accounts and videos) with appeal to wine consumers, especially millennials. The CA First project also made it possible to provide market intelligence to the California vintners and growers by conducting research with sommeliers, key members of the trade, in the trend-setting markets of New York and California. Research and recommendations were shared at a series of workshops around the state where sessions on creating marketing messages, utilizing social media for marketing and working collectively as a region and state, were also presented to improve the overall marketing skills and performance of the industry.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Industry Survey: The project was initiated in March 2010 with an on-line survey of 36 regional winery and grower associations throughout the state (22 responded) to assess marketing needs and expertise in order to determine priorities for the program activities and workshops.

Trade Research: WI conducted focus group research in 2010 (CA – 5 cities/25 participants) and 2011 (New York City – 24 participants) in these two key U.S. markets with sommeliers in trend-setting restaurants as a baseline for identifying and addressing impediments to trade support of CA wines. Findings were shared at workshops for vintners and growers and also used as a basis for planning our trade tasting events for California Wine Month and development of marketing tools.

Workshops: WI conducted best practices workshops in May 2010 (Paso Robles, Lodi, Sonoma) attended by 150 wineries and growers and 2011(Napa, Monterey, SF/Sacramento) attended by 174 vintners and growers presenting on regional marketing survey, results of the CA and NY trade focus groups, California Wine Month, creating a winery/vineyard message and social media. Information was also shared through WI and CAWG outreach to the industry.

Tools: WI and CAWG created numerous promotional tools, geared to millennial consumers, to improve awareness of CA wine regions. These included: A 56-page color "Discover CA Wines" brochure with in-depth text and photos on wines and regions and a detailed map of 100+ CA American Viticulture Areas which was widely shared with trade, media and regions, wineries and growers for distribution; an upgraded consumer website www.discovercaliforniawines.com, which increased regional pages to 33 from 13 on WI's previous website, and new social media accounts on Facebook "California Wines" and Twitter @CalifWines_US, launched in 2011. WI also produced "California Wines Road Trip" the first in a series of California wine videos that is being promoted through WI's website, social media accounts and publicity. A CA Wines PowerPoint presentation is also in development and will be provided to regions, wineries and vintners for education/presentation use.

Statewide Promotions: The statewide celebrations of California Wine Month (CWM) in September engaged wineries, growers, regional wine associations, retailers and restaurateurs to highlight CA wines throughout the month. In addition to engaging consumers through dozens of winery events and in-store promotions reaching more than 2000 U.S. outlets, WI and CAWG hosted multi-region tastings in 2010 attended by 190 wine trade and 59 media in SF and 112 trade and 34 media in LA. Events featured 15 CA wines regions, 80 vintners, growers and regional staff and 150 wines. In 2011, events in New York were attended by 150 trade and media and by 200 consumers, trade and media in SF. Education seminars and trade-hosted tables at these events contributed to trade and media improvement in CA wine knowledge based on event surveys. A favorable development was introduction of a second statewide program, Down to Earth Month, in April 2012 to highlight the sustainable practices of the state's growers and vintners. Additionally, the regional focus of this program enhanced the ability to collaborate with Visit California, the CA tourism entity, on media and consumer outreach programs.

Management: The project was managed by Wine Institute with CAWG providing staff and $ support.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Enhancing Industry Marketing Skills: A goal of the CA First project was to enhance winery, grower and regional association marketing skills which was accomplished by hosting marketing workshops, described above, in each year of the grant and sharing information through WI and CAWG newsletters, membership meetings and publications, including guides to Facebook and Social Media, reaching thousands of industry members. Post workshop/webinar surveys of attendees showed a significant (10%+) improvement in knowledge of topics/skills covered which was reinforced in direct feedback from industry members.

Creating/Updating Statewide Promotions Tools: The CA First grant helped to fund production of a collection of promotional tools that allow the CA industry to communicate with a collective voice and message about its unique attributes, especially the diversity of wine regions. WI/CAWG directly distributed 2500+ brochures to trade and media. WI's new consumer website www.discovercaliforniawines.com, launched in December 2011, has reached an audience 3881 unique monthly views, 70 percent new visitors and WI continues to promote and track visits to region sections. The new social media accounts on Facebook "California Wines" and Twitter @CalifWines_US, launched in July 2011 have attracted 642 likes/4048 weekly reach and 762 followers, respectively and continue to build audience. Equally important, these new tools allow project staff to share and promote information about CA regions, winery and grower activities and statewide promotions, CA Wine Month and Down to Earth Month, http://www.discovercaliforniawines.com/californiawinemonth/. The new video "California Wines Road Trip" has reached 2700 YouTube views in the first month of release www.discovercaliforniawines.com/roadtrip.

Increasing Trade & Media Knowledge: Increasing knowledge of CA wine regions among the wine trade (restaurant buyers/sommeliers/retailers) and media, both powerful influences on consumer choice in the wine category, was a key objective of the program. The CWM regional tasting events held each year of the project provided an opportunity for direct trade and media education and seminars aimed at addressing issues identified in focus group research. Post event surveys conducted following trade and media seminars/events confirmed that these activities enhanced the knowledge of the diversity of CA wines and regions with attendees providing a rating of 4.5 on a five point scale. Another key measure of increased media knowledge was publicity – stories in print, broadcast and on-line media generated by CWM and program activities. 2010 publicity reached 97 million consumer impressions in 2010, 50% more than the previous year and 200 million consumer impressions in 2011, more than doubling media coverage over the previous year.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The state's 3600 wineries and 4600 growers were key beneficiaries of the program both individually and collectively as members of 20+ regional winery and grower associations throughout the state that engage in marketing activities and as members of WI and CAWG. Direct participation in the annual CA Wine Month statewide promotion by 17 regional groups and hundreds of wineries and growers show that industry saw value in the activities both for their businesses and for CA wine as a whole. Additionally, regional associations participated in matching funds grants to host regional consumer events in SF and LA during CWM 2010 and to host a live remote of a popular radio program, Dining Around with Gene Burns, at the 2011 CWM consumer tasting event in SF. While many factors, including the overall economy, impact the sales of CA wines in the U.S. market, the project partners believe that this program has contributed to maintaining market share and growing sales. The retail value of CA wine sales in the U.S. continued to grow in 2010 to $18.5 billion (up from $17.9 billion in 2009) and to $19.9 billion in 2011 following recovery from a severe economic downturn which impacted restaurant business and consumption of wine out of home. CA wine share of the U. S. market was maintained at about 60% as the market itself grew. The state of California was also a beneficiary of this project as CA wine contributes $61.5 billion in economic impact, $12.3 billion in wages, 330,000 jobs and attracts 21 million tourists each year.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Industry Cooperation – The regional focus of this project helped to foster a strong cooperation among regional associations working towards a common goal of bolstering the image and success of California wines. Furthermore, the tools created, particularly the website, social media accounts and videos, provided high-quality vehicles for delivering the CA message and gearing that message to millennial consumers.

Project Partner – During the course of the project, management and staff changes at CAWG resulted in significantly less active involvement by the organization in the project on a staffing level although CAWG continued to provide minimal funding towards activities.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

A copy of the PowerPoint presentation, including samples of project materials is attached.

Project 27 - Sunsweet Growers (SG)

Final Performance Report

Project Title
Improving Grower Sales and Competitiveness by Promoting Prune Juice to Younger Consumers

Project Summary
The project had two closely related goals: 1) To increase, sustain, and maximize Sunsweet grower members' revenue and profit by renewing consumer demand for prune juice; and 2) To reverse the overall prune juice sales decline by making prune juice relevant to current and future consumers. The California market for prunes is currently in oversupply, specifically for small, unpittable fruit, which is used for prune juice. Household consumption of prune juice has been steadily declining over the past ten years. The current project created a new television spot with messaging based on consumer research findings. SG tested the new television spot in regional markets, and measured the growth impact. The communication is very timely because there have been several non-juice products launched in the past two years that target digestive health, competing directly with prune juice. Prune juice has been losing share of voice.

Prune juice uses smaller-size fruit and fruit with pit fragments, much of which is unsaleable. This fruit represents 50 percent of growers' revenue. Since 1998, prune juice household consumption has decreased from 6.4 percent to 4.2 percent, threatening growers' competitiveness and long-term sales.

Three reasons for the decline in the prune juice market are: 1) consumers dislike the taste, 2) new alternative digestive health remedies are available, and 3) there is a negative perception of prune juice in young Americans. This project directly addresses these challenges.

In conjunction with this new television spot, a new product was launched called Prune Juice Light. SG also launched completely new packaging which is much more contemporary and attractive to new consumers. Because of this, it was decided to create two new television spots so that SG could test the impact of the television advertising with a) new packaging, or b) the new packaging plus the new Prune Juice Light. SG was able to do this without going over the production budget. The number of markets being advertised did increase, which increased the overall media spending and Sunsweet's matching funds.

Project Approach
The major task in this project was to produce and broadcast a new Prune Juice television spot. The following outlines the tasks accomplished in order to meet the goal of increasing the demand for Sunsweet members' prune juice by 15 percent.

Tasks Accomplished:

1. Developed new strategic positioning for making prune juice relevant to today's consumer based on results from extensive research. The marketing team presented the recommended positioning to the Marketing Committee of the board of directors to gain input and support for the strategy.

2. Identified primary messaging points for the television advertising spot to communicate new positioning and benefits of prune juice, including the new product, to women aged 35 plus. As mentioned above, it was decided to create two spots so that television advertising could be tested with and without a new product. Essentially, the new packaging is so different that it serves as a new product. The marketing team worked closely with senior management to determine the messaging points. The development of these messaging points also led to updated communication in all marketing efforts of Sunsweet Juice.

3. Worked with advertising agency, Nice Advertising, to develop the television spot, including script development and filming. The advertising agency developed the spot using a creative brief set forth by the Sunsweet Marketing Team. All concepts and scripts were reviewed with senior management.

4. Television spot filming took place over the course of three days and included pre-production preparation, wardrobe review, talent warm-up, and location review. Production costs were within the budget specified. Post-production editing occurred over the following four weeks, prior to release to the television stations. The final television spot was approved by senior management.

5. Identified regional test markets based on the following criteria: a) mid-range prune juice development, b) retailer data availability, and c) marketing expenditure efficiency. The three regional markets chosen for the Prune Juice Light spot were Des Moines, Pittsburgh, and San Antonio. The decision was based primarily on the retailers who had been targeted for new distribution of the product and who met the criteria outlined above. The three markets chosen for the "Prune Juice only" television spot were Sacramento, Roanoke and Charlotte.

6. Developed media plan, including frequency of advertising, channel, program and daypart selection. Nice Advertising provided a recommendation based on the consumer target (Women aged 35 plus) and number of impressions desired. The final media buy represented 8 percent of the United States market. Final approval was made by senior management.

7. Prune Juice Light was launched in three retailers – Hy-Vee (Des Moines), Giant Eagle (Pittsburgh), and HEB (San Antonio). Product shipping began June 1, 2011.

8. Television advertising began in test markets on August 22, 2011 and was completed November 20, 2011.

9. Results of the campaign were measured through IRI/Symphony syndicated data and will continue to be monitored over the next year.

Goals and Outcomes Achieved

Goal #1 – Increase demand for growers' prune juice in test markets with new television advertising.

Outcome

The results of the television test were very positive, showing a 24 percent net improvement compared to unadvertised markets. In the markets where SG ran the Prune Juice television test, Sunsweet prune juice grew by 27 percent compared to the pre-test time period (August 28, 2011 through October 16, 2011 compared to June 27, 2011 through August 27, 2011). It also increased by 11 percent versus a year ago, comparing the same time frame (versus August 29, 2010 through October 17, 2010). This is significant, because in markets where the television spot was not run, Sunsweet Prune Juice declined by 13 percent.

Goal #2 – Successful sales of two to three new prune juice products in test markets ($300,000 to $500,000 in annual sales for test items).

Outcome

SG decided to launch only one new prune juice product due to budget and resource constraints. Additional items are currently being developed, but did not launch in time for this test. However, the launch of the one item, Prune Juice Light, has been successful. While SG continues to monitor sales, the revenue goal is expected to reach $300,000 per year. Prune Juice Light has currently gained a 10 percent share of the prune juice market. In addition, the product has a unit movement similar to PlumSmart Light at its launch, which currently contributes over $5 million in revenue to the growers.

In the markets where Prune Juice Light was tested, a television spot was run that was specific to that item. In those markets, test results showed a 39 percent growth versus pre-television for all Sunsweet Juice. Prune Juice, including the new item, grew 11 percent versus a year ago.

Goal #3 – Increase messaging point recall for new juice's taste and health benefits.

Outcome

SG has not conducted consumer research yet to determine any results in the consumer message take-away. At this time, the data results are strong enough to indicate that the message was understood. SG does not intend to change the message of the television spots. Based on the positive results of the television campaign, SG is planning to run national television spots in spring 2012, as budget allows. These test results certainly indicate that SG can bring new consumers to the prune juice category.

Beneficiaries

The beneficiaries of the grant are Sunsweet's 300 prune farmers, who represent 70 percent of prune sales in the United States, and who are all located in California. Prune juice contributes $56 million annually to the growers' revenue, 50 percent of the company's prune based sales, and is crucial to the success of their operations. The production of prune juice provides a market for fruit that would otherwise be unsaleable due to the size of the fruit or incomplete pitting.

California's prune plum growers are facing increasing pressure from low-priced foreign competitors. Only weather-related crop disasters in Argentina in 2004 and 2005 prevented record South American prune plum harvests, which they had in 2006. According to the independent Prune Bargaining Association, the 2007 crop in Argentina is expected to be larger than the record 2006 crop. Most of the Chilean or Argentinian grown dried plums are sold outside of the United States. However, a significant portion is used to make prune juice concentrate, which is sold to prune juice manufacturers in the United States for store brand prune juice. Store brand prune juice is sold at a discount to Sunsweet brand, and it tends to be of lesser quality and have more of a bitter and sour flavor.

Expected impact on local economy:
SG is located in California's Sutter County. Roughly one in 10 residents of Sutter County's 87,000 plus population live in poverty according to City-data.com, an online demographic database. The county's unemployment rate is more than twice the California average. This venture would initially create one to one and a-half new processing jobs with a total economic impact of 3.2 to 4.7 total new jobs by the end of the third year.

Fourteen percent of Sutter County's adult males work in agriculture, making it the County's largest industry. This venture will have a ready workforce able to fill the need and increased production. Sunsweet is one of the county's largest private employers, providing jobs in an area that is below average in education level: in Sutter County, only 15 percent have a bachelor's degree or higher, versus the United States average of 28 percent (City-data.com and United States Census Bureau). The unemployment rate is 10.2 percent according to the United States Department of Labor, much higher than the state's rate of 4.8 percent. Sunsweet currently employees 600 people at its Yuba City (Sutter County) processing plant and headquarters. Accordingly SG, success is of great interest to the community.

Sunsweet supports agriculture throughout the state. There are currently 67,000 bearing acres of prune trees in California. Sunsweet Growers' owner-producers account for nearly 37 percent of the total bearing prune acreage in the state. Accordingly, the processing and marketing success is of vital concern to the state's prune plum growers.

<u>Lessons Learned</u>
Sunsweet's previous experience with launching new television campaigns and new products played a role in the positive outcome of this project. In addition, working with Nice Advertising on the television spot production and development of messaging ensured a high quality result.

During the course of the project, SG redesigned Sunsweet packaging. This added complexity to the project and also resulted in the delay of the final production date. However, it was critical to test the new message with the new packaging, in order to know the true potential of the campaign.

Changing the packaging also introduced some declines in the general market, as the retailers switched from old to new on the shelf. This caused confusion with the consumer; however, SG was very happy to discover that the new television campaign was able to reverse this trend.

It was learned from this project that consumers are open to trying prune juice, especially when it is presented with a fresh message and a more contemporary packaging look.

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 28	**Project Title:** Measuring and Understanding the Pattern of Margins between Farm and Retail Prices for California Specialty Crops to Increase Grower Returns	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09046	**Date Submitted:** December 2012
Recipient Contact: Hyunok Lee, Department of Agricultural and Resource Economics	**Telephone:** 530-752-3508	**Email:** hyunok@primal.ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Retail prices of specialty crops have risen more rapidly than other food prices over recent decades, while farm prices have not kept pace with the retail price climb. According to the price indices published by the Bureau of Labor Statistics (BLS), retail prices for fresh fruits and vegetables have tripled, while retail prices for other food have doubled in nominal terms. Farm prices have risen by 70% for fresh vegetables and by 20% for fresh fruits (in nominal terms). The decline in the farm share means growers have not benefited from rising retail prices. Rising retail prices and falling grower shares have the potential to stifle both consumer demand and farm supply. The declining farm share among fresh produce, especially for fresh fruits, has been more pronounced. The widening price divergence between retail and grower prices has caused concern among farm observers and analysts. Understanding the facts and causes is the first step in addressing the problem.

The project objective is to detail the pattern of retail, wholesale and farm price movements for California specialty crops, analyze the patterns of margins, and provide vital information to growers and groups in a form that allows successful and effective marketing programs to be developed based on objective data and analysis. Historical Consumer Price Indexes (CPI) and Producer Price Indexes (PPI) for general food, fresh fruit and fresh vegetables illustrate the focal point (See appendix 1). All three CPIs increased together at a relatively low rate until the early 1980s. However, since then all three indexes increase at considerably different rates, showing that fresh produce prices rose far more than general food prices. The CPIs for fresh fruit rose most, increasing by 350% of the 1982 price, compared with 310% for vegetables and 230% for general food (Fig 1, appendix 1). Further, the divergence between PPI and CPI for fresh fruit, representing the general producer price and retail price levels for fresh fruit, can be consistent with the widening spread between retail price and farm price. Up to the 1970s, both indices remained constant, and between 1875 and 1985 they began to rise at the similar rate. However, from the late 1980s, these two indices tended to diverge significantly; the CPI rose very rapidly while there was little change in PPI, indicating that fresh fruit retail prices have risen more than any other food groups but producer received prices have either decreased or changed little (Fig2, appendix 1).

According to the U.S. Department of Agriculture (USDA), the share of farm value in retail value for fresh fruits has ranged between 16% to 19% over the period of 1997-2010 (Table 1, appendix 1). Farm share data by commodity group indicate that compared to the overall market basket, fresh fruit tends to generate a relatively low farm share, whereas animal meat and products tend to generate a relatively high farm share. The lowest farm share was generated by the cereal and bakery products, which in general are processed and contain high value added. This confirms project staff's expectation that product perishability lowers the farm share (such as fresh fruit or vegetables) and more processed products are associated with lower farm shares (Table 2, appendix 1). Among the goods which are processed relatively little, such as meat products, eggs, poultry, fresh fruit and fresh vegetables, fresh fruits tend to have the lowest farm share, which is consistent with the investigation using the price indices.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Industry perspective was provided by the industry steering committee which was a subgroup of the University of California Agricultural Issues Center (AIC) advisory committee. The advisory committee represents the leadership in a wide spectrum of agricultural community and meets biannually. Forming a subgroup of the AIC committee, project staff effectively piggybacked the regular biannual AIC advisory committee meetings.

The committee presented progress on the project including important findings and research goals. Insights and recommendations were provided. In some cases the committee guided how project staff can refocus the study to generate relevant information which can be of practical value to the farm community. These members were very knowledgeable and were eager to provide their views and insights. Most importantly, they were particularly helpful in providing insights on price formation at different stages of marketing chains and providing their evaluation to whether each sub-topic is of any relevance to the farmers.

To provide the context to the choice of the approach taken in this study, this section begins with reviewing previous studies with focus on the segment which is especially relevant to the project's approach. Then, the approach and methodologies used in this study are presented.

I. Literature review: The literature review is moved to appendix 2.

II. The approach used in this study: Previous research on marketing margins suggests some critical factors of the determinants of farm margins in vertically related food marketing systems. Two broad contexts summarized include market structure and data construction methods. Studies based on market structure argue that upstream marketers possess market power, which causes the market prices to be determined in favor of upstream marketers. As a result, farmers' margins are lower than what could have prevailed under the competitive situation. On the data construction methods, there are two following important observations. Discounted prices offered by mega grocery stores are not adequately represented in retail price calculations performed by public data collecting agencies such as BLS. This causes retail prices published by public data institutes to be higher than otherwise, which is in turn translated into lower farm margins. Another argument is that BLS's calculation methods of aggregate price indices contribute to lowering the farm margins. Specifically, BLS does not update the definition of constant fruit "basket" which is used in aggregate fruit indices, when consumers' preference and fruit diversity in the marketplace change. In light of these two broad directions of previous approaches, this study performs two separate analyses: 1) investigating price data to examine the possibility of market power (especially the market power of up streamers), and 2) investigating and calculating farm margins using alternative, improved price data.

Developing farm margins using improved data set: The fundamental issues related to data construction lie in the method of aggregation. Continuing on to this data related direction, this study investigates more in depth the consequences of data construction on farm margin calculation. The problem areas where further improvements are made include aggregation methods and the construction of retail data which are compatible to farmers' price in the calculation of farm margins. The data used in this study are constructed using the least aggregated data and much improved aggregation methods.

Aggregations are usually performed on three layers, over time, over commodities, and over geographic areas. To arrive at least aggregated data, this study adopted the least aggregated levels available associated with the data in terms of data interval, commodity, and location. The data intervals used are weekly and monthly levels, a specific fruit variety (such as red delicious for apples) for commodity, and specific U.S. regions (such as western urban or specific wholesale market) for location. Five representative fresh fruits selected are including fresh apples, table grapes, fresh peaches, fresh strawberries and Navel oranges. They are the major fruits produced in California, accounting for 70% of all fresh fruits in value (see appendix 3). To explain the methods used here, a brief overview of how BLS data are constructed is provided in appendix 4, and then the proposed alternative data construction method is provided.

Construction of quantity weighted prices: For each of five fruits, using monthly prices at retail and farmgate for the period of almost three decades, weighted annual prices are calculated. The weighted annual prices are calculated by averaging monthly prices using the corresponding monthly shipments as weights. The months used in calculation include only the months of the domestic season for the fruit in question. In general, grower prices are available only for the domestic season, but retail prices are often reported during the off season for imported products. Thus, retail prices only for the domestic season are used. Monthly shipment data available from the Agricultural Marketing Service (AMS) of the USDA are used as weights. Detailed information for data source is provided in appendix 5.

II.2. Investigating the market structure of fresh fruit marketing systems: To investigate the market structure, an econometric study is performed to investigate the market structure. One common assumption used in studies of price transmission is symmetry of responses to shocks. That is, the magnitude of price transmission across markets does not depend on the direction (up or down) of the initial price shock. If the markets were efficient, a price shock in one market affects the price of the related market in a symmetric fashion, suggesting that the test of asymmetry could be used to investigate market efficiency. The evidence of asymmetry is consistent with a market with asymmetric transaction costs, market power or some other deviation from perfect**.** A few studies applied to agricultural commodities have attempted to investigate empirically this assumption by allowing the possibility of non-symmetric transmission. Following the line of literature, commonly referred to as asymmetric price transmission, the present study adds to the price transmission literature on specialty crops by investigating the structure of price transmission in the context of the vertical market chain for fruit markets in the United States. Focusing on the initial shipping point and terminal (wholesale) links in the marketing chain, this study examines short-term as well as cumulative price responses of terminal prices to changes in shipping point prices. This study formally test the asymmetry of price transmission between the shipping point and terminal prices of fresh fruits, apples, table grapes, peaches, and strawberries, using weekly price data spanning from 1998 to 2011. A draft of the manuscript is attached (appendix 6).

A number of presentations have been made to industry groups based on research in this grant. These include:

- California Farm Bureau Federation Specialty Crops Committee (March 2012),
- Wells Fargo farm lenders annual meeting in Napa California (December 2012),
- Southern California Water Associations (August 2012),
- Board of Advisors of Simpatica Farms (major lemon and avocado grower) (October 2012),
- Food Foresight which has representatives from major farm and food marketing organizations (February 2011, February 2012, January 2013),
- California Agribusiness Executive Seminar (March 2012), with major fruit and vegetable growers from throughout California, including leadership from Paramount Farms, the major citrus firm, Taylor Farms one of the major lettuce producers, and SunMaid, the largest distributor of raisins.
- Results of this project have widely been communicated in the agricultural press and in interviews with other media.

The website for the project is: http://aic.ucdavis.edu/MarketingMargins/index.htm

Additional results from this project will be presented at the annual seminar of the Vegetable Seeds Association in Scottsdale, AZ (January 2013), the California agribusiness workshop in Davis, CA (March 2013), and Food Foresight in Sonoma, CA (February 2013). These meetings reach broad audiences with the least cost and additional demands on the farming and marketing community. Information was gathered on usefulness of the results in all of these meetings without demanding a formal survey of participants.

Usefulness of the study information is also demonstrated by continuing interest in the marketing margin subject expressed by the farm community. For example, a number of specialty crop farmers in California indicated the possibility that increasing imports attribute to lowering farm margins for specialty crops, especially fresh fruits. Marketing margin is a subject area which attention continuously is paid to, and even though the project is completed, project staff extends research effort to many sub-topics in this area. The linkage between imports and the marketing margin gap by investigating the import and other related data for the selected specialty crops in California is currently being analyzed.

Goals and Outcomes Achieved

- Supply the activities that were completed to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The first specific goal is to develop and provide information to describe current marketing margins for major California specialty crops, and the second specific goal is to assess the causes for the marketing margins by comparing across crops and evaluating the data statistically. The ultimate goal is to improve returns to farms and marketing organizations by making more information and data available. The data developed in this study are unique. The benchmark for the data and analysis is the aggregated general information on margins available from USDA and this study assessed the use of this information. Evaluating the usefulness of this study in achieving goals relies on performance measures applicable within a given timeframes. The project developed data on: 1) the extent of the project's coverage of the specialty crop industries, 2) the specific applicable new information this project delivers, and 3) the breadth and effectiveness of outreach across farm and marketing decision makers with new data. Activities on developing new improved data and generating information centered on these performance guidelines and specifics of the goals.

I. Output from farm margin analysis using shipment-weighted prices: Specific outcomes generated from weighted price calculation are presented for each of the crops that were considered, but detailed graphical and data information is deferred in appendix 7.

Apples: a) Both real retail and grower prices of apples in real value tend to be steady with little fluctuation over the last 30 years; b) Real retail prices range between 80 cents to a dollar and real grower prices fluctuate around 20 cents; c) Weighted retail prices are in general higher than unweighted prices, but for grower prices, these two pricing schemes make little difference; d) The share of imported apples in the US market is small; over the decades, the import share fluctuates at around 5 or 6%; and e) Grower shares which ranged between 20% and 25% until the early 1990s, began to fluctuated in a wide range, between 20% and 30% in the recent two decades.

Fresh Peaches: a) In real value, retail prices of fresh peaches have steadily gone up, while the grower prices have been steady with little change; b) This implies that the grower share in retail price has been steadily falling (falling more than 40% since 1980); c) When prices are weighted, retail prices tend to be slightly lower than unweighted prices while grower prices change little between these two sets of prices; and d) In terms of grower share, weighted grower shares are slightly lower than unweighted shares.

Strawberries: a) In real term, grower prices have been steady while retail prices have risen considerably (about 60%) even though they showed a slightly decreasing trend in the recent years; b) This implies that the grower share in retail price has been falling. The grower share has fallen from slightly more than 50% to about 30% over the three decades; c) Between the weighted and unweighted prices, little deviation was found for retail prices but large deviation for grower prices. Unweighted grower prices are consistently higher by about 15% than weighted grower prices, causing 15%-20% difference in grower share.

Table grapes: a) In real term, grower prices have been steady while retail prices have gone up until 2006 (over 40%) and then begun to decrease, which also implies that the grower share in retail price has fallen and then bounced back; b) between the weighted and unweighted prices, no consistent pattern for retail prices was found but a considerable deviation for grower prices. Unweighted grower prices are consistently higher by over 10% than weighted grower prices; and c) This also implies that the grower shares are higher under the unweighted price scheme. Under the weighted price scheme, the grower share has fallen from 22% to about 15% (using weighted prices) by 2005, but since then has fluctuated between 22% and 13%.

Oranges: a) In real term, grower prices have been steady while retail prices have gone up slightly; b) Unweighted prices have been slightly higher than weighted prices for both retail and grower prices; c) Unweighted grower shares are consistently higher than weighted grower shares. The weighted grower share fluctuated around 15% until about 1999 but since then it shows a slightly downturn and fluctuates between 10% and 15%; and d) Unweighted grower shares fluctuated at around 20% before the downturn and between 15% and 20% after the downturn.

From the investigation of five fruits, some commonality emerges. Real retail prices have gone up for almost all fruits, except for apples. However, real grower prices have been relatively steady. For all fruits except for apples, weighted prices are lower for both retail and grower prices. With an exception of apples, grower shares have been falling under both weighted and unweighted schemes. The comparison between weighted and unweighted prices indicates that the difference between the prices of these two weighting schemes is more pronounced for grower prices than retail prices. Among the fruits considered, the widest diversion between these two grower prices was found for strawberries. Grower shares were in general lower under the weighted price scheme.

II. Output from asymmetric transmission study: The study results on asymmetric price transmission indicate that there are "some" evidence of asymmetric transmission for apples but none for other fruits, suggesting that market power does not exist in the industries project staff considered. A copy of the manuscript entitled "Asymmetric transmission between terminal and shipping point prices for selected fruits," is attached as appendix 6.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

By providing objective public information for all major specialty crops, the project will benefit both producers and marketers. The California specialty crop farm sector is huge. Specialty crops are produced by half of all California farms (40,138 out of 81,033) and provide half of agricultural revenue in the state ($18.1 out of $36.6 billion). This study developed and disseminated objective new information on marketing margins. Developing historical and accurately assessed marketing margins is a critical part of this effort. Marketing margin information provides benchmarking to thousands of individual growers, workers and marketing firms and help them formulate more efficient pricing and successful marketing institutions and strategies.

The creation of this new source of information for use by industry decision makers allows fact-based review of marketing plans and pricing. Expanded demand through more effective market planning allows industry growth with higher returns per acre and per unit of input (for example, per acre-foot of water). Better data and analysis to support more efficient marketing decisions benefits farms, firms and consumers along the market chain. The potential gains to California specialty crop industries can range to billions of dollars as better data is transformed into more effective pricing and marketing with specific attention to grower returns.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

It would be difficult to develop the appropriate data to investigate marketing margins. However, the issues exhibited by BLS aggregate were perhaps more problematic than anticipated when they are combined with USDA prices. The marketing margins reported in official sources therefore must be used with great care and not misinterpreted.

Some important implications emerge from the study. Given the weighted scheme for calculating aggregate prices is a more accurate aggregation method than just simple averaging, the results on weighted prices are significant in two ways. First, the results that both retail and farm prices calculated under the weighted scheme were lower than simple averaged prices indicate that BLS's food price indices which are widely available may likely be upward-biased. That is, the inflation of food prices may be overestimated. Second, while both weighted prices were lower than simple averaged prices, the discrepancy between weighted and unweighted prices was deeper for farmer prices than retail prices. This implies that farm prices have been lower than what had been officially published before, and this is the same case with the farm share. The investigation on the fresh fruit market structure, for the four major fruits in California, shows that no statistical evidence was found consistent with the existence of market power by the down streamers, which was the similar conclusion made by Sexton and Zhang who studies fresh produce markets in California.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) not applicable to any of the prior sections.

This project provides a designated website http://aic.ucdavis.edu/MarketingMargins/index.htm
Some of the information provided in this website includes:
Annotated bibliography on marketing margins for agricultural and food products with emphasis on specialty crops: John Bovay
Asymmetric transmission between terminal and shipping point prices for selected fruits: Byung il Ahn and Hyunok Lee
Documentation of data sources: Hyunok Lee and Daniel A. Sumner
Analysis of marketing level weekly prices for selected fresh fruits: H. Lee, D.A. Sumner, and Jessica Vergati
Historical weekly terminal and shipping point prices for selected fruits (1998-2012): Hyunok Lee and Daniel A. Sumner
Analysis of weekly prices at retail, terminal and shipping point: Hyunok Lee
Farm price margins constructed under alternative price calculation: Hyunok Lee, Daniel Sumner and Jessica Vergati

Project 29 - Buy California Marketing Agreement (BCMA)

Final Performance Report

Project Title
California Grown Campaign 2

Project Summary
The purpose of this project was to conduct a "California-Grown" umbrella marketing effort that includes an economic impact study to quantify the reach of the California specialty crop industry. The economic impact data measures the ripple effect of expenditures by the specialty crop industry on the broader California economy. This data, coupled with the real-life stories of California specialty crop growers, are the foundation for the marketing campaign that gets to the heart of the value that the specialty crop industry delivers, and more importantly, provides compelling reasons why Golden State consumers should look for and buy California-grown specialty crop products whenever and wherever they shop.

Despite the important role that agriculture plays in our state, the industry tends to be undervalued and overlooked by Californians. Additionally, advances in agriculture have allowed a small percentage of our population to fulfill our food production needs and has created a disconnect between the production of food products and the end consumer. The overarching goal of this effort was to clearly and credibly quantify the tremendous value of the California specialty crop industry and reconnect Californians with the people who produce California's vast array of specialty crops.

The "California-Grown" consumer education campaign has received grants to fund state-wide promotional programs. Previous projects have employed various marketing tactics to encourage consumers in the state to seek out and purchase locally grown agricultural products. This project built upon previous projects by keeping the campaign visible to the state's consumers and humanized California agriculture by telling the stories of the state's farmers. This project also added additional content to the californiagrown.org consumer oriented website including the results of the economic impact study and complete grower profiles and photographs.

Project Approach
BCMA identified more than a dozen specialty crop growers who embody California agriculture and are ideally suited to help personify the results of the study and create a human connection to the data. Grower profile information was collected from these growers including history/California agricultural heritage information to feed human-interest style media coverage. A media kit was created featuring the grower stories and economic impact data. The media kit includes economic impact report press release, grower profiles and California specialty crop information and key messages.

Completion of an economic impact study examining the financial outputs related to 15 of California-grown specialty products secured a variety of credible, relevant statistics about California specialty crops and media-worthy economic impact statements.

The following are a few study highlights:

- The total economic impact of California's specialty crops in terms of business activity created by the industry is $15.9 billion annually.
- The industry's spending creates 137,435 jobs.
- The industry generates $5.2 billion in labor income.

Created advertising campaign featuring specialty crop growers including radio, print and in-store elements which was placed in spring 2011:

- Free Standing Inserts
  - 75 newspapers state wide
  - Total circulation of 4.5 million
- Shopping Carts
  - 520 stores
  - Safeway, Vons and FoodMaxx
- Floor Talkers
  - 171 stores
  - Los Angeles and San Francisco
  - Save Mart, Food Maxx and Lucky's
- Metro Traffic Radio
  - 261 total spots
  - Los Angeles, San Francisco, San Diego, Fresno, Riverside, Sacramento, Stockton and Modesto
- Broadcast Radio
  - 266 total spots
  - Three spot rotation
  - Top market talk radio stations
  - Sacramento and Fresno markets

Impact report, industry fact sheets and grower profile stories were posted to www.californiagrown.org and publicized to the media via statewide press release, audio news release and media relations:

- 40 plus media placements reaching an audience of more than 10 million
- Coverage in *The Sacramento Bee*, *Sacramento Business Journal*, *Western Farm Press* and an upcoming cover story for *California Farmer* magazine.

Conducted a consumer awareness survey to determine effectiveness of campaign and action-oriented purchasing outcomes:

- 90 percent of total survey respondents indicated that buying agricultural products from California is an extremely or very good way to support the local economy.
- 52 percent of respondents indicated the advertising campaign was more likely to inspire them to seek out and purchase California-grown specialty crops.

While the entire project was overseen by BCMA Executive Director, Maile Shanahan Geis, the project partners Fleishman Hillard Public Relations and MJR Creative Group made considerable contributions to the project effectiveness. The team at Fleishman Hillard Public Relations took the lead on developing media materials and garnering positive news coverage for the project.

The team at MJR Creative Group developed all graphic design for the advertising and media materials; they also utilized their advertising expertise to negotiate media placement and rates for the project advertising campaign.

Goals and Outcomes Achieved

To measure the outcomes of the campaign, a consumer awareness and propensity to purchase survey related to California-grown specialty crops was conducted. BCMA expected to see a five percent increase in awareness and three percent increase in the propensity to purchase California-grown specialty crop products among those surveyed.

- 90 percent of total survey respondents indicated that buying agricultural products from California is an extremely or very good way to support the local economy. From previously collected data, a benchmark of 30 percent was established. The results from this study show that consumer attitudes have changed significantly regarding the importance of purchasing California-grown products.
- When asked specifically about the current advertisement, 52 percent of the respondents indicated it was more likely to inspire them to seek out and purchase agricultural products from California as compared to only 49 percent from our benchmark statistics.
- 58 percent of respondents indicated they have heard of or seen advertisements or publicity for the "California-Grown" Campaign.

Beneficiaries

The BCMA is a joint effort of 15 agricultural industry groups representing the products of California's farms and ranches. While these 15 member groups are the initial stakeholders, the campaign we have implemented is generic in nature and has positive benefit on all specialty crops grown in California.

The campaign message "Be Californian, Buy California-Grown" instills a sense of pride in choosing products that are produced in the state. In turn, this effort has increased sales of California's specialty crops across the board and created a lasting connection between Californians with their food supply that will continue to positively affect the sales of crops into the future.

Ninety percent of total survey respondents indicated that buying agricultural products from California is an extremely or very good way to support the local economy. The results from this study show that consumer attitudes have been positively impacted regarding the importance of purchasing California-grown products thus having a positive effect on sales of California-grown specialty crops as a whole.

Generating positive news coverage for California's specialty crops is an enormous benefit to the industry as a whole. This project achieved 40 plus positive media placements reaching an audience of more than 10 million.

Lessons Learned

In today's climate consumers are hungry for information about the people behind their food and other agricultural products. This project proved to be a timely and positively received effort by offering in-depth grower profile information, interesting statistics and captivating photographs to help tell the story of California’s specialty crops. No unexpected or undesirable outcomes were experienced.

Contact Person
Maile Shanahan Geis 916-441-5302 / 916-612-0996 maile@californiagrown.org

Additional Information
Please visit californiagrown.org to view complete grower profiles for each of the featured growers.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 30	**Project Title:** Western Pistachio Association (WPA) Pistachio Industry Recovery and Re-building Effort	
Grant Recipient: Western Pistachio Association, now re-organized as American Pistachio Growers	**Grant Agreement No.:** SCB09016	**Date Submitted:** December 2012
Recipient Contact: Richard Matoian, Executive Director	**Telephone:** 559-475-0435	**Email:** rmatoian@americanpistachios.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

In March 2009, a single California (CA) pistachio processor announced a voluntary recall of pistachios due to potential *Salmonella* contamination. The recall was enacted on a precautionary basis prior to any reported illness, and in fact, no illnesses did occur. However, the ripple effect to the pistachio community was massive. Immediately following the recall announcement, CA pistachio processors reported sales declines of 60 percent.

The primary purpose for submission of this project was to support an industry recovery and re-building effort in light of the nationwide voluntary recall of pistachios. The re-building effort was a layered, multi-year, multi-target audience process intended to unify the pistachio community, and work collaboratively with key stakeholders and food safety experts with the goal of restoring the public's confidence in pistachios. The re-building plan was built on the key pillars of research, industry action, education, reassurance and recovery.

The re-building effort was of utmost importance to the competitiveness of the pistachio industry, a key CA specialty crop. In 2009, more than 800 CA growers tended to 198,500 acres of pistachios planted throughout 22 different counties. And, with nearly 35 percent of the industry's acreage being "non-bearing," the need to rebuild consumer confidence was critically important to the future of the industry. Further, CA produces 98.5 percent of the nation's total domestic pistachio production, so this food safety issue could not be ignored. The timing of the grant was critically important for the pistachio industry. The award helped to initiate work on a number of very important activities.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

The activities of the pistachio recovery and re-building effort can be summarized as follows:

Research:

- Pistachio retail sales data was secured, representing 52 regional markets in the U.S., and representing over 55 percent of all grocery sales.
- Sigma Research conducted 760 consumer and 150 health professional interviews (twice during a seven month period).

Action, Education and Reassurance:

- Updated industry Good Agricultural Practices (GAP) guidelines. Communicated GAP guidelines to entire pistachio industry—1,200 member mailing list. Publicized updated guidelines to 18 agriculture media outlets. Industry GAP presented to over 2,000 growers.
- Media trained 25 key members of pistachio industry and 5 staff.
- Secured two food safety experts from the University of CA and one national food safety expert
- Developed and disseminated 24 different fact sheets, press releases and podcasts
- Created first time Crisis Communication Plan for pistachio industry.
- Economic Impact Study (EIS) conducted involving producers and processors. Disseminated results to 500 at industry presentation, and in press release to over 18 agriculture media outlets.

Recovery/Market Expansion:

- New website launch experienced over 14,000 visitors in first month.
- Consumer related media impressions resulted in 427 million impressions, including 339 million in print, 38 million television and radio broadcasts, and 50 million online.
- Industry Ambassadors secured interviews on over 30 televisions shows and programs.
- Reached out to over 10,000 Registered Dietitians to promote the healthfulness of pistachios.

The pistachio industry worked with Dr. Dennis Tootelian, CA State University, Sacramento, on the industry's EIS. His expertise in EIS development insured a quality document would be produced. Dr. Linda Harris, food safety expert at the University of California, Davis (UCD), and Bonnie Fernandez-Fenaroli, at the Center for Produce Safety, UCD, provided their expertise in food safety. Fleishman-Hillard expertise in the development of a Crisis Communication plan, and their guidance dealing with the media and consumers on the food safety issue and recovery effort was very valuable. Henson Consulting led the effort in the recovery of pistachio marketing and their public relations expertise was utilized extensively. Most importantly, pistachio growers and processors stepped up when this industry needed their input and guidance—in the midst of a food safety crisis, all banded together to insure that pistachios were safe to consume and to assure consumers of the commitment of the industry to protect the safety of their food supply.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

From its inception of the grant in October 2009 to the present, American Pistachio Growers (APG) has aggressively executed activities and programs to support both the recovery and market expansion of pistachios. The various activities that were completed can be summarized as follows:

- Presentations were made to agricultural groups regarding management of a food safety recall/crisis. Presentations involved sharing best practices with other organizations in the post-pistachio recall environment. Presentations were made to over a dozen agricultural groups and over 2,000 growers.
- Development and launch of a new website initially focused on food safety (www.thegreennut.org). This website evolved over time to be more consumer focused, and ultimately became www.americanpistachios.org.
- Extensive media relations outreach to print, broadcast and digital communications outlets. Positive coverage related to the health and nutrition benefits of pistachios were secured in leading lifestyle, fashion, sports magazines, numerous websites as well as a number of television and radio stations.
- Identification, recruitment, development and launch of pistachio Ambassador spokespersons, specifically focused on nutrition, fitness and healthy eating. Five Ambassadors were engaged and had placements on over 30 televisions shows and radio interviews. Additionally two third-party food safety advocates were secured to be utilized as necessary
- Totaling all APG consumer related media impressions during the grant period, a little over two billion consumers were reached. Work specifically related to this grant resulted in 427 million impressions. This far exceeds the 50 – 75 million goal projected in the original grant submission.
- APG was able to conduct a two-wave Usage & Attitudes study with Sigma Research intended to provide "before and after" perspectives on targeted consumer opinions and purchase behaviors, as well as awareness of the industry's health benefit messaging. Sigma Research's findings showed that the public relations campaign's focus on the nutrition research, health benefits messaging and the wholesomeness of pistachios has made a significant, positive impact on how consumers perceive, buy and consume pistachios in just a few short months. The research was conducted between spring 2010 and summer 2010. Some key findings include:
  - Unaided mention of pistachios being healthy/good for you was up +23 percentage points from 23% pre to 46% post-wave.
  - Purchase frequency increased significantly, from 9% to 21% for the entire sample set.
  - Consumption of pistachios rose significantly, from 5% to 20% as measured by the number of respondents who said they ate pistachios "more than once a week."
- For the first time, the CA pistachio industry was able to conduct a comprehensive EIS. The EIS was conducted with Sacramento State researcher, Dennis Tootelian, Ph.D. The study examined the effect of the pistachio industry's expenditures – both from growers and processors – on the overall economy. The study quantified the extent of which the pistachio industry infused dollars throughout key economic drivers, such as employment, taxes and property values. Key results included:

  - $672.3 million annual in business activity, or $1.1 million each day in California.
  - CA pistachio growers spend nearly $409.1 million each year to produce the pistachio crop. This spending spurs a wave of ripple effect economic activity.
  - Creation of 5,820 full-time equivalent jobs each year in CA. With this employment, more than $221 million is generated annually in wages and salaries for new employees, as well as for the expanded incomes for existing industry jobs.
  - More than $24 million annually in tax revenue and other business licenses and fees are generated from the economic activity created by CA pistachio growers.
  - Publicity on the EIS garnered 4.5 million highly favorable media impressions; thereby, achieving the goal of 3 – 5 million media impressions projected in the original grant submission.
- Development of a Crisis Communication Plan for the pistachio industry, including management tools resulting from the 2009 salmonella recall. This was the first time such a plan had been created for the pistachio industry.
- Media training took place for twenty Board members, key growers and industry members. The focus of the media training was to assure these spokespersons could effectively speak before the media, highlighting the key points related to the growing, harvesting, processing and marketing of American grown pistachios.
- Domestic Retail Pistachio Sales Data. The industry secured sales data generated through Information Resources, Inc. (IRI), an entity that reports on domestic grocery store sales data. For the first time, the industry had access to retail store pistachio sales data, from 2009 to the present. The sales data showed the effect of the salmonella crisis, which began in March 2009 and the resulting drop in sales that continued through late August of that year.
- A new website was established in February 2012, www.americanpistachios.org The look and feel of the website has been maximized for consumers and health professionals. Additionally, both the grower and consumer website has been combined into one site, with a login for growers to access the APG site. The new site had over 14,000 people viewing its web pages in the first month of its launch, compared with just 1,200 people viewing for the same period of time the year prior.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Beneficiaries from the project include the immediate pistachio industry (pistachio growers and processors), others within the marketing chain (marketers, brokers, wholesalers, re-baggers, retailers), and ultimately consumers.

Consumers were the audience this grant was targeted to affect. Consumers were reminded that pistachios were safe to consume and the *salmonella* issue was an isolated incident that affected less than ½ of 1% of all pistachios sold in the U.S. With 427 million consumer impressions reached through the specific focus of the project, APG believes that most consumers were touched by the strong food safety and nutrition message. Results from surveys and retail grocery store sales indicated that consumers could not recall any specific food safety issue related to pistachios just months after the *salmonella* issue.

The greatest benefits generated by the project to the pistachio industry were in three main areas:

- Development of a Crisis Communication Plan—a first for the pistachio industry; and a needed document if another crisis were to develop.
- Conducting the pistachio industry EIS—another first. This quantified the economic impact of this industry in a number of key economic areas. The study continues to be quoted from extensively today.
- Disseminating domestic retail sales data. This important data helped to quantify the loss of sales due to the salmonella issue in 2009. Now its use assists the industry comparing sales of pistachios to other common nuts.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

1. The timing of the grant award was critically important for the pistachio industry. The award helped to initiate work on a number of very important activities.
2. The need for a Crisis Communication Plan (or retaining a firm that has experience in crisis planning) is important. With one, you will be confident facing a crisis.
3. Consumers can be negatively affected by a food safety scare, but can forget the issue if the press does not continue to report on it, or if no illnesses occur.
4. Continuing to talk about a specific food safety issue with consumers after the fact can cause confusion. In other words, if it's not an issue, don't continue to talk about it.
5. The results of the EIS were positively surprising to both staff and the industry, and the results will continue to be utilized for some time.
6. With the purchase of retail sales data, it is now known that while pistachio sales volume dropped by 60% for a 2-month period, prices remained unchanged during that time.
7. As a result of this grant, retail sales data continues to be purchased and distributed each quarter, showing the effect of any potential public relations activity on sales. The industry can now monitor the positive effect of promotions in any area of the country, or the negative effect of any issue on sales.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attachments provided with this report include:

1. Pistachio industry Economic Impact Report.
2. Domestic grocery store sales data showing the effect of the salmonella issue in on pistachio sales.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 31	**Project Title:** Specialty Crop Growers Partner with City of San Francisco for Healthy People and Bottom Lines	
Grant Recipient: Great Valley Center	**Grant Agreement No.:** SCB9028A	**Date Submitted:** December 2012
Recipient Contact: Linda Hoile, Program Manager Jami Westervelt, Senior Director of Programs and Operations	**Telephone:** (209) 522-5103 ext. 140 (209) 522-5103 ext. 122	**Email:** linda@greatvalley.org jami@greatvalley.org

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Eating food that is grown locally has become a phenomenon. Consumers are interested in the social, environmental, and economic benefits of eating food from local sources. Throughout California momentum for this movement is at a peak and continues to build. Today, more than ever, consumers want to know where their food is from; they want transparency from the farm to their plates. This grant project was inspired by a recommendation from the San Francisco Urban Rural Roundtable's (URRT) to increase the amount of locally grown and identified agricultural products making their way into the City of San Francisco.

This project provided the citizens of San Francisco with more locally-grown food while increasing the sales and long-term sustainability of specialty crop growers in the 150 mile radius/16 county area of the San Francisco Food shed. The intended impact of this initiative was to support the regional agriculture industry, reduce dependence on foreign imports and climate impacts, and help to connect the city's residents with fresh, locally and regionally produced food.

Encouraging city food preparers to buy locally grown produce helps minimize the city's overall environmental impact as it pertains to food consumption. Furthermore, increasing consumption of fresh fruits and vegetables can help curb the rising rates of obesity, diabetes and heart disease, which are pressing health issues in our society.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

This project required the input and collaboration from many stakeholders. The following entities were project partners, providing valuable contacts, resource lists, educational materials and expertise: Marin Organic, Community Alliance with Family Farmers (CAFF), and Om Organics (formerly Farms Reach). Each of the partners was responsible for providing input and support in order to reach project goals and complete deliverables.

It is important to note that Brentwood Agricultural Land Trust (BALT) was initially identified a project but was unable to participate and complete work in the project work due to staffing issues. Great Valley Center (GVC) was able to move the project forward without their participation and reallocate a portion of the funds set aside for BALT to the other project needs.

Om Organics provided a Bay Area Food Organizations directory as an inventory of organizations in the San Francisco Food Shed, and was responsible for setting up the database of participating growers, buyers and distributors and managing the distribution system used for food ordering and tracking.

CAFF worked with Om Organics on the logistics of packaging, transporting, storage and final delivery of product and the development of the ordering and communications for the distribution system.

Marin Organic worked in collaboration with CAFF to create sales leads and marketing opportunities, including planning and implementation of trade missions.

The first steps were to identify and survey potential buyers in San Francisco. Large purchasers of specialty produce were targeted, including high-end hotels, caterers and restaurants, as well as markets carrying organic produce and large institutions such as juvenile hall and the VA hospital. The surveying process provided an opportunity to ascertain buyers' produce needs and to educate them on the benefits of buying locally grown products.

The next step was to survey the local and regional growers of specialty crops to determine their current markets and distribution, and to explore their interest and capacity to supply produce for the San Francisco markets. Grant partners began building a database of ideal producer and buyer participants for the food distribution model project.

The grant partners planned and held an internal trade mission, bringing in potential buyers and distributors to the half-day event held at Mills College in Oakland. The forum entitled "Scaling Up Local" featured a lunch showcasing local produce and included a panel discussion with produce distributors discussing how to work with local growers and the benefits of purchasing locally grown foods. The trade mission also provided a networking opportunity for high-volume food purchasers to connect with distributors and local growers.

Marin Organic organized a trade mission which brought Whole Foods Market management and buyers out to West Marin for a field visit of specialty crop farms.

The grant partners also held "reverse" trade missions – scheduling outreach appointments with potential buyers in San Francisco, meeting and providing them with educational materials and information on locally grown specialty crops and regional growers, and inviting them to participate in the new food distribution model that was being established.

After enlisting participating producers, buyers, three distributors and the Growers Collaborative as the product aggregator, and establishing a database of available specialty crops, the distribution model became operational (see Attachment 3). By July 2010, many of the buyers had placed orders through the system. However, as time went by, many of the buyers and distributors chose to buy directly from the growers, which undermined the project model and the outcomes tracking that was built into the system.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

A majority of the grant deliverables were achieved, as were the overall qualitative goals. The project conducted trade missions and individual outreach contacts with high-volume food buyers in San Francisco, including hotels, restaurants, caterers, wholesale distributors and health food stores. Through this marketing outreach connections and relationships between growers, buyers and distributors were established; the benefits of using locally grown specialty crops were promoted; fresh produce requirements and availability were surveyed, and a distribution infrastructure between growers and buyers was constructed.

The project developed a specialty crop distribution model, through which large San Francisco buyers ordered specialty produce, growers supplied the specialty crops through the Growers Collaborative (GC), and participating distributors delivered the products from farm to buyer.

Through this grant project, several lasting connections were established that continue to bring additional fresh, locally grown produce into San Francisco. In early 2011, CAFF and the GC engaged one of the largest distributors in the nation, Sysco Foodservice, which supplies restaurants, schools and other large clients across San Francisco. Through a signed agreement, Sysco now offers locally grown specialty crops to their clients in the city, sourced by the GC. Through this partnership, GC was also able to participate in the Sysco Food Show, providing access to hundreds of foodservice operators and the opportunity to encourage use of locally grown products in their menus. This event also provided GC an opportunity to encourage attending Sysco account managers to suggest local produce to their customers.

Additionally, Marin Organic worked closely with Whole Foods Market to increase the amount of local specialty crops offered in the chain's three San Francisco stores. This involved a multilateral approach of meetings with regional buyers and management, staff education, and organizing a trade mission/field visit which brought management and buyers out to specialty crop farms in West Marin County. This work resulted in an overall renewed commitment by Whole Foods Market to offer local products in their San Francisco and other Bay Area locations.

Marin Organic continues to build upon the foundation laid by this grant. In 2012 they hosted a networking "meet and greet" event in San Francisco that introduced Marin Organic farmers to new potential clients in the city. They have also revamped their Supporting Business Program (see Attachment 2), establishing a membership structure that provides for sustainability as an organization promoting the specialty crop growers in their area.

This grant resulted in an increased supply of source identified, locally grown specialty crops entering the city of San Francisco. The project helped to expand markets for the growers as new connections between buyers, distributors and growers were built. Specialty crop growers also were able to increase their knowledge of product demands, packaging and pricing. Many high volume food buyers in San Francisco were provided a greater awareness of the variety of specialty crops available in the region, the benefits of buying locally grown produce, and how to easily access local produce sources.

The objective of the grant program (SCB09028A – Specialty Crop Growers Partner with City of San Francisco for Healthy People and Bottom Lines) is to increase the amount of locally grown and identified agricultural products making their way into San Francisco was achieved. Specialty crop growers in the 150 mile radius/16 county area of the San Francisco food shed area increased market contacts and sales of their products, briefly through the food distribution system model and eventually through buyers and distributors buying directly from growers as a result of the connections established through the efforts of this grant, (grower information/marketing profiles, sales calls, trade missions and reverse trade missions, etc.).

We estimate, based on sales made through the distribution model, and through the Growers Collaborative agreement with the food mega-distributor Sysco, and Marin Organic's strengthened sales relationship with the three Whole Foods stores in San Francisco and other important sales relationships established, that the performance measure of a 10-15% increase in sales of local specialty crops to San Francisco was exceeded by the end of the 18 month period. However, the project partners in implementing the grant found that their participating growers were guarded about sharing initial sales volumes and were unable to gain this critical information from many of the growers. They were therefore unable to establish a baseline of sales from participating growers, making it impossible to provide a definitive outcome measurement for the percentage increase in sales.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Specialty crop growers in the 150 mile radius, 16-county food shed area benefitted through an expansion of their markets in San Francisco, increased access to wholesale customers and through an increased knowledge of market demands, including requirements for quality, packaging and pricing. Marin Organics worked closely with 14 North Bay Growers, and CAFF created over 20 farmer profiles that were used in marketing the growers' products to food service and end customers.

A number of large scale buyers of food in San Francisco, including Whole Foods Market, San Francisco Juvenile Hall, Paula LeDuc Catering, Taste Catering, Gap's in-house food service department, W Hotel, Living Room Events Catering, Ritz Carlton Hotel, Palace Hotel and St. Regis Hotel, benefitted by their increased access to fresh, local and regionally-grown produce at good prices.

Growers Collaborative, a food aggravator, and several food distributors also benefitted through their participation in the project, including Sysco Foodservice, Fresh Point, San Francisco Specialty, Vegiworks, Thumbs Up, Earls Organic and Veritable Vegetable, by increasing their customer base and their knowledge of specialty crop growers and buyers.

Additionally, grant partners CAFF, Marin Organic and Om Organics benefitted through their work on this project, becoming better advocates and marketers of specialty crops within the San Francisco Food Shed area; establishing new and deepening existing relationships with distributors and buyers, and by clarifying the needs of specialty crop producers and buyers.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.
- If there is a remaining balance, explain why the project did not utilize all awarded grant funds.

GVC found that building meaningful and successful relationships takes time and purchasing decisions are not made overnight. However, the project partners were able to continue and make significant headway in building up new San Francisco contacts, relationships and business for the specialty crop growers in the region.

The logistics of moving fresh produce from small farms into the wholesale distribution supply chain can be quite complex. Small farms often specialize in unique products and prefer direct sales in order to receive a premium price, while wholesale produce distribution relies on consistency, high volume and good pricing to maintain the chain from field to kitchen.

It was difficult to engage the growers during their busy harvest season of May through September, and it proved almost impossible to bring buyers out to the farms, so GVC took up "reverse" trade missions (taking growers into the city for outreach calls on hotels, restaurants and other institutions). Project staff also held a successful "internal" trade mission (inviting buyers and distributors to a forum/tradeshow-type event in Oakland. This event also included educational panel presentations and a lunch showcasing local, seasonal produce.

Tracking the full quantitative impact of the project proved exceptionally difficult. After the initial survey results were aggregated, it became clear that each grant partner was working independently to bring specialty crops from their respective regions in the San Francisco markets. Results of the connections established between growers and buyers were to be documented through the food ordering system that was created, but much of the ordering became direct (grower to buyer) or grower directly to large distributor (Sysco) circumventing the project's established food distribution model for ordering and tracking. Thus, consistent information was not recorded into the distribution system as outlined in the program model.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attachments:

- Attachment 1 - CAFF Final Report 2011
- Attachment 2 - Marin Organic Business Member Program
- Attachment 3 - Food Distribution System Model
- Attachment 4 - Marin Organic Final Report for 2010 & 2011

Link to marketing material used during project:

Buy Fresh, Buy Local – Eater's Guide to Local Food – Bay Area Edition

http://caff.org/wp-content/uploads/2010/07/CAFF_BA.pdf

Reference/research document used by grant partners:

Link to San Francisco Foodshed Assessment:
http://www.farmlandinfo.org/documents/37187/ThinkGloballyEatLocally-FinalReport8-23-08.pdf

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 32	Project Title: A Growing Movement to Seed Change	
Grant Recipient: Lake County Health	**Grant Agreement No:** SCB09039	**Date Submitted:** December 2012
Recipient Contact: Denise Pomeroy	**Telephone:** 707-263-1090 x202	**Email:** denisep@co.lake.ca.us

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Lake County is challenged with economic and health issues; it ranks 53rd of California's 58 counties for poorest health due to death from all causes, and was ranked the 14th most stressed economy of 3,414 counties nationwide with populations over 25,000 according to the Associated Press Economic Stress Index in 2009. This was the broad context for the project, "A Growing Movement to Seed Change,"--- as a vehicle to impact population and economic health of the community. Motivation was rooted in seeding health and economic change, literally from the ground up. Timing of the project coincided with a countywide obesity prevention initiative and realization that increasing access to, and consumption of, healthy locally grown produce would be a boost to local agriculture and farmers (a mainstay of our economy), as well as a boost to community health.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activities centered on the promotion of local produce via "Eat Fresh Buy Lake County Grown" messaging, logos and www.lakecountygrown.com online Farmer's Market linked to an inaugural Local Food Forum (Summit) and Food Guide as rallying and galvanizing activities of the project. The project also included a Farm to School/Institution expansion aimed at increasing institutional purchasing by 20%. Farm to School was launched as part of an obesity prevention initiative that overlapped with the project. The rationale was to utilize these activities to increase market opportunities for farmers, thereby increasing production of specialty crops by 20 acres. All project goals related to these activities were accomplished.

The Food Forum and Food Guide have been effective awareness-raising and galvanizing tools to take advantage of the local food movement. Significant results were accomplished in the Farm to School (F-S) program as one school district was featured on CBS Morning News for the exemplary model they have developed. Five school districts participated in F-S; purchases of local produce increased by 20%; and institutional purchasing increased by 20% in 3 senior centers, 3 restaurants and one casino; all of which met the goals of the project. F-S is gradually increasing market opportunities for farmers as food service directors become savvy in from-scratch cooking methods and processing large quantities of fresh produce for immediate and long-term use.

The online ordering system will require longer than this grant term to develop full potential. A major accomplishment was its launch and the fact that it is being sustained beyond the grant term via a transition of the website from the Farm Bureau to North Coast Opportunities (NCO), a community based organization. NCO functions as the community action agency in Lake and Mendocino counties and is involved with a number of food system activities. Over the grant term, www.lakecountygrown.com has been open to the public for one complete growing season and a portion of two additional growing seasons. It is still in the process of becoming established and thus the impact of online ordering as a tool for increasing market opportunities and crop production cannot be quantified at present. One indication of its potential for increasing market opportunities is the fact that one major grower has now placed all his produce into the online market.

Specialty crops have increased by 20 acres, but not by means entirely related to this project. Unusual, uncontrollable events that transpired over the course of this project include the loss of the Farm Bureau director to a serious illness which impacted the online ordering implementation, as well as the severe national economic downturn that has hit California especially hard. Recommendations for the future include drawing from the Community Nutrition Expansion Project (CNEP) funding to continue updating of the Food Guide as an educational tool, and to continue moving crop production issues through agricultural and nutrition venues.

The project partners have been pivotal to the success in meeting project goals and objectives. *County Health Services* was integral to fiscal and procedural expertise, especially in addressing online system adjustments related to the loss of the Farm Bureau's director. The *Lake County Farm Bureau* provided the design, development, implementation and launch of the online ordering system. *NCO* has been an important partner in opening the way for low income populations to access more local foods by including locally grown produce within the food banks they operate. In June 2012 NCO took over the administration of the project's website and will work on its long-term sustainability by increasing product availability and connecting to the community cooperative to create strategies that facilitate working in tandem. *The Network for a Healthy California* has been instrumental in providing classroom nutrition lessons and food service training, and implementing complementary strategies such as Five-a-Day and Rethink Your Drink, as well as making a wealth of educational materials available. *The Local Food Roundtable* comprised of a cross section of attendees ranging from farmers and interested citizens to policy makers, has been an invaluable partner in more fully developing the potential of the local food system and providing a venue for networking and connecting the dots across various entities. The *Roundtable* established two subcommittees to focus on increasing production of specialty crops and to increase access to healthy foods across all population sectors. *Women, Infants and Children Program* has been a partner in providing nutrition education and most recently has become involved with nutrition education in schools via CNEP. The project *Steering Committee* comprised of the Ag Commissioner, Farm Bureau, Cooperative Extension, Farmer's Finest Collaborative and County Economic Development, has also been invaluable to project implementation.

Once the project ended, the North Coast Opportunity (NCO) has taken responsibility of continuing the project work. Therefore, the dairy references on the website were not a part of the website content during the duration of the project, and thus, have been recently added by the NCO.

During the course of the grant, Lake County Public Health made it the upmost priority not to allow a non-specialty crop to be incorporated on the website. All orders came through the sub-contractor who made sure only specialty crops items were available and sold. This was a weekly process that was conducted throughout the entire grant term.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Local Food Forum: The inaugural first countywide Food Forum was a means to begin creating cohesion in community messaging related to impacts of nutrition, local agriculture production, market opportunities and economics. It was an excellent vehicle for networking and creating common ground. At public request to make Food Forums an annual event, project goals were expanded to include a second Food Forum as a means to conclude this project, discuss accomplishments and future opportunities.

Local Food Guide: A template for the Food Guide was developed late 2010 with release spring 2011. About 10,000 were distributed through various organizations, such as Farmer's Markets, public and private organizations, as well as inserts in the local newspaper. A unique feature of the Food Guide is its section on nutrient content of various specialty crops, and general health benefits of good nutrition. Organizations such as Public Health and the hospitals have utilized it as a tool for nutrition education. In response to very positive feedback, project goals were expanded to include a second edition.

Promotional Activities: A suite of activities worked in tandem with the Food Forum and publication of the Food Guide to focus attention on launch of the online Farmer's Market. Promotional slides were run during intermission at the local cinema reaching 10,000 movie goers per month; placing an ad in the popular Mendo/Lake Family Life Magazine got the word out to about 6,000 students/families via school distribution, as well as to another 1500 residents in various locations countywide. Table tents with Eat Fresh messaging were placed in restaurants. Promotions were conducted at all local food-related events, such as the annual Pear Festival, County Fair, Farmer's Markets, Chamber of Commerce mixers, organizational board meetings, Iron Chef cook-offs, press releases, and special articles featuring local farmers. Data related to usage of the online ordering system is as follows:

- 28 farmers registered to participate online (of about 40 viable specialty crop farms); 23 were trained on the how to use the system, and 18 overall have been selling online
- 208 customers registered online, with 104 customer sales and 420 total purchases; there was a total of 19 institutional sales
- 217 products were offered online; items most frequently purchased were Hosui Asian Pears, Red Slicer tomatoes and Brandywine tomatoes
- Nearly $10,000 in total sales; the highest period of sales was November 2011 with 68 orders

Baseline for the promotional activities was zero; this was a first-time endeavor to engage the public with local food system development via a Food Forum, Food Guide, and focused messaging: Eat Fresh, Buy Lake County Grown. This was also a pioneering effort to launch and implement an online Farmer's Market to conveniently link farmers to the public and institutions electronically as a tool to increase consumption and production of specialty crops. One may deduce a 100% increase in activities.

Farm to School/Institution: Kelseyville Unified Schools, featured on CBS Morning News, increased local purchase from baseline 10% to over 60%; in the other schools, baseline of less than 5% increased to 20% measured by purchasing records. Local senior centers and restaurants have also increased purchase by 20% per grant targets. This project has put a spotlight on the benefits of purchasing local products, and institutions are increasing purchase of local produce, but it cannot be concluded that all of these increases are directly attributable to this project since "buy local" has diffused nationwide.

Increased Crop Production: The goal was to increase production from 30 to 50 acres. Specialty crop production has burgeoned more than 20 acres when assessing walnuts and grapes. Although this project did not have specific crop targets, the aim was to increase smaller scale vegetable and fruit production. By October 2011, approximately 20 acres were added as 8.5 acres of hops, 1.5 acres of pomegranates and 12 acres total of peaches, apples, plums, and strawberries; olives increased by 27 acres; thus reaching project targets. However, in looking at the most recent 2010 Ag Commissioner's crop report, there was a decrease in vegetable production by about 10 acres as the economy has weakened.

General Outcomes: Gauging by the numerous ways this project has interfaced across multiple venues to address local food system issues, with most recent reference to this project made by the Board of Supervisors in discussions about outsourcing of food for the local jail, it can be said that outcomes have been met to begin galvanizing the community toward support of a local food system; to expand existing local food system efforts; to increase local markets for farmers, to increase acres of specialty crop production and to increase local access to nutritious foods. This project has increased discussion regarding the parallel nature of increasing markets, increasing production, and the challenge of doing both concurrently.

Beneficiaries:

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

This project has reached into nearly every nutrition/food access/food system group in the community. It has been a catalyst for food system networking activities, for expansion of F-S implementation and related policies countywide, and has been the organizing focus for the Food Access & Nutrition Education workgroup and the Farm Production workgroup. A conservative estimate of 30,000 beneficiaries has been affected by the project based on the following: Children under age 18 comprise about 20% of the population, thus nearly 13,000 student beneficiaries result by means of F-S. When considering that children have at least one parent, another 10,000 can be added to the total. Beneficiaries also include school food service staff, teachers, school board members, and school administrators who have made a commitment to putting F-S into policy. The online system engaged 28 farmers and over 200 registered customers. When considering local and regional interfacing among the agricultural community, public and private entities, restaurants and other institutions, families and customers served by these entities, as well as groups like the Local Food Roundtable, it conveys a ripple of benefit across the entire community of 65,000. $80 million in economic benefit to the community would be generated if each person in Lake County spent $25/week on local products instead of on imports.

Lessons Learned:

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

To find a unifying concept that will rally support across sectors, the project found that focus on nutritional value of veggies, fruit, and nuts and projects like Farm to School that benefit children's academic performance and better population and economic health elicit cooperation and seed change.
Online ordering systems have enormous potential, but the pioneering nature of this undertaking may take up to 5 years to fully establish. Time the launch of the system to take advantage of a full growing season and be unrelenting with marketing. It's important to build sustainability measures into the system at the start. With the sharp downturn in the economy, this project was hesitant to charge service fees to farmers and discovered it's increasingly more challenging to put service or user fees into effect the longer the project continues. A number of services can be built into the system to generate fees, such as brokering contracts between farmers and institutions, delivery fees from farmer to customer drop points, or assisting farmers in placing their products online. It is important to discuss service fees with growers and buyers and test/incorporate them while the project is still in design.

There is a potential to grow, process, market, distribute and sell local pear/apple sauces and vinaigrettes, dried fruit/veggies, flour and nut butters, and have nearly a year-round growing season if crop production could be better organized and sequenced. This would create jobs and contribute to self-reliance. It would take a one-time infusion of funds totaling about $1 million to bring this to fruition. Without that, Lake County will be challenged just to maintain its current capacity and will remain limited in growth.

Food System development has political/philosophical/ideological implications that can become impediments to progress. A unifying concept, such as F-S will provide common ground. F-S demonstrated that farmers can extend availability of local produce to schools by the kind of crops selected and how they sequence planting their crops.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

The Food Forum nutrition information and Food Guide is located on the Public Health website; http:/health.co.lake.ca.us.

Project 33 – Ecology Center (EC)

Final Performance Report

Project Title
Ecology Center Nutrition, Food and Farming Programs

Project Summary
California Specialty Crop (CSC) farmers struggle with high production costs and losses due to perishability that increase the farther CSCs are shipped. Simultaneously, California's low income populations are suffering disproportionately from diet-related diseases while receiving over $2.5 billion yearly in food benefits. The issues for both farmers and residents are being exacerbated by the economic crisis that began in 2007. A 2000 Berkeley Food Policy Council community survey showed the top barriers to purchasing CSCs for low income residents were convenience, money, access and knowledge about preparation. In order to expand the local market for CSCs while addressing California's epidemic of diet-related diseases, the California Department of Food and Agriculture (CDFA) approved EC's proposal to address these issues using: 150 Farm Fresh Choice (FFC) at-cost CSC produce stands at subsidized afterschool sites; city-wide planning focused on increasing CSC availability through the creation of the Berkeley Food Policy Council (BFPC); 150 Berkeley Farmers' Markets (BFM); and assistance getting and using wireless Electronic Benefits Transfer (EBT) devices and market scrip for 20 more farmers' markets statewide.

Overall the goal was to develop low income shoppers as a long-term regular local market for CSCs by reducing economic, educational and access barriers and tapping into over $2.5 billion in federal food benefits that are currently not widely or directly accessible to small CSC growers.

Project Approach
The three major approaches used are: 1) Developing access and increasing shoppers to local CSC direct marketing venues, 2) Creating a new Berkeley Food Policy Council to leverage key community partners in increasing the purchase of CSCs by low income residents, and 3) expanding the availability of EBT at farmers markets across the state. All three of these efforts have been highly successful this year.

EC's Statewide Farmers' Market EBT Program exceeded expectations in 2010.
A solid set of support materials (some bi-lingual or multi-lingual) was created for markets adopting EBT and made them available on the website and by request. An intensive outreach and promotion effort was completed creating an extensive list of market managers and community partners (over 300 and growing), tapping into opportunities through CDFA communications with market managers, and contacting market managers and associations directly. Technical support was provided to over 30 market associations statewide, touching over 70 total markets. The California Department of Social Services was advised and supported in developing the statewide Farmers Markets EBT Advisory Committee. The EC supported and advised ALBA Organics on getting Assembly Bill 537 passed. Finally, EC consulted and advised on the issue of farmers' markets at flea markets and their ability to offer EBT access.

There is a groundswell of markets adopting EBT and new markets starting with EBT, and redemption of EBT at farmers markets is growing rapidly.

EC built the Berkeley Food Policy Council (BFPC) to leverage community partners in increasing the consumption of CSCs.

Informational interviews of key stakeholders were completed and the timeline to meet their needs was adjusted. The EC recruited and convened a steering committee that has met at least monthly since July of 2010. An initial four-hour kick off Summit was held at the David Brower Center on September 10, 2010, with over 30 participants from diverse and relevant backgrounds representing over 20 organizations. Working groups were established, which created strategic work goals that were presented to the whole Council at the second quarterly meeting at the Clark Kerr Campus of University of California, Berkeley, on December 10. In spite of the late start resulting from the Vision 20/20 process (mentioned in last report) in which many BFPC partners were engaged, the project has made numerous strides and proposed its first local legislative proposals and project collaborations. The strategic goals presented at the December meeting are currently being compiled for final approval at the March 2011 quarterly meeting.

EC's effort to increase the demand for CSCs has been successful.

Additional small markets in the area of the programs have started selling CSCs and expanding produce sales in their stores; this is a great trend and shows the success of the outreach and consumer expansion efforts. During the grant term, EC submitted the winning bid to open a new farmers' market in Albany, California, which will increase the number of CSC farmers able to sell in the region, as well as the number of customers served in 2011. EC's goals have been met for the Farmers' Markets (150), and the customer survey at the BFM gave important feedback for improvement. The survey illustrated that targeted outreach strategies work better than newspaper advertising. The EC developed and released a press release promoting the CDFA hearings on reselling at farmers markets, and provided written comment and public testimony to relieve fears customers may have had about reselling at markets as a result of the sting operations in Southern California. Farm Fresh Choice (FFC) produce stands also met their goals (153) for this period. The cooking demos and tastings were highly attended and outreach to low income communities was stronger than ever. The FFC Program served nearly 15,000 people (14,781) during this grant term with professional level cooking classes, CSC produce stands, Nutrition Education events and youth trainings. In addition, FFC gave out 2,140 CSC tastings and distributed 9,191 recipes, Harvest of the Month newsletters (produced by Network for a Healthy California) and other nutrition education materials.

There were strong partner contributions from a broad range of organizations and businesses. In the BFPC, many of the organizations that sent letters of support for this grant came through on their commitments by participating in the steering committee, offering many hours of staff time, and sharing contacts and resources to make the Council a success. Since then, others have become involved in the working groups as well. Cal Dining offered the meeting space for free at the December BFPC meeting. The Institute for Food and Development Policy provided a presentation of their report for that meeting, which was facilitated by the Executive Director of the California Food and Justice Coalition. Slow Food recruited and placed dozens of volunteers at community gardens during the "Dig in Day of Acton." The Mayor's office has invited the EC to participate in the Mayor's Health Task Force. Partnerships with Pacific Coast Farmers Market

Association, Kitchen on Fire and Bauman College have allowed EC to produce high quality cooking classes and demos at farmers' markets. These emerging partnerships have been highly successful and represent great potential for the future.

Goals and Outcomes Achieved

Outcome 1: Increase the number of Farmers' Markets in California that accept EBT benefits from 118 to 138 as measured by the number of authorizations from California Department of Social Services for CFM wireless Point of Service devices and by actual EBT sales/usage at the new markets.

The EBT Farmers' Market Specialist hit the ground running this spring by researching and developing updated materials for market managers. The new *Simple EBT Guide for Farmers' Market Managers* has updated information that compiles information from a number of sources and makes it easy for market managers to understand the processes to start and run EBT services at markets. This guide and additional technical assistance was provided to 33 market associations. Also prepared were customizable templates for posters, fliers, press releases, ads, scripts and standardized forms and vendor training tools for markets to use.

With tools in place, the EC began an intensive outreach and promotion campaign to let market managers and community partners know about the resources available to them and the benefits to farmers of accepting EBT at their markets. EC researched and complied a growing list of over 314 market managers and community partners with whom we an initial communication was sent informing them of EC's services. Key individuals were contacted at state agencies and informed that they could refer relevant inquiries to EC for support.

Finally, technical assistance was provided to 33 market associations (certificate holders) representing 72 markets and an estimated 642 CSC producers, helping them on a range of items, including:

- Preparing their application (14)
- Developing a staffing plan (14)
- Training vendors (7)
- Setting up logistics, record keeping and accounting systems (13)
- Promoting the launch with signs (3), posters (2), fliers (11) and media work (5)
- Offering free start up scrip (10)

Twenty-four of the market associations worked with used EC's Simple Guide. Recently a survey was sent out to clients that were serviced to capture results, number of CSC farmers served, suggestions for improvements and more. The response to the survey has been slow and the results are still being compiled.

In December 2010, EC successfully recruited, trained and transitioned the contract from Penny Leff to Carle Brinkman, the former Regional Manager for Alameda County from Pacific Coast Farmers' Market Association. Ms. Brinkman was selected from a competitive pool of respondents and comes with a thorough understanding of EBT at farmers markets, state agencies, growers and market operations to be highly successful in furthering this program in 2011.
Ms. Brinkman has hit the ground running and is developing regional efforts in San Diego County

and other regions as a new focus and partnering more deeply with Roots of Change to help new EBT markets find ways to top-up their outreach efforts, and benefit from the top-up experiences of the Farmers' Market Consortium.

Outcome-Oriented Objective 2: Complete a BFPC Strategic Plan to coordinate existing programs identifies gaps and better incorporate health service providers. The primary goal of this plan is to increase the consumption of CSCs through community partnerships with an increased focus on the health benefits of consuming CSCs.

In July 2010, the EC convened the first meeting of the steering committee of the Berkeley Food Policy Council. This steering committee was comprised of an executive director, educator, food producer, youth program manager, public health professional, market manager, community gardening coordinator and school garden manager. This committee met numerous times in the following months to plan the first general meeting and recruit members to a four-hour Summit on September 10, at the David Brower Center. The first general meeting, or "Summit", had 34 participants from 22 organizations. The meeting was professionally facilitated and combined introductions and networking, information sharing, break out groups, brainstorming and working group creation. During this first meeting the BFPC members chose the direction and activities they wished to see the Council take for the next year.

The first collaboration of the new Council connected a large volunteer pool through the Slow Food Dig in Day of Action with the local community gardens in Berkeley. Dozens of volunteers came out to help weed, build and engage with the local community gardens. Local Youth Leaders at Berkeley Youth Alternatives (BYA) directed volunteers and educated them on local food access and nutrition issues. The event was followed by a community potluck at the BYA Garden Patch.

In October, Martin Bourque and Armando Nieto attended the Roots of Change conference in Los Angeles and were able to represent the BFPC. This conference gave the BFPC some statewide visibility, and connection to numerous other Food Policy Councils including the Los Angeles Food Policy Task Force who had just released their impressive report at a ceremony with Mayor Antonio Villaraigosa. This network offered many resources to restarting the BFPC, helping to address important governance question and more.

At the invitation of the Mayor, the Ecology Center has been representing the BFPC at the Mayor's monthly Health Task Force Breakfasts. This meeting of the leadership of the region's leading health care facilities and organizations gives EC a perfect venue to present information and stay current on developments in the health care sector. These presentations offer high level entry and access to decision makers that we will need to build strong collaborations with the health community going forward. The EC presented the Veggie Rx concept, which was well received, and discussions have begun with Alameda County Health Department and Lifelong Medical Care to explore such a partnership.

The working groups have developed strategic work plan and agenda for 2011. The main focus of the group is to share information and develop stronger partnerships and programmatic collaborations and to improve the policy landscape to reduce the disparities in diet related illnesses through the increased consumption of fresh fruits and vegetables for low income communities. Working groups are currently grouped around a citywide marketing campaign, leadership development for outreach in the Spanish speaking community, urban food production, youth job creation and defining a policy agenda. These priorities were presented to the whole group at the December meeting.

The December 10 general meeting of the Council was at the Clark Kerr Dining facilities and highlighted the work they have done to incorporate more farm-to-fork contracting through their Real Food Challenge. Thirty-five individuals attended the meeting from 27 organizations. Armando Nieto a professional facilitator with decades of experience facilitated the meeting. The meeting included a valuable presentation on the findings of a recent study by the Institute for Food and Development Policy on lessons learned in their national survey of what is working and what is not in food policy councils.

The results of the working group's initial efforts were presented and reviewed by the larger group. These are now being complied into a document as the draft strategic plan for review and approval at the next meeting. A survey of participants was performed after each meeting to provide feedback on the event and Council structure to date. The results are highly positive and constructive suggestions are being incorporated by the steering committee. A Google group has been established to facilitate communications and a Google website to house contact lists, shared documents and more.

Outcome-Oriented Objective 3: Increase the number of subsidized after school site FFC Farm Stands from two to three, increasing shoppers from 600 per month to 800 per month; provide 12,000 CSC tastings at Stands and community events to residents who are predominantly low income and/or of color.

The EC opened the new stand at Frances Albrier afterschool program as planned and completed 153 urban produce stands in 2010. The FFC held or participated in a total of 167 training, outreach, tasting and cooking demo events with a total of 14,781 contacts and distributing 2,140 free CSC samples and 9,191 nutrition education materials, including recipes and copies of the Harvest of the Month newsletter. The EC trained a growing group of 26 youth interns during the year developing youth advocates for CSC consumption. In addition to the new produce stand, shoppers are now able to get fresh local organic foods at a number of low cost locations nearby. While this means our weekly produce-stand shopper rates did not reach the goals established, we are pleased that the larger goal of increasing the availability and demand for CSCs is increasingly being met. In addition, the FFC Youth are canvassing the neighborhoods of the stands during the week to encourage more shoppers by passing out fliers, engaging community members and educating them on the CSC availability. This is a new effort but it is already increasing shopper numbers by 150 percent at two of the stands.

<u>Beneficiaries</u>
The Projects primary beneficiaries are CSC growers. The program overall directly served an estimated 685 CSC growers. Through the Farmers' Market EBT Program EC served an estimated 642 at 72 markets by helping the market associations to move forward in accepting and promoting EBT. The Statewide EBT sales at farmers' markets increased by over 60 percent

in 2010. With more than $2.8 billion in projected food benefits for 2011, EC looks forward to this growth continuing in the future. At the BFM, 46 CSC growers were directly served by increasing the number and frequency of shoppers though events and promotions. FFC served these same farmers directly and many more indirectly through the nearly 15,000 low income client contacts EC had throughout the year promoting and educating the public to eat more CSCs. More importantly, these contacts have a broader effect over time as strong values and behavior change are developed in the youth that come through this program. These changes affect their families and slowly alter the norms and behaviors of their boarder community. Of course, these health-focused contacts also benefitted the clients in improving their self-efficacy, knowledge and economic access to CSCs. The EC has indirectly served CSC growers through the BFPC, and as this group grows and develops it has strong potential to leverage a significant amount of purchasing through the many active partners.

Lessons Learned

Early in the project it became clear that some kind of incentive was needed for the EBT program. Market Managers are very busy and something was needed to get their attention. Free tokens were offered and posters/fliers were designed for them and have built that into the 2011 budget. Having additional funds for "topping up" and other customer incentives would be very helpful but were not in the scope of this or future proposals. However, through the process of researching best practices for topping up, EC also learned more about Wholesome Wave's work with a "Veggie Rx" program on the east coast. This has led to extremely positive program and partnership development, and EC is hopeful to be able to launch an East Bay Veggie Rx program in the next 12 months as a way to further increase CSC market share and consumer health.

In the BFPC it became clear early on that another collaborative project within the community was going to impact the partners' ability to participate in the BFPC. In order for the BFPC to be successful, it would need to wait to start the project until the other cross sector project was completed. Listening and adjusting to accommodate partners was an effective strategy in getting strong participation from the beginning.

As mentioned earlier, the Farm Fresh Choice stands exceeded their community contacts significantly, but the shopper rate dropped. Upon talking (informally) with shoppers to find the cause of the drop-off, two positives became apparent. The first is the aforementioned addition of CSCs in several local shops that previously provided little or no produce. This is seen as an excellent indicator of community demand. The second lesson learned was that shoppers eventually "graduate" from the FFC produce stands and moves on to shop other places. While this is also an excellent indicator of increased preference and self-efficacy, this served to remind staffs that ongoing efforts must be made to "recruit" new shoppers from the communities served. Those outreach efforts are now underway and are doing very well.

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California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.: 34	**Project Title:** Head Start Nutrition Garden Program	
Grant Recipient: Western Growers Foundation	**Grant Agreement No.:** SCB09007	**Date Submitted:** December 2012
Recipient Contact: Paula Olson	**Telephone:** 949-885-2249	**Email:** paula.olson@wga.com

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Studies show that all youngsters (ages 2 – 5) are eating 80% of recommended fruit and only 25% of recommended vegetable servings. Their diets are directly linked to their socioeconomic status, with those in need consuming the least amount of fresh fruits and vegetables (ISSUE).

This project impacted 100 Head Start sites and approximately 3,000 Californians between the ages of 2 and 5 that live at or below the poverty level. Head Start sites also offer nutrition information and education to the parents and families of the students, which at minimum increased the 3,000 to 6,000. As stated in the video: adults learn too!

One-third of America’s children are overweight or obese. About a third of obese children become obese adults. The estimated annual cost of treating obesity-related illness in adults is $147 billion (Health Affairs (2010):364-271).

The motivation for this project is for both the health of our children and the health of our economy.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

- Awarded 100 Head Start centers $600 each to grow and sustain their edible garden
- Delivered garden and education supplies to each participating site
- Created and administered on-line survey of grant recipients and reviewed survey result to select those Head Start schools to be filmed
- Conducted at least 10 site visits
- Filmed, edited and produced a video, “Seven Tips for Head-Start and Pre-school Edible Gardens.”

- Distributed 200 of the 500 videos through Head Start to other Head Start centers with 300 going out to all pre-schools and schools, on request.

Head Start, particularly, Paula Carrino, was instrumental in promoting the application process, reviewing the applications and assisting with distribution of materials.

Western Growers Foundation (WGF) staff, in addition to administering the grant (accounting, sourcing materials, promotion) coordinated site visits, directed filmmaker, edited and promoted film.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Head Start staff reviewed more than 140 applicants to select 100 Head Start Centers to receive the grants (goal #1). By providing these grants, the number of Head Start fruit and veggie gardens increased by 130% -- from 75 to 175. At least 10% of these centers also offer family education, as explained in the video (target). The video was posted on August 22, 2012: http://www.westerngrowersfoundation.org/news/headstart/video and received 270 views in the first week; the goal was 500 views. (Target). This press release went out on 8/30/12 and considerably more web activity is anticipated: http://bit.ly/S2jL8S
WGF, along with key partners, such as Life Lab, has created and re-designed www.csgn.org which is an easily accessible site filled with school garden resources. The video will be posted on this site in September. (Goal #2)

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

California Head Start has a funded enrollment of 111,561 children and serves more than 126,000 families. (http://caheadstart.org/facts.html) One hundred of these centers have new gardens. Sharing garden successes and tips through the video has already spread throughout the Head Start community.

The video will provide additional resources to those interested in starting a garden.

The California produce industry represents more than $20 billion dollars. As children learn to enjoy fruits and vegetables, they are not only improving their own personal health, but they are supporting one of the state's most important industries.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

With a change in WGF staff, timing was a bit of a challenge. Ultimately, WGF was able to stay on track with the project plan, except in one area. The video was posted later than expected (August 2012, instead of February 2012). That said, WGF is still reaping the benefits of shared successes in pre-school gardening and will monitor the interest going forward. This has been a win-win-win for school gardening, the children, communities and the produce farmers.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

The video can be viewed at: http://www.westerngrowersfoundation.com/news/headstart/video

One of the recipients expressing appreciation is:

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 35	Project Title: Linking Ethnic Specialty Crop Producers and Low-income Consumers through Marketing and Nutrition Education	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09017	**Date Submitted:** December 2012
Recipient Contact: Lucia Kaiser	**Telephone:** (530) 754-9063	**Email:** llkaiser@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

To address the economic constraints low-income populations face in consuming more fruit and vegetables, the federal Special Supplemental Nutrition Program for Women, Infants and Children (WIC) began in October 2009 to distribute vouchers to low-income women with children to buy fruits and vegetables. As a result, WIC participants currently receive vouchers with a monthly cash value for fruits and vegetables, which consist of $6 for children and $10 for women.

In an analysis of the potential impact of food type on WIC expenditures, the U.S. Department of Agriculture (USDA) estimated milk would remain the highest cost food with fruit and vegetables ranked fourth, just slightly less than breakfast cereals (Hanson and Oliveira, 2009). The USDA projected a net increase of $76 million in farm revenues from the addition of the fruit and vegetable vouchers to the WIC food packages. Pilot studies, conducted in New York and California, reported that cash-value vouchers increased WIC participants' purchases of fruits and vegetables (Herman et al., 2006; Klein, 2008 per ERS73).

To realize fully the health and economic benefits of the new fruit and vegetable voucher may require new strategies to improve access to and utilization of fruits and vegetables in WIC populations. This project examined the potential for small-scale farms in California to market locally grown produce to WIC clientele. The motivation for this project was to explore whether a Farm-to-WIC intervention, coupled with vendor education on produce handling and WIC client education, can increase local availability of culturally preferred foods and utilization of the cash-value produce vouchers. The project was expected to: 1) enhance small growers' financial viability and access to new markets; 2) provide WIC clientele with better access to more nutritious and culturally-appropriate produce and expanded nutritional knowledge; and 3) enhance the sales and profitability of WIC-only stores and provide high quality produce to WIC clientele.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

A team of University of California Cooperative Extension (UCCE) academics and staff developed a Farm-to-WIC project to connect small local growers with WIC stores in the following three counties: Alameda (highly urbanized), Tulare (largely rural) and Riverside (combination). Activities also included nutrition education to the local WIC clientele, postharvest research, and produce handling training to employees of the participating WIC-only stores, which included Prime Time Nutrition, Fresco Marketplace, and Fiesta Nutrition.

In 2010, the Nutrition Advisors conducted a survey of WIC clientele in the three counties to identify the preferred stores to target for the project and the produce items to be included. The participating UCCE Farm Advisors reviewed the preferred items and identified 18 crops that could be produced in their counties and handled safely by small-scale growers. These crops included broccoli, cabbage, carrots, cantaloupe, grapes, lettuce, nopales, oranges, spinach, strawberries, sweet potatoes, tomatoes, tomatillos, bell pepper, collard greens, mustard greens, green beans, and watermelon. Under supervision of the Agricultural Economics Specialist, the Small Farms Project Staff contacted the preferred stores, provided each manager with a county-specific survey results, and requested a meeting to discuss logistics for purchasing WIC-popular crops from small-scale local growers. In August 2010, the Small Farms Project Staff initiated contact with buyers from the preferred stores, including regional grocery chains; however, only the produce buyers from WIC-only stores were interested in the project. At least three stores in each county were selected, which resulted in one chain with three sites in each county totaling nine participating stores.

The farm advisors in the three counties contacted small-scale growers who might be interested in supplying produce to the WIC buyers directly and attempted to set up meetings with store buyers. In Alameda County during October 2010, a Farm Advisor worked with a small grower to prepare a list of crops offered and facilitated a meeting at grower's farm with the buyer from Prime Time Nutrition. In Tulare County, another Farm Advisor worked with small-scale grower to introduce him to the WIC store owners as well as helped him arrange to sell watermelons to the store owners. Unfortunately, this sale was not able to be made due to unforeseen constraints. Because the project team was not able to break the initial economic barriers faced by small-scale growers, many activities related to these growers was not able to take place such as assisting growers in determining appropriate handling distribution/methods. Also, this same impediment prevented small grower meetings and workshops to be conducted.

After determining that connecting individual small-scale growers with individual WIC stores proved to be too difficult to overcome during the grant term, the Agricultural Economics Specialist and the Small Farms Project Staff refocused efforts on another avenue to reach the projects goals. The project team decided to locate regional produce aggregators and distributors who purchased from local small-scale ethnic growers in order to integrate small-scale growers into the existing WIC store produce supply chain. To start, the Small Farms Project Staff contacted ALBA Organics, a regional produce distributor, who distributes for organic farms in Monterey County.

In March, 2011, Prime Time Nutrition's buyer negotiated the purchase of 160 cases of lemons from France Ranch/Homegrown Organics through ALBA Organics. In May 2011, ALBA Organics sold 500 boxes of the strawberries to Prime Time Nutrition for their Northern California stores. These two purchases totaled a little more than $10,000, of which approximately $5,000 went to local small-scale ethnic growers. The ALBA Organics manager was satisfied with these sales and was willing to negotiate on price to secure future business from Prime Time. However, in the long run the Prime Time buyer decided not to participate. In Tulare County, a Farm Advisor attempted to contact the head buyer for a regional produce distributor, OK Produce, which was supplying the three targeted Tulare County WIC stores with direct delivery twice each week. OK Produce was not responsive to the project team. In Riverside County, the owner of the three targeted WIC stores in the Coachella Valley contacted the project staff in 2011, seeking assistance in locating a full-line produce distributor that would deliver to his desert stores. The Agricultural Economics Specialist and the Small Farms Project Staff located a non-profit food security organization with a mission of increasing access to fresh produce in low-income communities. The organization's director was willing to purchase produce from larger local growers and deliver to the WIC stores, but was unable to package the produce as needed and deliver it for a price that the store was willing to pay.

When numerous and varied attempts to connect small-scale farms to WIC-only stores were not successful, the UCCE team began to focus its efforts on addressing other project goals such as providing culturally relevant nutrition education to WIC clientele and improving the quality of the produce in the WIC-only stores. Working under supervision of the Nutrition Specialist, Nutrition Project Staff developed 18 fact sheets each featuring a single fruit or vegetable. These fact sheets were specifically designed to fit the needs of WIC clientele. In the final survey conducted among 61 WIC participants in 2012, 95% (58) reported that the information in the fact sheets was useful and among these, 75% (45) said they preferred the fact sheet (paper handout) over other mediums to receive the information. The Small Farmers Project Staff and the Nutrition Project Staff also developed a colorful "What's in season poster?" as a guide for buying locally-grown produce. The Nutrition Specialist and the Nutrition Advisors conducted WIC clinic staff training in Alameda, Tulare and Riverside between April and May 2012 (see Attachment 1 to view PowerPoint). Approximately 150 WIC staff participated in the trainings. In addition, Nutrition Advisors and Project Staff presented posters and an oral presentation at the following three conferences: Childhood Obesity Conference in San Diego (June 2011); American Dietetic Association in San Francisco (September 2011), and WIC Annual Conference in Palm Springs (May 2012).

Efforts to improve produce quality included research and extension activities. The Postharvest Specialist conducted research to examine the effect of a range of temperatures on nutritional content of ten vegetables, including artichoke, arugula, asparagus, beans, broccoli, cauliflower, kale, snap peas, spinach and zucchini. There was considerable variation in Vitamin C content and antioxidant activity, and the losses varied according to temperature and vegetable. Generally, visual appearance is a sound indicator of nutrient retention for the following vegetables: artichoke, arugula, green beans, cauliflower, kale, snap pea, spinach and zucchini. Educational efforts included training of personnel in distribution centers and WIC-only stores regarding postharvest handling requirements of fresh fruits and vegetables. The four formal trainings reached mostly a female audience, with a minimum of 5 persons per training. The Postharvest Specialist led all trainings and made numerous store visits in Alameda, Tulare and Riverside counties.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The first project goal was to establish effective and safe distribution systems to have culturally appropriate produce from small specialty crop producers to WIC consumers. The project team sought to assist five to eight growers in each county to increase annual sales by 20%. Appropriate distribution systems were explored for small growers, both directly and through regional distributors. The UCCE team facilitated many meetings and contacts between growers and WIC-only stores, but none of these efforts were successful in overcoming the economic barriers that individual smaller-scale farm face in the WIC supply market. In-depth interviews were conducted in 2012 among five store owners or managers representing more than 230 California WIC-only stores. The store owners reported that the introduction of fruit and vegetables vouchers had led to either an increase in or had no impact on the number of WIC shoppers in their stores. Their responses were mixed regarding the impact on overall sales volumes; even those whose sales volume increased did not have increased profits.

Secondly, the UCCE team set a goal of educating WIC consumers regarding produce handling and nutrition. In addition, the team was to develop 12 produce handling and nutrition information fact sheets as well as increase usage (redemption) rate of new vouchers to 75%. 18 nutrition factsheets were developed and distributed to the targeted stores, which resulted in 1,800 in each county and totaling 5,400. In addition, three WIC agencies received 10 CDs with all factsheets and posters to managers and 1,000 factsheets to staff, which totaled 3,000. Although these products were well-received, statewide WIC data suggest that redemption rates of the WIC vouchers was probably already much higher than originally anticipated with reaching more than 90% by 2012. In both 2010 and 2012, UCCE learned from client surveys the quality of the produce is the most important factor, even over price and family preference, in selecting where to shop and what to buy. Many people report using their produce vouchers all at once suggesting produce is not immediately eaten after purchasing, but rather sits for days in the home. Thus, the real issue is not as much increasing redemption rates, but rather improving post-harvest handling to maintain quality of the produce longer after purchase.

The final major project goal was to assist WIC-vendors with produce handling practices and determine what postharvest conditions limit quality and nutrient losses for 12 key produce items. Experiments were conducted on 10 items, including artichoke, arugula, asparagus, beans, broccoli, cauliflower, kale, snap peas, spinach and zucchini. Vendors in the three counties received training on new practices to implement to maintain freshness and nutrient value of the produce. The UCCE team conducted trainings on produce handling in WIC-only stores and determined how a range of temperatures affect the marketable and nutritional quality of vegetables.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

In California, the nation's largest WIC program, 82 local agencies serve about 1.43 million participants at 623 local centers. WIC participants redeem their vouchers at 4,000 grocery stores statewide. About 40% shop at WIC-only stores, which only stock and sell WIC-authorized foods. WIC's caseload reflects California's diversity with 78% Latinos, 8% Caucasian, 5.5% African American 5.5%, 5% Asian, and 0.87% Native American, thus key beneficiaries include the diverse WIC clientele and vendors.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Small-scale farms face several barriers to entry when seeking access to the WIC fruit and vegetable voucher supply chain. These farms lack economies of scale in production; therefore, they cannot provide competitive pricing when selling direct to WIC-only stores or through produce distributors. The WIC-only stores are competing with established large retailers that operate with very small margins. When the project transitioned to involving ALBA Organics, a few sales transactions were made with the WIC-only store chain. ALBA Organics had several "assets" that the individual small producers were lacking: (1) ALBA Organics is familiar with produce industry standards; (2) it has a cooler facility and equipment to store and load the buyer's trucks; and (3) it has third party food safety certification and liability insurance. Additionally, the sales of local product occurred at the peak of the season when the price was low and product supply exceeded what could be sold directly by the growers. In conclusion, an individual smaller-scale farm offering limited product volumes, such as those included in the UCCE project, is not an attractive supplier to them when they need produce with high quality, steady supply and competitive prices.

Most WIC participants found the factsheets useful, especially the nutrition information and the tips on how to choose, store, and prepare the produce. Most expressed they learned something new from the factsheets. For example, several people were surprised at the differences in the shelf-life of various fruits and vegetables. Many mentioned that they had never eaten a certain type of vegetable before (collard greens, mustard greens, nopales, sweet potatoes and spinach), but liked the tips on how to prepare them. Other participants were surprised that these fruits or vegetables can be served to infants, particularly bell peppers, green beans, collard greens, tomatillos, and watermelon. WIC staff can utilize this information to promote fruit and vegetables to the clientele.

It was determined that visual appearance is a good indicator of good nutritive value for many vegetables. This message should be emphasized for produce handlers and consumers at the WIC stores. For many of the WIC-only store employees, store training is needed on topics such as temperature management with limited options, control of water loss, compatibility issues with focus on ethylene sensitive produce, minimizing decay, managing product turnover, and postharvest conditions to retain nutrients, among others. In most of the WIC-only stores, there were two temperature options: refrigerated shelf space at about 5C (41F) or ambient holding at 15-30C (59-86F) depending on location and season. Some of the more popular items (like avocadoes and mangoes) may arrive at the store unripe. Therefore, careful management of the ripening process is needed to prevent losses. For example, limes are popular and problematic. A potential solution involves a technique of intermittent warming, or switching the limes back and forth between the two temperature options.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections. See attachments

California Agriculture article:
http://californiaagriculture.ucanr.org/landingpage.cfm?article=ca.v066n01p15&fulltext=yes

Fact Sheets and posters:
http://ucanr.org/sites/comnut/mothersyoungchildren/Fact_Sheets/

Project 36 - Trust for Conservation Innovation (TCI)

Final Performance Report

Project Title

Healthy Food Access, Small Farm and Nutrition in Six California Foodsheds: A Consortium Promoting Supplemental Nutrition Assistance Program (SNAP) and Women, Infants and Children (WIC) Voucher Links with Farmers Markets

Project Summary

Roots of Change (ROC) formed the California Farmers Market Consortium (CFMC) in 2009/2010 as a pilot year with a specific interest in increasing the sales of eligible specialty crops at farmers markets in the following counties: Alameda, Fresno, Los Angeles, Monterey, San Diego and San Francisco. ROC was also able to bring in San Benito, San Mateo, Santa Cruz and Sonoma counties during this pilot year. CFMC's goal was to address two problems: 1) to increase the sale of specialty crops to a new market segment, which helps the specialty crop farmers that supply the urban core markets with healthy, fresh produce; and 2) to improve the nutrition of low-income underserved communities that suffer disproportionately from diabetes and other nutrition related diseases.

There is a substantial financial loss to the state when many eligible families do not participate in CalFresh (food stamp) benefits. The state is the largest agricultural producer in the United States, yet millions of Californians lack access to fresh fruits and vegetables, specifically low-income communities with higher rates of health disparities. The United States Department of Agriculture's (USDA) 2007 data show that only 48 percent of eligible Californians participated in CalFresh, leaving approximately $4.8 billion in CalFresh purchasing power of specialty crops unused. Evidence clearly suggests that in a state where food is a foundation that supports its role on the global stage, California can do better to nourish its citizens while improving the income of small farmers and the public image of California agriculture.

ROC chose partner organizations throughout California to encourage and enable federal nutrition benefit clients to purchase specialty crops at farmers markets with their benefit funds, and create a learning community to direct market eligible specialty crops to nutritionally vulnerable citizens. ROC initially brought on six partners in six California counties, but it was expanded to include three new partners in four additional counties during the grant year. Below is a list of each ROC partner and CFMC member, and the targeted regions:

- Agriculture and Land-Based Training Association (ALBA): Monterey, San Benito and Santa Clara counties
- Community Initiatives/Campaign for Better Nutrition (CI/CBN): San Francisco County
- Fresno County Economic Opportunities Commission (EOC): Fresno County
- Hunger Action Los Angeles (HALA): Los Angeles County
- International Rescue Committee (IRC): San Diego County
- Pacific Coast Farmers' Market Association (PCFMA): Alameda and San Francisco counties
- Sonoma County Department of Human Services (SCDHS): Sonoma County
- Sustainable Economic Enterprises of Los Angeles (SEE-LA): Los Angeles County

- Urban Village: San Mateo County

Project Approach

ROC coordinated the activities of the CFMC, which were made up of nine subcontracted partners in each of the target counties, to maximize shared learning from innovations of individual partners. The CFMC held monthly conference calls from October 2009 to November 2010 and met for three face-to-face meetings in San Diego, Alameda and Fresno counties to confer on best practices. ROC supported partners with financial oversight; staffing for outreach; assistance in the waiver applications process; a reporting methodology; an initial $36,000 in cash for “top up” incentives; and evaluation materials. ROC also contracted the firm Blueprint R&D to perform an analysis and evaluation of the yearlong project.

Each of the partners worked to increase purchases of eligible specialty crop products at target farmers markets within their county by 1) implementing the technology needed to redeem food assistance funds; 2) implementing top up incentive programs; 3) performing community outreach about eligible specialty crop products; 4) conducting on-site cooking demonstrations using eligible specialty crop products; and 5) gathering metrics data on a monthly basis on each of the collaborators’ contracted quantitative and qualitative terms in accordance with grant reporting outcomes.

The CFMC is committed to increasing access to and consumption of specialty crops. The following specific guidelines have been developed to ensure this project solely benefits specialty crops:

- ROC signed formal contracts with each of its lead partners that state the projects will “solely enhance the competitiveness of specialty crops.”
- The incentive (Market Match) tokens/vouchers provided to Cal Fresh/WIC clients to spend at farmers’ markets have “fruits, veggies and nuts only” printed on them and cannot be used on non-specialty crops.
- ROC provided each of the CFMC partners with resources and information on eligible specialty crops.
- ROC staff conducted site visits to partner farmers’ markets to train market managers about procedures, and that outreach and Market Match can only be used for specialty crops.

Now that the pilot year has been completed and all CFMC partners are up and running at the same speed, CFMC has new projects that ROC plans to implement in the coming year to improve and expand each region’s program. Some significant contributions from our CFMC partners this pilot year include:

- PCFMA and IRC presented various models of top up programs at California Small Farm conference in San Diego and Community Food Security Coalition conference in New Orleans. Market managers from around the country attended the workshop.
- ROC and IRC were instrumental in leveraging the $16 million Center for Disease Control award to San Diego County, with $450,000 designated to increasing the number of farmers markets participating with nutritional assistance programs.

- IRC co-hosted with the California Endowment a visit from First Lady Michelle Obama to the New Roots Garden in San Diego, highlighting the farmers' market top up program and new immigrant farmers.
- ALBA hosted a dinner, "Bridging Opportunity – Local Chefs and Beginning Organic Farmers," highlighting 25 local specialty crop farmers.
- ALBA reached approximately 200,000 people via Public Service Announcements on Radio Campesina.
- HALA held food stamp outreach gatherings at Korean Resource Center and Apostles of Christ Church, resulting in attendance of 500 clients.
- Local Channel 7 (ABC) interviewed CBN for a public affairs segment on August 15, 2010. This interview highlighted the three farmers markets in San Francisco that are promoting EBT, WIC, Senior Fruit and Vegetable Vouchers and the top up incentive.
- Fresno EOC worked with the Central Valley Health Network, Congressman Jim Costa's office and Eric Amador (former White House chef) to organize and host the Valley Nutrition Event, which highlighted farmers markets, EBT and top up.

The following unusual developments arose during the grant year:

- All consortium partners reported that there were delays in specialty crop availability from many farmers due to weather conditions throughout the state. This caused seasonal markets to open later than anticipated (mid-April to early May).
- The California Department of Food and Agriculture granted ROC permission to add Community Initiatives/Campaign for Better Nutrition as a new partner to replace San Francisco Food Systems, which was unable to complete its contract. At the same time, other organizations contacted ROC interested in becoming part of the CFMC, and ROC allocated funds from their own coffers to bring in three new partners.
- Due to restrictive regulations of San Francisco Department of Public Health, cooking demonstrations in this county were more challenging and costly, causing our San Francisco partners to reduce the number of cooking demonstrations.
- Urban Village created a farmer's market in the Cow Palace to bring local produce to a greatly under-served area within a low-income Asian community. This market attracted mostly Hmong specialty crop farmers and five organic farmers, but consumer attendance was poor and the market ultimately closed. Although we have not yet thoroughly analyzed the reasons, we learned that many of the Asian residents preferred to commute to Chinatown and purchase food in this neighborhood.
- The Valley Center Farmers Market that IRC had opened ultimately closed due to its location in a rural area. Many residents lacked efficient public transportation and had better access to alternative produce stands closer to them. IRC opened another farmers' market in another part of San Diego before the end of the grant year.

<u>Goals and Outcomes Achieved</u>

Activities included CFMC partners connecting with community-based organizations (CBOs) to distribute material about the new top up program to WIC/EBT/Farmers' Market Nutrition Program (FMNP) and seniors; direct-mailing information fliers to hundreds of CalFresh participants that gave information on which farmers' markets accepted EBT; holding food stamp trainings at churches and community centers to encourage new enrollment; and holding monthly and weekly cooking demonstrations that solely featured specialty crops from those markets.

ROC also ran a pilot program with VISA and nine specialty crop farmers to test handheld EBT devices in farmers markets. The activities included training these farmers on the new mobile technology that could benefit their sales in the farmers markets.

Highlights of the outcomes achieved include:

- ROC far exceeded the goal of raising $200,000 top up funds. The CFMC successfully leveraged program support to raise a total of $351,900 for top-up and match incentive funds from a variety of private and public sources, including Health Net, Center for Disease Control, Health Trust, Wells Fargo Bank Foundation, Kaiser and multiple private donors. Given the timeline, a majority of these funds will be spent in 2011-2012.
- The goal of 650 specialty crop farmers that were participating and benefiting from this projected resulted in 755 specialty crop farmers by year's end.
- TCI accomplished the original goal of 33 farmers markets with an additional 34 markets utilizing the new top up.
- TCI initially planned to have the VISA handheld devices tested in 24 farmers' markets, but by the end of the three-month trial, the nine participating farmers had tested them in 105 farmers markets.
- TCI had hoped to reach 645,000 clients through CBOs and flyers, and reached 689,345 clients.
- The original goal of benefiting an average of 510 WIC, CalFresh and senior clients in underserved communities on an average market day was exceeded. Approximately 858 WIC, CalFresh and senior clients in underserved communities throughout the state gained increased access and affordability to eligible specialty crop items at participating farmers markets.
- The goal of enrolling 1,050 new CalFresh clients resulted in the enrollment of 2,195 new CalFresh clients.
- The goal of 114 cooking demonstrations that educated consumers about healthy and fresh specialty crops resulted in a total of 150 cooking demos held statewide.

<u>Beneficiaries</u>

A total of 755 eligible specialty crop producers who sell eligible specialty crops in 10 target counties benefitted from this project through increased sales, both through redemption of federal nutrition benefits and incentive funds. In three of the target regions EBT redemption increased more than 100 percent. Redeemed EBT dollars from all nine CFMC partners totaled nearly $200,000. As of December 2010, the CFMC distributed approximately $124,350 of the nearly $352,000 in top up funds raised during the pilot year, with an additional $227,650 left to spend in top up funds. In addition, nine specialty crop farmers participated in the workshops on new handheld devices with VISA, and increased their revenue stream by $1,500 during the three-month trial period. All total, this project has brought approximately $553,500 in new revenue for specialty crop farmers in 46 farmers markets.

Other beneficiaries include federal nutrition benefit program clients (including SNAP, WIC FMNP, Seniors' FMNP, WIC FVC, and Social Security Insurance) who were proximal to the 46 participating farmers markets in the 10 target counties. The CFMC reached at least 689,345 clients through direct mailings, flyers sent to CBOs, flyers sent home with children from schools in the 10 participating counties, radio public service announcements on Spanish-speaking stations, and events held at the markets. ROC enrolled approximately 2,195 new CalFresh clients, and an average of 858 clients per market day benefitted from the match incentive dollars to increase their purchasing power at the farmers markets for specialty crops.

This project also brought EBT to nine newly opened farmers markets; trained specialty crop farmers on the new technology of handheld EBT devices in partnership with VISA; and promoted specialty crops throughout the state through new and traditional media and outreach to more than 597 community based organizations. Going into the second year of the CFMC project, ROC and its partners plan to expand top up into more markets throughout the state, and increase redemption of EBT in each region.

Lessons Learned
ROC met or exceeded all its measurable outcomes except for three:
1. Connect nine new markets with EBT/WIC/FMNP.
2. Bring new EBT to 10 existing markets.
3. At participating markets, conduct 38 pre-enrollment screenings.

The pre-enrollment screening numbers turned out low due to issues the partners had with enrolling clients on-site at the markets. CFMC have instead partnered with authorized agencies that can do this. Had the San Mateo market not closed, TCI would have achieved nine new markets with EBT capabilities. The majority of the 46 markets TCI was in already had EBT capabilities, and an outcome of 10 markets was probably too high of a goal given the benchmark.

Another lesson learned occurred during data collection. Although TCI exceeded the average number of top up clients served per farmers' market day and TCI increased their EBT and WIC redemption, these metrics were difficult to measure over the course of the grant year due to the complexity of measuring redemption in multiple markets with multiple partners, and in multiple months throughout the state.

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Project 37 - California Department of Education (CDE)

Final Performance Report

Project Title
Food for Thought

Project Summary
Thirty-three percent of low income children start kindergarten already overweight or obese; therefore, what happens in preschool is crucial. Nutrition policies and practices matter profoundly and nutrition education must be an integral part of preschool routines to help mitigate preschool obesity and help children establish healthy eating habits. Many California preschools are not utilizing a competency based nutrition education curriculum; thus, these funds were used to offer preschools the opportunity to implement a nutrition education curriculum, *Food for Thought* (FFT) that is in alignment with the CDE's Nutrition Education Competencies for prekindergarten and the Preschool Learning Foundations. In addition, many studies show that children eat far less than the recommended servings of fresh fruits and vegetables (F/V). Nutrition education is an effective way of overtly shaping food choices among young children and can play a significant role in helping increase acceptance of F/V during mealtimes and snacks at preschool and home.

The purpose of this grant was to promote the use of the FFT nutrition education curriculum in Child and Adult Care Food Programs (CACFP) center-based sponsors in order to increase preschoolers' acceptance and/or consumption of F/V.

Grant activities included:
1. Providing statewide training on the FFT.
2. Identifying FFT coaches to extend training in local regions.
3. Conducting meal observations and teacher interviews to determine impact of the FFT.

Project Approach
The project approach was to use the FFT in preschool classrooms and promote the consumption of F/V. The FFT curriculum activities bring preschoolers in direct contact with F/V and provides for quality interactions and teacher facilitated instruction. A goal was to train preschool staff to implement F/V curriculum lessons. By educating staff, the staff will in turn provide meaningful opportunities for children to get involved, learn about healthful foods and foster an early appreciation for fresh F/V.

In addition to a large scale statewide training, the grant used a coaching strategy to increase the use of the FFT in local communities. A coach was selected in each region of the state to promote the importance of nutrition education in preschool and the consumption of F/V. The coaches were early childhood educators who received FFT training and had implemented the curriculum. The coaches used their knowledge and skills to encourage and teach other teachers how to use the curriculum. The coaches focused on the F/V curriculum lessons thereby allowing children to experience and taste a variety of fresh F/V.

Goals and Outcomes Achieved

Increase the use of the FFT by 25 percent in preschool programs through statewide training of teachers and coaches:

- Established baseline data on the current use of the FFT at the outset of the project by developing a pre/post survey on the use of FFT.
- Issued the online statewide pre-survey to CACFP center sponsors on the use of the FFT.

Baseline data was established from the outset of the project via an online survey:

- There were 171 survey respondents.
- 35 percent had heard of the FFT.
- 25 percent had adopted the FFT.

Conduct free statewide training on the FFT:

- Identified training locations in the 11 superintendent regions.
- Prepared and e-mailed training announcement to CACFP sponsors.
- Planned and developed a four-hour training program on the FFT. This included development of Power Point slides and notes, task analysis for onsite cooking stations, identified Web resources and handouts.
- Offered training in 11 Regions.

Registered 223 individuals to take the FFT training:

- Only 178 individuals from 113 child care agencies completed the FFT training and received Certificates of Completion.
- There were 45 individuals who registered but did not attend the training.

Videotape one of the statewide training sessions:

- Videotaped the FFT training presentation at the San Diego location.
- Digital Video Disc is on file and will be posted on January 6, 2012 to the Healthy and Active Preschoolers Web site, www.healthypreschoolers.com

Identify 11 regional coaches and provide specialized training for them to promote and train others in their regions on the use of the FFT:

- Recruited coaches via the initial online survey.
- E-mailed an information packet (including coach duties and expectations) and questionnaire to interested individuals.
- Selected 11 coaches.
- Planned and developed a four hour training session for coaches.
- Training topics included: Gardening, basic nutrition and how to promote the FFT.
- Offered coach training in Santa Cruz at Life Lab, Bringing Learning to Life in the Garden.
- Provided coaches with a starter kit to promote and train other preschool teachers in their region.
- Kit included: 25 copies of the FFT, supplies and equipment to carry out training demonstrations and activities.
- Nine individuals committed to be coaches, representing nine regions.

- Nine coaches were trained and received a Certificate of Completion.
- Coaches signed pledge to train a minimum of 25 individuals.
- Coaches trained 230 preschool staff in their regions from 34 child care agencies.

Increase the use of the FFT by 25 percent in preschool programs through statewide training of teachers and coaches:
- Re-issued pre/post online survey to CACFP sponsors to determine if the use of the curriculum increased by 25 percent.

There were 145 post survey respondents. See below for some highlights:
- 76 percent had heard of the FFT.
- 60 percent had adopted the curriculum.
- 77 percent now conduct nutrition education activities at center.
- Post survey results indicated an increase in the use of the FFT in child care programs by 35 percent, 10 percent higher than expected.

Increase the acceptance versus consumption of F/V among preschoolers by 20 percent by conducting observations of children at mealtimes in two to four regions at 25 to 30 sites to determine if the FFT nutrition education intervention increased acceptance of F/V:
- Developed a questionnaire to interview teachers about their perceptions of children eating F/V at mealtimes.
- Developed observation tool to observe preschoolers eating F/V at mealtimes. Note: The questionnaire and mealtime observation tool were combined into one instrument.

Identified four coaches in four regions to carry out teacher interviews and observations at 25 to 30 sites before and after FFT was implemented:
- Coaches were trained on how to carry out the interviews and observations.
- Four coaches from Fresno, Los Angeles, San Bernardino and Santa Cruz visited 19 sites and conducted teacher interviews and observed mealtimes.

Results

Of the 19 sites, 14 percent were already using the FFT before the teacher interview and meal observations. After the FFT was introduced, 100 percent were using the FFT curriculum:
- 582 children were observed at various meals before the FFT was implemented.
- 559 children were observed after FFT trainings.
- Pre FFT trainings, 97.7 percent of children ate their F/V at mealtimes.
- Post FFT trainings, 98.21 percent of the children were observed to be eating their F/V.
- Only 0.44 percent increase in consumption of F/V was observed post FFT trainings.

Conclusion
There was no significant increase of F/V consumption among preschoolers between pre and post FFT intervention. Many children were eating F/V prior to the FFT intervention. Notably, in two

out of four regions, some agencies were offering new and different kinds of F/V as a result of FFT intervention. Also, there was a significant increase in the use of the FFT curriculum.

Beneficiaries

The FFT training was offered statewide and a variety of child care programs participated in the workshops. The training was marketed to CACFP center-based sponsors including independent nonprofit agencies such as Head Start, state preschools and Community College child development centers.

Based on the results of the online statewide pre/post FFT survey, post survey results indicated an increase in the use of the FFT curriculum. Eighty-two percent of agency respondents indicated that they were using the FFT as a result of a staff member attending the FFT training. It also appears that of those trained and using the curriculum, the frequency of use also increased. Twenty-nine percent were using the curriculum daily (an increase of 16 percent from pre survey results) and 38 percent are using the curriculum weekly (an increase of 18 percent).

Overall 430 early childhood educators were trained in the use of the FFT representing 148 child care agencies. The use of the coach trainers proved to be advantageous. Through the regional coaching model, coaches reached more teachers. Also, based on verbal feedback, it appears that the teachers were more receptive to the training from their peers.

Lessons Learned

The CDE met the goals of the project except for the goal to increase the acceptance and consumption of fresh F/V among preschoolers by 20 percent.

This was an ambitious goal and more time was needed to conduct observations in 25 to 30 sites. The coaches only reached 19 agencies. In hindsight, the contract period should have been 18 months instead of 12 months. There was also a delay in getting the contract in place, which impacted project timelines. The coaches felt rushed to complete their training and conduct mealtime observations.

More guidance should have been given to the coaches in the selection of sites for meal observations. At many of the selected sites, children were already consuming F/V; therefore there was no significant increase in the consumption of F/V even after the FFT intervention.

Also in order to determine the number of children potentially reached, the subcontractor should have included the number of children impacted on the registration form. As a result the CDE cannot estimate the number of children reached through this statewide training.

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 38	Project Title: Detection and Control of Verticillium Wilt on Lettuce	
Grant Recipient: US Department of Agriculture, Agricultural Research Services	**Grant Agreement No:** SCB09023	**Date Submitted:** December 2012
Recipient Contact: Steve Klosterman	**Telephone:** 831-755-2845	**Email:** Steve.Klosterman@ars.usda.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The soilborne fungal pathogen *Verticillium dahliae* causes Verticillium wilt disease on lettuce and other specialty crops in California. All spinach seed in California is imported, and the seed imported from the US Pacific Northwest or abroad are heavily infested with *V. dahliae*. Thus, spinach crops produced in the Salinas Valley may contribute to Verticillium wilt epidemics on lettuce and other crops by increasing pathogen concentrations in the soil. Furthermore, the exotic strains imported into California on spinach seed could be the more virulent forms of the pathogen threatening a wide array of high value crops in coastal California and the economic sustainability of this region. The first appearance of Verticillium wilt on lettuce in central coastal California was reported relatively recently, in 1995, and had since spread throughout the production region of the Salinas Valley. As a result, there was a timely need to develop an assay for rapid detection and quantification of *V. dahliae* in spinach seed, to determine where the fungus is located in infected spinach seed to develop effective seed treatments, and to develop lettuce and spinach varieties that are resistant and limit spread.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

The goal of objective 1 was to detect and quantify *Verticillium dahliae* in spinach seeds. The project team achieved this goal by first collecting spinach seed lots from commercial sources and seeds from the USDA spinach germplasm collection. Then the level of infection in the seed lots was determined based on semiselective plating assays. In the 15 seed lots that were collected from the US Pacific Northwest and Europe, the percentage of seeds infected ranged from 0.3% to 85%. This finding was based on the plating of 400 to 600 seeds per seed lot on the semiselective medium and scoring for the presence of the fungus after 10 days. During the course of the project, Co-PD Steve Koike (UCCE) completed these analyses for 20 seed lots for the detection of *V. dahliae* in seed health tests using semiselective media. In collaboration with Co-PDs Beiquan Mou and Krishna Subbarao, plating of seeds from the USDA spinach germplasm collection revealed the presence of the fungus in some accessions tested, suggesting that some accessions from the spinach collection are naturally infested with *V. dahliae*. The testing of 24 of these accessions revealed that 7/24 accessions were infected with *V. dahliae* and the percentage of seeds infected in these seven samples ranged from 5% to 65%.

Co-PD Koike also co-delivered a seed testing workshop at the University of California, Davis, in 2010, and asked the participants questions relating to objective 1 of this CDFA proposal. Nearly half of all respondents indicated a high significance for a rapid, DNA-based detection system that can determine the amount of *V. dahliae* present in spinach seeds.

PD Klosterman, in collaboration with the project Co-PDs, completed the development and validation of the DNA-based technique for the detection and quantification of *Verticillium dahliae* in spinach seeds. The DNA-based assay (quantitative real-time PCR, qPCR) takes advantage of DNA sequence that is specific to *V. dahliae* and the related species, *Verticillium longisporum*. Initial screening of spinach seeds using the qPCR assay for detection and quantification of the fungus was focused on seeds derived from spinach accessions from the USDA germplasm collection. The qPCR assay detected *V. dahliae* in 23/24 of the seed samples, which suggested that the DNA-based assay can be more sensitive in detection of the fungus in these seeds and provided additional evidence that some accessions from the USDA spinach germplasm collection are naturally infested with *V. dahliae*.

For screening of commercial spinach seed using the DNA-based assay, the project team focused on the quantification of *V. dahliae* using 15 seed lots with known levels of seed infection based on plating assays with semiselective media. For qPCR sampling, a grinding mill was employed to thoroughly grind three replicates of 1000 seeds per seed lot. Because spinach seeds are very tough to grind, this made the sampling process more efficient and more uniform than hand grinding. Six DNA extractions were prepared from each of the three ground samples and analyzed by qPCR. Based on these analyses, the reliable detection level by qPCR is 1.3% infected seed. Below the 1.3% level, detection of the fungus was not consistent. Analyses of the 15 commercial spinach seed lots revealed variability in the qPCR values obtained when correlated to percent infection values obtained by plate assays with semiselective media. However, the qPCR values obtained from three replicates of 1000 seeds from a single seed lot were consistent. Furthermore, for the 15 seed lots tested, qPCR values > 31 corresponded to < 1.3 % infected seeds. A comparison of the results obtained from two different real-time PCR machines was also performed since not all laboratories are expected to have the same equipment for conducting qPCR. The results of this comparison revealed a high correlation of qPCR values for both instruments.

The presence of another species of *Verticillium*, *Verticillium longisporum*, was a concern for the validation of the qPCR method since this *V. longisporum* shares DNA sequence in common with *V. dahliae* and could possibly be a contaminant of spinach seeds. As the name suggests, *V. longisporum* produces spores that are nearly twice as long as those from *V. dahliae*. Thus, one way to differentiate *V. longisporum* from *V. dahliae* is to make spore length measurements for comparison. Even though the long-spored isolates of *V. longisporum* are not expected to be associated with spinach, since *V. longisporum* infects other types of plants, tests were performed to examine whether *V. longisporum* was detectable in any of the 15 seed lots. A species-specific DNA-based PCR test specific for the detection of *V. longisporum* revealed that *V. longisporum* was not detectable in any of the seed lots. Additionally, the spore lengths of 100 spores of an isolate of *V. longisporum* from cauliflower were 8.75 ± 1.55 µm, whereas the spore lengths of the isolates from spinach seeds were 3.91 ± 0.80 µm (based on the measurement of 5000 spores obtained from 50 isolates of 5 different spinach seed lots). Taken together, these results indicated that *V. longisporum* is not a contaminant of spinach seeds and that the qPCR assay specificity was not compromised.

An additional concern following the initiation of this SCBGP grant was the probability that the DNA-based qPCR test cannot discriminate between live and dead fungi in plant tissues. If seeds are stored for an extended period of time, some of the fungus would die. PD Klosterman, in association with Centrillion Biosciences, a California-based biotech company, identified highly expressed genes that may be targets for screening live fungi in spinach seeds, and the project team is continuing to analyze sequences highly expressed in microsclerotia in *V. dahliae* for this purpose.

In conclusion, the qPCR assay will be useful to limit the number of seed lots that would require testing via more time-consuming techniques that rely on visual observation of the fungus growing from the seed. The qPCR assay was capable of consistent detection of the pathogen at the 1.3% level of seed infection. Additionally the assay is specific for *Verticillium dahliae* and *V. longisporum*, and the project team confirmed that *V. longisporum* was clearly not detected in the seed lots tested. However, additional testing of isolates within the genus *Verticillium* with this and other DNA markers would be useful in view of recent taxonomic revisions to the genus. Additionally, the project team is pursuing the detection of additional candidate genes for the detection of the live fungus in vegetable seeds.

A poster presentation and an oral presentation on the qPCR assay for the quantification of *V. dahliae* in spinach seed was delivered at the American Phytopathological Society meetings in Charlotte, NC and Honolulu, HI in 2010 and 2011, respectively. As the goal of objective 1 was completed, PD Klosterman and staff (USDA ARS) delivered a workshop in June, 2012 in Salinas, CA to representatives of the spinach seed production industry from Europe and the US Pacific Northwest. The workshop entailed instruction on the application of the DNA-based qPCR technique for detection and quantification of *V. dahliae* in spinach seeds. At all presentations, funding from the California Department of Food and Agriculture was acknowledged.

The goal of objective 2 was to assess where *V. dahliae* is localized in spinach seed. In collaboration with Co-PD Krishna Subbarao (UC, Davis) and Co-PD Beiquan Mou (USDA ARS), experiments were completed to determine where the fungus is located in spinach seeds and in infected plants. A commercial spinach cultivar was inoculated with a strain of fluorescently-tagged *V. dahliae*, and the seeds and other tissues were examined at different timepoints using specialized microscopy that allows 3-D imaging. Over a 2.5 year period, approximately 20-25 trips were made from Salinas, CA to the UC Davis campus (Davis, CA) to analyze the spinach seeds and other tissues.

The results from the work to examine the localization of *V. dahliae* in spinach seed demonstrated qualitatively that the fungus appears heavily localized within the seed tissue of the outer fruit wall, but not in deeper, more centrally located, embryonic tissue. Also, the project team verified that the fungus is not present in pollen produced by the mature male plants. This research has provided additional insight into the colonization of spinach plants by *V. dahliae*, from infected seed through plant maturity. At 10 weeks after inoculating the spinach seedlings with the fungus, the water conducting xylem tissues of infected plants were thoroughly colonized with the fungus.

Spinach seeds were also analyzed for fungus in fungicide-treated seeds or in untreated seeds that were infected with *V. dahliae*. Two different fungicides with two different modes of action were used in these experiments. Co-PD Subbarao and staff demonstrated that even though the fungus did not grow out of the treated seeds on culture medium, the fungus was able to grow out of seeds on culture medium after the seeds were broken open. Additional DNA-based qPCR tests by PD Klosterman revealed that the amount of pathogen DNA detectable was consistently lower in the fungicide-treated seeds. However, DNA of the pathogen was still detectable. These results revealed that while the fungus was able to survive within the seed after the application of two different fungicides, there was a clear reduction in the detectable levels of the fungus.

A manuscript was submitted for publication which describes the localization of the fungus in seeds and plants. Co-PD Subbarao presented the research findings to the California Leafy Greens Research Program twice in 2011. In the submitted manuscript, and at all presentations, funding from the California Department of Food and Agriculture was acknowledged.

The third goal of the project was to develop lettuce and spinach varieties that are resistant to *V. dahliae*. The project team continued screening the Western Regional Plant Introduction Station (WRPIS) *Lactuca* collection for resistance to race 2 isolates of *V. dahliae*. More specifically, the project team research used a working collection of the WRPIS located in Salinas, CA. The screening strategy used greenhouse testing of up to eight plants of 160 accessions per year in unreplicated plots to identify candidate sources of resistance. This is followed by replicated greenhouse experiments to confirm resistance. Verticillium wilt disease development in lettuce is dependent on plant development, and in some genotypes symptoms are not expressed until the plant reaches flowering (Hayes, Vallad, Subbarao, personal communication). For this research, the plants were maintained in the greenhouse until flowering began, at which time disease evaluations are conducted. This substantially lengthened the duration of each experiment, but was necessary to reduce the number of false positives. At all stages of testing, crown sections of asymptomatic plants are plated on NP10 media to determine the presence / absence of *V. dahliae* stem infection. To date, the project team has confirmed partial resistance (disease incidence significantly lower than 'Salinas') in four accessions (Hayes et al. 2011). The project team will continue evaluations of 28 PIs that have promising levels of resistance will continue. Co-PD Hayes presented the research findings biannually during the project to the California Leafy Greens Research Program.

The project team has finished the preliminary screening of the USDA spinach germplasm for resistance to a race 1 isolate of *V. dahliae* and resistance screens were also performed with a Race 2 isolate of the pathogen. Severity of Verticillium wilt symptoms were rated weekly (starting 3/4/11) using a scale of 0 to 4 whereby 0 = no symptoms, 1 = lower leaves with patches of yellow areas, 2 = middle leaves with patches of yellow areas, 3 = upper leaves with patches of yellow areas, and 4 = all leaves died. Wilting time of leaves was also noted in these experiments. After the final rating, roots were cleaned of sand and cut longitudinally to evaluate disease severity as the % pale brown discoloration of vascular tissue in the roots, crown, and lower stem, characteristic of Verticillium wilt. The growth period of the inoculated plants were compared with the uninoculated control. Genotypes showed great variability in disease incidence and severity. Six putative resistant accessions had no disease symptoms, low seed infection % from the NP-10 plate assay, and low pathogen copy numbers in qPCR tests. Based upon these results, some accessions show partial disease resistance. But at this time, there are no sources of spinach with complete resistance to *V. dahliae*.

The seeds of the partially race 2-resistant lettuce accessions are publicly available for distribution, through Co-PD Hayes in Salinas, CA or via the USDA Western Regional Plant Introduction Station in Pullman, WA.

California industries involved in plant breeding were also made aware of the partially resistant accessions at the biannual California Leafy Greens Research Program meetings.

In summary, work to identify lettuce with resistance to race 2 of *V. dahliae* is ongoing, as is the work to identify spinach with resistance to both race 1 and race 2 of the pathogen.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Goal 1: Develop a rapid detection assay for *V. dahliae* in spinach seed
Actual Accomplishments:

1. A rapid detection assay was developed for *V. dahliae* in spinach seed, taking advantage of an analytical grinding mill for efficient seed sampling, reliably detecting the fungus at the 1.3% seed infection level. For assay development, 15 commercial seed lots were assessed for the percentage of seeds infected with *V. dahliae*.

2. Questionnaire delivered to participants of seed health testing workshop in 2010.

3. A detailed manuscript on the assay for detection and quantification of *V. dahliae* in spinach seed was written and published in 2012.

4. The rapid detection assay was also used to examine levels of the fungus detectable in fungicide-treated and untreated seeds. Seed health tests were conducted on six seed lots that were treated with a fungicide. The project team noted consistently lower amounts of detectable DNA of the fungus in treated seeds as compared to untreated seeds, suggesting pathogen DNA degradation in response to the fungicide treatment.

5. PD Klosterman delivered a workshop on the assay application to seed industry representatives in June, 2012.

6. The project team identified highly expressed genes that can be targets for screening live fungi in spinach seeds, and are continuing to analyze sequences highly expressed in microsclerotia in *V. dahliae*

Goal 2: Determine where the fungus is located in spinach seed to develop effective seed treatments.
Actual Accomplishments:

1. It was determined that *V. dahliae* heavily colonized throughout the thick fruit wall or pericarp, but not the centrally located embryonic tissue

2. Colonization of the infected plants was examined, revealing complete colonization of the xylem tissue at 10 weeks after inoculation

3. Determined that the fungus, *V. dahliae*, did not grow out of intact fungicide-treated seeds but did grow out of fungicide-treated seeds that were broken open, indicating that the some of the fungus survives within the seed, even following fungicide treatment

4. A detailed manuscript on the analyses of *V. dahliae* colonization of spinach was written and submitted for publication in 2012

5. An email survey was not conducted to determine the usefulness of the localization data. During the project, at the biannual California Leafy Greens Research Program meetings, the project team assessed the usefulness of the localization data via personal conversations with those involved in the production or application of seed treatments. These conversations revealed a consensus among scientists and industry representatives that knowledge of where the pathogen was localized in the seed was required to determine the effectiveness of seed treatments.

Goal 3: Identify lettuce and spinach resistant to *V. dahliae* to limit spread via seed
Actual Accomplishments:

1. Lettuce accessions with partial resistance to race 2 of *V. dahliae* were identified in field trials.

2. Five candidate spinach accessions with resistance to *V. dahliae* were identified.

3. The rapid detection assay for *V. dahliae* in spinach seed, developed for goal #1, was also used to measure amounts of fungal DNA in infected spinach plants vs those non-infected, suggesting potential application for a tool to assist in quantifying the pathogen for plant resistance screening.

4. The project team did not distribute seeds to the private seed companies. However, the seeds of the partially race 2-resistant lettuce accessions are publicly available for distribution, through Co-PD Hayes in Salinas, CA or via the USDA Western Regional Plant Introduction Station in Pullman, WA. California industries involved in plant breeding were also made aware of the partially resistant accessions at the biannual California Leafy Greens Research Program meetings. Partially resistant spinach accessions require additional verification before public release.

Outcomes Achieved

1) A DNA-based assay for the quantification of seeds infected with *V. dahliae*; and the sharing of this information with California industries and private laboratories
A rapid detection and quantification assay was developed for *Verticillium dahliae* in spinach seed, taking advantage of an analytical grinding mill for efficient seed sampling, reliably detecting the fungus (Duressa et al. 2012). Using the DNA-based assay staff was able to quantify the amount of pathogen in spinach seed lots at the 1.3% seed infection level (Duressa et al. 2012). Staff then provided additional data based on plating assays showing that commercial seed lots are often infected with *V. dahliae*. The percentage of infected seeds in fifteen commercial seed lots ranged from 0.5 to 85%. A questionnaire was delivered to participants of a seed health testing workshop in 2010, in which half of the respondents indicated a high significance for the DNA-based assay that can determine the amount of *V. dahliae* present in spinach seeds. Also, representatives of two of the major private companies that produce spinach seed from the US and Europe were invited and attended a workshop convened by the project director on the DNA-based assay held in Salinas in June, 2012. Information on the DNA-based

assay for *V. dahliae* in spinach seed was also provided in three annual research reports to the California Leafy Green Research Program (http://www.calgreens.org/current_reports.html) and in oral research reports at six biannual meetings of the California Leafy Green Research Program. The publication on the subject (Duressa, D., Rauscher, G., Koike, S.T., Mou, B., Hayes, R.J., Maruthachalam, K., Subbarao, K.V., Klosterman, S.J. A real-time PCR assay for detection and quantification of *Verticillium dahliae* in spinach seed. Phytopathology, 102:443-451, 2012), is now in wide circulation through the peer reviewed journal Phytopathology, and describes the DNA-based assay in detail for quantification of *V. dahliae* in spinach seed. The journal Phytopathology reaches hundreds of subscribers in the discipline of plant pathology, including readers in public and private institutions.

2) The ability of the private seed testing laboratories to adapt this technology and identify seed lots with high infestation

In the published work on this topic (Duressa, D., Rauscher, G., Koike, S.T., Mou, B., Hayes, R.J., Maruthachalam, K., Subbarao, K.V., Klosterman, S.J. A real-time PCR assay for detection and quantification of *Verticillium dahliae* in spinach seed. Phytopathology, 102:443-451, 2012), staff have tested additional parameters to make the technology more user friendly, and assessed the application of the DNA-based assay on different types of measurement instruments. Representatives of two of the major private companies that produce spinach seed were invited to the USDA station and given the opportunity to learn how to conduct the DNA-based assay with reduced costs and available instruments in June 2012.

3) Data on the localization of the fungus in spinach seed, providing information for treatments that reduce seed infection rates to below the target of 10% (the Mexican government importation standard)

Staff determined that *Verticillium dahliae* heavily colonized throughout the thick fruit wall or pericarp, but not the centrally located embryonic tissue. It was further determined that the fungus, *V. dahliae*, did not grow out of intact fungicide-treated seeds but did grow out of fungicide-treated seeds that were broken open, indicating that the some of the fungus survives within the seed, even following the application of two different fungicide treatments. These results on the localization of the fungus in spinach seed and the effect of two fungicide treatments have now been published for wide public distribution. Also, during the project, at the biannual California Leafy Greens Research Program meetings, staff assessed the usefulness of the localization data via personal conversations with those involved in seed production or application of seed treatments. These conversations revealed a consensus among scientists and industry representatives that knowledge of where the pathogen was localized in the seed was required to determine the effectiveness of seed treatments. The publication in the peer reviewed journal Phytopathology (Marathachalam, K., Klosterman, S.J., Anchieta, A., Mou, B. Subbarao, K.V. Colonization of spinach by *Verticillium dahliae* and effects of pathogen localization on the efficacy of seed treatments. Phytopathology, (http://dx.doi.org/10.1094/PHYTO-05-12-0104-R) provides the detailed data on the location of the pathogen in spinach seeds.

4) Resistance or susceptibility data for over 450 accessions of lettuce and over 240 accessions of spinach

Over 600 accessions of lettuce were screened for resistance to *V. dahliae* using race 2 isolate of the pathogen. Resistance or susceptibility data of lettuce have been published and candidate accessions were identified with partial resistance in spinach for further analyses. The seeds of the partially race 2-resistant lettuce accessions are publicly available for distribution, through Co-Project director Hayes in Salinas, CA or via the USDA Western Regional Plant Introduction Station in Pullman, WA. California industries involved in plant breeding were also made aware of the partially resistant accessions at several of the biannual California Leafy Greens Research Program meetings. Five candidate spinach accessions with resistance to *V. dahliae* were identified and those accessions showing partial resistance require additional verification before public release. The publication (Hayes, R. J., K. Maruthachalam, G.E. Vallad, S.J. Klosterman, I. Simko, Y. Luo, and K. Subbarao. 2011. Selection for resistance to Verticillium wilt caused by race 2 isolates of *V. dahliae* in accessions of lettuce. HortScience 46:201-206) provides resistance or susceptibility data of lettuce accessions.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Those that benefit from the project include thousands of California personnel involved in growing, shipping, processing, transporting, distribution and retail of lettuce and other specialty crops; seed testing and production industries in California; and residents within production areas from reduced fumigant use. California specialty crop growers benefit by reducing the numbers and amounts of exotic strains of the pathogen that are introduced into the California soil. Lettuce production alone in coastal California is more than a $1 billion industry and the 2008 production value of California spinach was over $121 million. If left unchecked, *V. dahliae* threatens lettuce production in coastal California, while simultaneously reducing spinach production because of grower concerns about planting infected seed. Because *V. dahliae* is cross-pathogenic on a variety of specialty crops grown in rotation with lettuce and spinach and a perennial problem once introduced, a conservative estimate of the economic impact is the millions of dollars in savings from a reduction in fumigation use. The qPCR test developed in this project for monitoring and quantifying the pathogen will benefit California specialty crop industries, as well as spinach seed producers in the US and abroad. Specifically, the DNA-based assay can be useful to quickly assess levels of seed infection in seed lots, and thereby reduces the need for more time consuming assays for the detection of the fungus in seed lots. The seed industries further benefit from the knowledge obtained on the localization of the fungus in spinach seed to improvise protocols or chemical formulations of fungicides for seed treatments. The specialty crop industries in California also benefit from the use of lettuce and spinach accessions, identified in goal 3 of this project, with partial resistance to race 2 of *V. dahliae*. These plant accessions can be used programs that aim to breed for resistance to *V. dahliae*.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

One of the key lessons learned is that it is difficult to determine the precise percentage of fungus-infected seeds per seed lot based only on the DNA-based assay for quantification of the fungus. The rationale for this is probably because the amount of fungal infection per seed is not the same in each seed lot. This is also the reason that for a specified range of qPCR values obtained from spinach seeds in the range of 29-30, the project team recommends additional seed health tests on semiselective medium or a similar test for additional verification. Nevertheless, seed lots with qPCR values $\geq$ 31 were correlated with $\leq$ 1.3% infected seed, and is an important conclusion from the project. Threshold levels of the acceptable amount of *V. dahliae*-infected seed per lot may vary by location. For example, Mexico does not allow importation of spinach seed lots that are $\geq$ 10 % infested with *V. dahliae*.

An unexpected result of the project was the finding that many spinach accessions available for germplasm screening for resistance to Verticillium wilt are infected with *V. dahliae*. The negative results demonstrating that the pollen of infected male plants was not colonized with *V. dahliae* are also of interest. If pollen of the spinach plants was infected with *V. dahliae*, the pathogen could be more readily dispersed via wind. Such transmission on pollen could and also lead to infection of female flower parts and the seed.

Although spinach accessions with complete resistance to *Verticillium dahliae* have not been identified, the project team found more spinach accessions with partial resistance to race 2 of *V. dahliae* than to race 1 of *V. dahliae*, which is the opposite of the situation characterized in lettuce. Another unexpected result of the project was the finding that the fungus can survive within spinach seeds that had been treated with two different types of fungicides. This was unexpected because the fungus did not grow from intact, treated seeds on culture plates. However, when seeds were broken open, the fungus was able to grow.
Whether or not some of the spinach plants are colonized with *V. dahliae* is difficult to determine without laborious and time-consuming tests. An additional means to quantify the resistance more quickly, that may be based on the qPCR test for pathogen quantification in the plant, would be beneficial for that aspect of the project.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Publications:

Duressa, D., Rauscher, G., Koike, S. T., Mou, B., Hayes, R. J., Maruthachalam, K., Subbarao, K. V., and Klosterman, S. J. 2012. A realtime PCR assay for detection and quantification of Verticillium dahliae in spinach seed. Phytopathology 102:443-451.

Hayes, R. J., K. Maruthachalam, G.E. Vallad, S.J. Klosterman, I. Simko, Y. Luo, and K. Subbarao. 2011. Selection for resistance to Verticillium wilt caused by race 2 isolates of *Verticillium dahliae* in accessions of lettuce. HortScience 46:201-206.

Klosterman, S. J. Development of a rapid, quantitative, DNA-based assay for *V. dahliae* in spinach seed. 2010 Annual Report to the California Leafy Greens Research Board (Annual Reports for this project were also submitted in 2011 and 2012).

Presentations:

Duressa, D., Rauscher, G., Koike, S. T., Mou, B., Hayes, R. J., Maruthachalam, K., Subbarao, K. V., Klosterman, S. J. 2011. A realtime PCR assay for detection and quantification of Verticillium dahliae in spinach seed. Presented at the American Phytopathological Society meeting in Honolulu, HI.

Maruthachalam, K., Klosterman, S. J., Subbarao, K. V. 2011. Colonization of spinach (*Spinacea oleracea* L.) by GFP-tagged *Verticillium dahliae*. Presented at the American Phytopathological Society meeting in Honolulu, HI.

Duressa, D., Rauscher, G., Koike, S. T., Mou, B., Hayes, R. J., Maruthachalam, K., Subbarao, K. V., Klosterman, S. J. 2011. A realtime PCR assay for detection and quantification of Verticillium dahliae in spinach seed. Presented at the 57th Conference on Soilborne Pathogens at the University of California, Davis, CA.

Rauscher, G., Mou, B., Hayes, R. J., Koike, S. T., Maruthachalam, K., Subbarao, K. V., Klosterman, S. J. 2010. A qPCR assay for detection and quantification of Verticillium dahliae in spinach seed. Presented at the American Phytopathological Society meeting in Charlotte, NC.

Klosterman, S. J. Development of a rapid, quantitative, DNA-based assay for *V. dahliae* in spinach seed. Presented at the biannual meetings of the California Leafy Greens Research Board (2009, 2010, 2011, 2012) held in Seaside, CA or Coalinga, CA.

Subbarao, K. V. Localization of *V. dahliae* in spinach seeds and plants. Presented at the biannual meetings of the California Leafy Greens Research Board (in 2010, 2011, 2012) held in Seaside, CA or Coalinga, CA.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 39	Project Title: Development of almond, stone fruit, and walnut rootstocks with improved resistance to soil borne pathogens.	
Grant Recipient: US Department of Agriculture, Agricultural Research Services	**Grant Agreement No.:** SCB09040	**Date Submitted:** December 2012
Recipient Contact: Daniel Kluepfel	**Telephone:** 530-752-1137	**Email:** Daniel.Kluepfel@ars.usda.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The California (CA) fruit and nut tree industries require rootstocks with superior resistance to soil-borne pathogens. The need is critical because of the phase out of methyl bromide, the non-sustainability of alternative fumigants, a lack of economical, effective control measures for key soil-borne pathogens, and the importance of maximizing productivity of CA fruit/nut orchards. Rootstocks were indentified with resistance to the targeted soil borne pathogens, *Agrobacterium tumefaciens*, *Phytophthora* species (spp), phytoparasitic nematodes and *Armillaria* spp.

To remain competitive and sustainable, CA fruit and nut industries must make economically and environmentally sound advances in the development of novel disease resistant rootstocks. Currently, field and nursery production of almond and walnuts is dependent on soil fumigation to control soil-borne pathogens and avoid replant disorders. The fumigant of choice, methyl bromide, is being phased out and is available only through temporary critical use exemptions. Furthermore, fumigants such as 1,3-D and chloropicrin are increasingly restricted due to legislative mandates to reduce atmospheric emissions of volatile organic compounds and fumigant label requirements designed to protect humans from acute and chronic exposures to fumigants. The motivation for this project is to deliver improved nut and fruit tree rootstocks resistant to the key soil-borne pathogens and replant disorders thereby reducing dependence on soil fumigants while maximizing yields over the life of the orchard.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Commercially available rootstocks were examined as baseline checks and a novel set of promising wild germplasm and species hybrids that had never been evaluated. The novel genotypes were generated using *Prunus* and *Juglans* germplasm from the USDA/ARS National Clonal Germplasm Repository. Genotypes for screening were initially propagated as seedlings or clonal genotypes and then micro-propagated in tissue culture if they showed superior resistance. Sufficient plant numbers were propagated in order to provide material for resistance screening for each of the target pathogens. Evaluations for resistance to *Agrobacterium* and *Phytophthora* spp. were conducted in the greenhouse. Evaluation of resistance to plant parasitic nematodes was completed in replicate field plots. Genotypes growing well and not supporting nematode reproduction were selected. Tolerance to replant disease (RD) was assessed in fumigated and non-fumigated plots in soil with a history of replant disease. Resistance to *Armillaria* was conducted in an invitro system which facilitated rapid reproducible infection and evaluation. Once putatively disease resistant genotypes were identified, clonal copies (conventional or invitro) were generated for testing of susceptibility to the other target pathogens being examined. In addition, the USDA/ARS proceeded to the germplasm blocks and made directed crosses between parental trees whose open pollinated progeny show elevated levels of disease resistance. The resulting progeny were screened to determine the segregating nature of disease resistance.

Project partners included key nurseries that graciously provided common and novel rootstock genotypes for the screening and propagation efforts. In addition the USDA/ARS contracted with a plant propagation company who was very helpful in the invitro propagation of recalcitrant genotypes. In addition the USDA/ARS Research Center in Parlier, CA graciously provided field sites which allowed the project to examine the resistance of various genotypes to replant disease.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Goal/Outcome 1. *Identify novel genetic sources of resistance to the major soil-borne diseases of Almond and Walnut rootstocks including; crown gall, Phytophthora spp., Armillaria root disease, lesion nematodes, and microbial mediated replant disease.*

Armillaria resistance - *Juglans regia* is susceptible to Armillaria root disease in CA. The relative resistance of new clonal, Paradox rootstocks was evaluated, along with clonal genotypes of the Northern CA black walnut (NCB) rootstock *J. hindsii* ‘W17’, English walnut scion ‘Chandler’, and the *Juglans* relative *Pterocarya stenoptera* ‘WNxW’ (Chinese wingnut). Two months after inoculation with 3 *A. mellea* strains, the most resistant and most susceptible Paradox rootstocks were AX1 and VX211, respectively, with 9 versus 70% mortality for all 3 strains in all three experiments. This range of resistance may reflect the broad genetic background among the Paradox rootstocks, possibly from the different wild species of black walnut that make up their maternal lineages. These results support the hypothesis that there exists considerable variability in the genus *Juglans* for resistance to *Armillaria* root disease which may be exploited for commercial development.

Phytophthora Resistance - In almond and stone fruit rootstocks, susceptibility to *Phytophthora niederhauseri* was relatively high among selections with: peach parentage; peach x almond parentage and (peach x almond) x peach parentage. Mean percentages of crown rot (CR) were 37-100%. In contrast, rootstocks with plum parentage were less susceptible (CR 1-30%).

Among the 17 new walnut rootstock selections with *J. microcarpa* in their parentage, several developed small amounts of root and CR in soil infested with *P. cinnamomi* or *P. citricola*. The *J. microcarpa* x *J. regia* 'Serr' clones JM7, JMS3, and JMS5A all developed ≤30% crown length rotted and ≤30% root rot by both pathogens. The *J. microcarpa* x *J. regia* 'Serr' clones JM8 and JMS12 had ≤30% crown rot and ≤50% root rot with both pathogens. *J. microcarpa* open pollinated selections, as well as some *J. microcarpa* × *J. regia* 'Serr' selections were more susceptible and developed ≥50% crown rot and/or ≥50% root rot.

Assessment of RX1 and Paradox rootstocks at a site infested with *P. cinnamomi* revealed 2nd-year tree mortality was 17% on Paradox, compared to 0% on RX1. All trees on RX1 are alive and growing well. *Phytophthora cinnamomi* was isolated from 63% of dead trees and 40% of poorly growing trees on Paradox, indicating *P. cinnamomi* infection was a principal cause of death in the trial. Superior performance of RX1 in this trial validates earlier evaluations.

Resistance to replant disease (RD) - Field evaluations of resistance to RD among the 22 rootstocks for almond and stone fruits were informative. Rootstock trials indicate an increase in stem diameter growth was affected by highly significant interaction of rootstock x soil fumigation treatments for experiments with rootstocks from CA and Oregon nurseries. Although all rootstocks tested suffered some degree of reduced growth due to a lack of pre-plant soil fumigation, most rootstocks with peach parentage were relatively susceptible while most rootstocks with peach and almond parentage did better, and rootstocks with plum parentage were variable. Similar results were obtained for tree height and pruning weights.

These results suggest resistance to the RD complex is 1) <u>more</u> than a simple matter of inherent rootstock vigor and 2) <u>more</u> than a simple matter of how genetically divergent a replanted rootstock is from the rootstock preceding it at an orchard replant site. Our results suggest peach x almond hybrids and some of the most vigorous peach rootstocks may be less impacted by RD than Nemaguard peach. This work has shown that not all of the stocks tested are acceptable for almond or other crops of interest, and regardless of RD risk, growers should carefully consider all of the demands of a site before making a rootstock selection.

Nematode Resistance – The USDA/ARS demonstrated tolerance to the root rejection component of the replant problem among several *Juglans* species. Three years after removing an orchard on *J. hindsii* cultivar (cv) of NCB, the tree growth of three replanted species showed complete tolerance to root rejection. These rootstocks included: 1) *Juglans regia* cvs Serr or Chandler, 2) *Juglans microcarpa x J regia CV* RX1, 3) *J cathayensis* seedlings including *J. cathayensis* #21 clones. By comparison, replants showing no tolerance to root rejection include: 1) *J. hindsii* cv NCB, 2) *J. hindsii x J. regia* hybrid clone UZ229 while 3) *J. hindsii x J. regia* hybrid clone VX211 showed slight tolerance to root rejection. In the third year of studies 400 new hybrids were examined including various *J. microcarpa* x Serr and a few J. cat #21 x Serr. Again, *J. microcarpa* x Serr hybrids show good 1st-year growth in the presence of root rejection which is a big step forward for selection of novel disease resistant rootstocks.

The search among *Prunus* selections for tolerance to root rejection has not been as fruitful. There does appear to be partial tolerance to root rejection within peach x almond hybrids as well as some plum parentage. Much of the Prunus evaluations involved a search for sources of nematode resistance that were more durable. In 2012 a study of the best selections were planted into soil that had either been fumigated or not. Root rejection was not present but root lesion nematode was plentiful. Each of these is already resistant to root knot nematodes. This will provide a six year evaluation of the following rootstocks: Bright's Hybrid 5 and Hansen 536 are already reported to have 2 years of *P. vulnus* resistance; Sam 1 and Krymsk 99 have already shown one full year of *P. vulnus* resistance, HBOK 1 exhibits good ring nematode resistance but variable resistance to *P. vulnus,* Krymsk 1 is the standard for *P. vulnus* resistance and Nemaguard has limited *P. vulnus* protection.

During the past two growing seasons, four rootstock field trials for almond were established in the central and northern San Joaquin Valley. Among rootstocks being trialed is a Flordaguard x Alnem (peach x almond) hybrid that has performed well against root knot nematode. Over 200 clones of this hybrid are being evaluated in the trials, with the candidate rootstock being grafted to the important 'Nonpareil,' 'Monterey' and 'Butte' almond cultivars. The tree growth measurements indicate that the Flordaguard x Alnem hybrids are among the most vigorous rootstocks being trialed.

Crown Gall (CG) resistance - CG resistant seedlings were identified from 11 of 12 species tested Juglans *sinensis* was the only species tested that did not yield any resistant seedlings. *Pterocarya pterocarya* had more resistant individuals (44.83%) than any of the *Juglans* species tested, with *J. regia* (44.12%) a close second. *Juglans* hybrid, *J. ailantifolia* and *J. mandshurica* had a higher percentage of resistant individuals than any of the black walnut species, 40%, 30.58% and 24.32% respectively. The black walnut species with the highest percentage of resistant individuals was *J. microcarpa* (15.29%) better than *J. nigra* (14.29%), *J. major* (12.48%), and *J. californica* (9.09%). *J. cathayensis* (8.33%) and *J. hindsii* (8.22%) had the lowest number of retained individuals.

J. microcarpa rooted cuttings derived from plants previously identified as CG resistant continued to show resistance. Eighty-five percent of retested cuttings were resistant while 50% of *J. major* cuttings were resistant. In contrast, all *J. hindsii*, *J. regia*, and *J. ailantifolia* rooted cuttings retested were susceptible. *Pterocarya pterocarya* rooted cuttings from identified resistance seedlings also continued to exhibit CG resistance (60%).

Since the open pollinated seedlings from *J. microcarpa* accessions consistently exhibited lower disease ratings relative to other *Juglans* sp. tested, efforts were focused on *J. microcarpa*. Directed crosses were made using *J. microcarpa* mother tree crossed with pollen from *J. regia* CV *Serr*. One hundred-sixty five hybrid progeny from these crosses have been stratified, germinated, cultivated and inoculated with *A. tumefaciens*. These progeny are segregating for CG resistance. CG resistant progeny have been placed into invitro culture for large scale increase and subsequent field testing. Analysis of these progeny will facilitate characterization of the genetic loci which mediate CG resistance in *J. microcarpa* seedlings.

Goal/Outcome 2*. Generate Sequence Polymorphisms (SNP) markers and characterize map genes / Quantitative Trait Loci (QTL) governing resistance.*

A total of 64,851 SNP-containing DNA sequences from publicly available sources have been assembled. Of the total, 17,291 are from peach and almond from the Expressed Sequence Tags (ESTree) database, 40,794 are from peach from the Genome Database for Rosacese (GDR), and 6,766 (109 almond and 6,657 peach) from the National Center for Biotechnology Information (NCBI). The data is being evaluated for duplicate SNPs, which will reduce the total number of putative SNPs to between 40,794 and 64,851. This suggests many SNP containing sequences in the database may be originating from duplicate regions of the genome.

However, uniquely mapping SNP-containing sequences will be useful for genotyping peach-almond hybrids while overlapping peach and almond SNPs suggest immediate genotyping utility for these hybrid types.

***Goal/Outcome* 3.** *Generate/propagate pure species and interspecific hybrids involving resistant wild species genotypes and scion cultivars for use in disease resistance testing/mapping.*

Across the 4 *Juglans* species examined, a 14% rooting efficiency of the dormant hardwood cuttings was observed. *Pterocarya* spp continue to show CG resistance and are amendable to propagation of hardwood cuttings with a rooting efficiency over 50%.

Seven of the best CG resistant lines were introduced into invitro culture to produce clonal replicates for testing resistance to nematodes and *Phytophthora*. *J. cathayensis* selection #21 was crossed with 3 *J. hindsii* mother trees in order to develop nematode resistant Paradox with *J. hindsii* parentage. From 100 crosses on each of the 3 parents, only 6 seeds were obtained and cultured. Rooted clonal plants were produced for pathogen resistance testing. Recently an additional 527 plants were provided for *Phytophthora* testing. One hundred and thirty-five genotypes were established in culture from zygotic embryos for initial pathogen testing, and 7 of the promising selections for CG resistance were introduced to culture from nodal cuttings. Approximately 12,000 micro shoots were rooted with 70% efficiency, resulting in 7,875 fully established plants developed for pathogen testing. Methods for rapid and efficient establishment of new seedling genotypes in tissue culture were developed by culturing immature zygotic embryos. Improved methods for ex vitro rooting of established plants in the greenhouse using etiolated material and greenhouse stool beds were developed A total of 5,855 plants have been provided to date for pathogen resistance tests, 4,147 for *Phytophthora*, 1,061 for *Armillaria*, 402 for nematodes, and 378 for CG testing.

In all, 1,397 *Juglans* interspecific hybrids were produced during the project which has been propagated through embryo culture and clonal multiplication for evaluation of disease resistance. In addition, approximately 1,000 interspecific *Prunus* hybrids were generated using 6 different *Prunus* pollinated with pollen from 16 different *Prunus* spp. These novel hybrids represent the most genetically diverse collection of *Prunus* germplasm ever assembled for disease resistance evaluation and use as potential rootstock selections for the almond industry. Ovules from the fruit from these crosses were placed into in vitro ovule culture from which generated rooted clones for screening key pathogens. Nine new rootstock accessions were introduced to the field screens for root knot and root lesion nematodes at the Kearney Agricultural Center. Four accessions were established in the plot during 2011, and another five during 2012. The remaining invitro cultivated hybrids are increased and used in ongoing disease resistance screening.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Benefitting groups include the walnut and almond industries of CA and the walnut timber industries of the Midwest. This includes both nursery and production operations.

The walnut industry in-shell value in 2011 was estimated a $1.06 billion. The USDA/ARS estimates that the current CG incidence alone reduces effective yield by approximately 10% which represents a loss of ~$106 million which would be saved with rootstock resistant to CG. The almond value in 2011 was estimated at $2.69 billion. The USDA/ARS estimates that the current CG incidence alone reduces effective yield by approximately 5% which represents a loss of ~$134 million which would be saved with rootstock resistant to CG It would be conservative to estimate the values given above for CG losses could be doubled when Armillaria, Phytophthora and lesion nematodes are considered. Consequently, the USDA/ARS estimates the walnut and almond industry could save $400 million per year if disease resistant rootstocks were widely available and used.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Attempting to identify and develop disease resistant genotype for any woody perennial, and fruit and nut trees in particular, is a tremendous challenge. One of the lessons relearned is just how important it is to coordinate activities between plant pathologists, plant breeders, plant physiologists, and plant geneticists. For example, isolation of disease resistant genotypes which are recalcitrant to invitro propagation, or are difficult to cross with commercially viable genotypes, is of little use. None of this is possible without close collaboration and communication. Since trees are very slow to grow, if an available window of time is missed, researchers cannot simply grab a few more seeds and try again as is possible with corn or soybeans. One unexpected outcome was the discovery that the walnut genus, *Juglans microcarpa* appears to contain a variety of genetic loci which impart resistance to multiple pathogens and ease of zygotic embryo rescue in *Juglans*.

Nearly all of goals of the grant were achieved. However, given the slow nature of dealing with tree genetics/breeding, the USDA/ARS may have been a bit over zealous in a few goals However, the USDA/ARS is well on the way to generating commercially viable disease resistant rootstocks for the tree crop industry.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Not Applicable

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 40	Project Title: Sustainable Grape Pest Management for California Using Weather Data, Models, and Cultural Controls	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09047	**Date Submitted:** December 2012
Recipient Contact: Walter Douglas Gubler, Department of Plant Pathology	**Telephone:** 530-752-0304	**Email:** wdgubler@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The purpose of this project was to develop sustainable pest management programs for California grape production by using science-based decision tools, which have the potential to reduce agrochemical inputs. Based on the outcomes of a pre-project survey conducted within California grape growers, this project aimed to develop a statewide applied research program to increase the use of weather data, cultural control methods and disease risk models. Oregon State University's (OSU) Integrated Plant Protection Center (IPPC), under the coordination of the Western Weather Workgroup, provided centralized, quality-controlled weather data from thousands of public and private stations as well as 10 disease model outputs that employ real time and forecasted weather data. This project planned to expand the accessibility, accuracy, and ease of use of grape disease risk model outputs in California using this public weather station network. It also aimed to increase coverage beyond existing stations through data gridding and interpolation, and creation of a virtual weather station network. A centralized internet site would be made available to both real and virtual weather station networks. Although fairly conservative, the Gubler-Thomas (GT) model for grapevine powdery mildew had consistently reduced fungicide use in California by 2-3 applications per acre over 200,000 acres for 12 years. This project aimed to test less conservative modifications to the model based on recent outcomes on the impact of high temperature on the fungus biology, and combine the model with sampling of early season vineyard inoculum and new molecular diagnostic techniques, such as quantitative Real Time Polymerase Chain Reaction (PCR), with potential to further reduce fungicide use. In addition, the project aimed to test cultural control methods that alter canopy microclimate to improve disease control, such as the use of air blast sprayers to reduce Botrytis bunch rot as well as testing the Broome *et al.* Botrytis infection risk model with improved high resolution weather forecasts. The California grape industry would benefit from this work through more precise timing of fungicide applications or the use of cultural practices, both of which can reduce fungicide use while giving equivalent or better disease control. Environmental and human health benefits would accrue from reduced pesticide use.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Objective 1: Demonstrate the use of public weather data (real, virtual, and forecasted) and disease risk model outputs to guide grape pest management decision-making.

Disease model integration with insect and crop models, weather data and forecasts
The developments supported in part by this project include the integration of a comprehensive array of decision support tools into a single interface, including multiple plant disease risk models (i.e. the Gubler-Thomas powdery mildew index and the Broome Botrytis bunch rot infection risk index), plus numerous insect pests. Two 5.5-6.5 day hourly, site specific forecasts were also integrated, the Fox Weather LLC forecast, which is optimized for agricultural needs including conservative forecasts of moisture and nighttime low temperatures (thus providing a more robust warning for at-risk microclimates), and the National Weather Service (NWS) National Digital Forecast Database (NDFD), which is a standard having lower bias and average error measurements.

Virtual weather stations
During development of disease mapping algorithms, an intermediate product, "virtual weather stations" was developed by Oregon State University Integrated Pest Protection Center (OSU-IPPC) using IPPC V2 data to help growers with disease model estimates for locations lacking weather stations. These IPPC V2 virtual weather stations (deployed for this project during the 2011 and 2012 growing seasons) make use of "smart interpolations" of weather data from nearby observing stations. This method involves a series of quality assurance tests for the nearby observing station data, elevation plus distance weighting of the data, and an elevation-regression based estimation of the data for a prescribed location. The error rates for this method were consistently less than for other production-ready methods of virtual weather data estimation. These other methods include forecast-based (both NWS NDFD and Fox Weather, LLC day-zero forecasts) estimation of data, and National Oceanic and Atmospheric Administration (NOAA) NWS RTMA (Real-Time Mesoscale Analysis) data, which is like a "nowcast" forecast model with real-time bias correction from weather stations. Current IPPC V2 error rates generally range from 0.5-1.1 °C (mean, 0.71) for hourly temperatures, 0.6-1.5 °C (mean, 1.04) for hourly dew point, and 4-10% (mean, 6.3%) for relative humidity. An additional virtual data type, the state-of-the-art Parameter-elevation Regressions on Independent Slopes Model (PRISM) analysis system, is now fully developed but not yet integrated into production. It shows promise as having the lowest error rates yet available for virtual weather data.

Gridded and mapped weather and disease model outputs.
Currently, IPPC V2 weather data is processed and available as web-displayed grids and maps for the project regions, which are linked from the main "MyPest Page" (Attachment 1 and 2). This interface provides daily and hourly views of gridded weather and model predictions at an 800m spatial resolution. In addition, the grids are selectively overlaid on Google maps for precise interpretation and interaction with the maps (zooming, panning, variable opacity of overlays, terrain and satellite backgrounds). Also, a "5-day loop" button animates the selected grid to show the change over time leading to current conditions, in the manner of "radar loop" maps as originally envisioned when this project was proposed. The potential for improved visualization and decision support using this technique shows great promise. These tools are currently in a beta-test phase, and

are actively linked to online decision tools for the end of the 2012 growing season, ready for testing and to begin eliciting feedback from end-users.

Objective 2: Refine Gubler-Thomas powdery mildew risk index (high temperature thresholds) and link with early season vineyard inoculum monitoring using real time PCR diagnostic technology.

Refine the High Temperature threshold of the Gubler-Thomas Grapevine Powdery Mildew Model

In the period March-August 2010-2012, UC Davis set-up replicated trials in different locations in California (Sacramento, Solano and Fresno Counties) to test three years of revisions to the high temperature threshold of the GT model. These locations had weather stations and included researcher controlled fungicide applications based on the original model and its revisions. At all sites, trials were set-up following a randomized complete block design (4 blocks in 2010, 6 blocks in 2011-2012) with 3 plants per unit. Every week, from May to August, disease incidence and severity was assessed on 10 (2010) and 18 (2011-2012) samples per unit (leaves and/or clusters). Data analysis was performed using a mixed model approach. Means comparison was performed via Tukey Honestly Significant Difference (HSD) test using Least Squared means.

Compared to the untreated control, all the model driven treatments at all locations exhibited lower powdery mildew incidence and severity (Attachments 3, 4 and 5). A similar number of fungicide sprays was applied to the blocks during the course of this project. However, the timing was slightly different due to temperature-driven variations of the model revisions (example in Attachment 6). Statistical analysis of combined data for the 3 years of the project demonstrate that among the revisions tested, GT 38Cx2hr exhibited statistically significantly lower incidence and severity on leaves than did the other revisions (Attachment 7). The level of control exhibited by both the original model and GT 38Cx2hrs over the 3 years was statistically equivalent to that of calendar based treatments, but with as many as 4 fewer fungicide applications. As far as clusters were concerned, GT 38Cx2hrs and the Mahaffee revision of the GT model exhibited lower incidence than did all other treatments and, with GT 36Cx4hrs also lowered severity. Based on the outcomes of this research, 38Cx2hr is being proposed as a revision to replace 35Cx15min into the high temperature threshold of the GT model.

Early season pathogen detection

For the first time in California, UC Davis Department of Plant Pathology demonstrated and used early season rotorod spore trapping in vineyards combined with highly sensitive quantitative Real Time Polymerase Chain Reaction (qPCR) to determine if and when the powdery mildew pathogen *E. necator* is first detected in the air. In the period March-June 2010-2012 spore trapping trials were set up in different locations in California to monitor early season vineyard inoculum (Attachment 8). The vineyards were visited weekly to collect and replace the spore trap sampling units and to visually inspect the plot and rate for disease. The day following the collection, the DNA was extracted in the lab and qPCR runs were performed. Data were used to correlate estimates of aerial spore density according to the spore trap catches with observations of visible mildew colonies. The rotorod spore traps coupled with qPCR were efficient at all locations in detecting early season vineyard inoculum. According to rotorod traps, increasing spore density quickly resulted in a saturation of disease incidence on leaves (Attachment 9). The ultimate goal is to use information about spore load to further refine fungicide spray application timing; there is no need to spray for a disease if the pathogen is not yet present in the vineyard. One of the outcomes of this objective is that two commercial companies have formed a joint venture to provide spore sampling data to growers in the north coast production area. This information will allow growers to confidently withhold fungicide applications until spore detection thus potentially further reducing the number of overall applications.

Objective 3: Refine cultural controls for Botrytis bunch rot including use of empty air blast sprayers and the Broome et al. infection risk model with local, forecasted weather data to predict infection events

UC Davis have conducted two years of research trials at Napa and Kern Counties (2010-2011) on the use of the Broome *et al*. Botrytis infection risk model to time fungicide applications using real time and forecasted weather data, as well as using empty air blast sprayers to dry the grapes after a wetness event. At both sites, trials were set-up following a randomized complete block design (4 blocks) with 3 plants per unit. Weather data was assessed through nearby public weather stations and disease incidence and severity data were collected at harvest. Data analysis was performed using a mixed model approach. Means comparisons were performed via Student's T-test using Least Squared means. Data analysis shows that fungicides applied following the Broome *et al*. Botrytis infection risk model calculated by using the high resolution forecasted weather data available on the "Mypest page" developed during this research project, exhibited statistically significantly lower levels of disease incidence and severity compared to all the other treatments (Attachment 10).

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Project impact on the use of the GT model

A survey of a randomly selected subset of raisin and table grape growers was conducted in 2010 to determine extent of use of the GT model at the start of this project. A post project follow-up survey for wine grape and raisin grape growers was conducted to assess project impact based on changes in responses to these questions.

Baseline and follow-up data was used to examine the evolution of powdery mildew management and PMI use among the surveyed growers. Based on follow-up survey responses, the use of Powdery Mildew Index (PMI) has increased steadily over the last few years. Among wine grape growers, the percentage of growers who reported using PMI "heavily" or "often" has increased from about 50% in 2007 to about 75% in 2012. The percentage of growers who never use PMI stayed around 10% (Attachment 11). Raisin grape growers are not far behind with about 20% reporting to never using PMI and about 75% using PMI "heavily" or "often" (Attachment 12). Onsite weather stations were reported as the main source of PMI data for about 50% of the wine grape growers. However, since 2007 private companies have been gaining ground as the second largest source, currently at about 40% (Attachment 13). Raisin grape growers typically run much smaller operations and the majority receive PMI data from a free source: 60% reported receiving PMI data from a free website and only 10% from an onsite weather station. The majority of PMI users report increase in trust from the initial year of PMI use to 2012. Almost 83% of PMI users report increased or stable level of trust in the PMI, with 47% of growers reporting "strong" to "total" trust in the index, a major increase from 16% of growers in 2007.

About 17% of wine grape growers and 25% of raisin grape growers end up discontinuing the use of the PMI. The major reasons for not using PMI or discontinuing its use have remained the same over the course of the last few years: most growers not using PMI report a strong preference for a calendar schedule (28% of wine grape growers and 80% of raisin grape growers) and do not think that benefits of using the PMI justify the hassle of flexible spraying schedules (18% of wine grape growers and 60% of raisin grape growers). Another major reason for not using PMI is availability (20 % of wine grape growers and 30% of raisin grape growers). Most of the non-adopters believe that available PMI data is not specific enough to their vineyard, mainly because of the lack of nearby weather stations. The main motivation for PMI use for all growers is to reduce the probability of powdery mildew outbreaks. The second most important motivation is reducing chemical costs. However, wine and raisin grape growers differ in how much importance they place on cost savings. For wine grape growers chemical costs have been a decreasing concern over the last several years and they report using the PMI primarily as an outbreak prevention tool. Raisin grape growers place almost as much importance on chemical cost savings as they do on preventing powdery mildew outbreaks and for them PMI is also an important cost cutting tool.

In conclusion, the use of the PMI has been slowly increasing and the majority of PMI users are happy with the product. Wine and raisin grape growers approach disease management products such as PMI with different expectations. Wine grape growers with higher value operations look for data specific to their vineyard that will help preserve the value of their crop. They are more likely to rely on onsite weather stations as a source and some use PMI as a backup to the established spraying schedule. Raisin grape growers operate with tighter margins and favor free access to PMI data from public sources (UC IPM) or as a bundle with other services. They look to PMI use as a way to save on chemical spraying costs as well as preserve the crop value by preventing powdery mildew outbreaks. While a lot of the concerns regarding PMI use are shared by both groups of growers (availability of PMI specific to the vineyard and difficulty switching to flexible spraying schedules), the solutions to these problems would have to be specific to each group. Higher cost solutions to improve PMI availability such as onsite weather stations or private sources of high quality data would be more appealing to wine grape growers while raisin grape growers would likely be only tempted by additional free or low cost access.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Given the tremendous interest expressed by California grape growers on the outcomes of this research, 18 new weather stations were purchased with part of this grant funds to be incorporated into the public real and virtual weather station network developed and demonstrated during the course of this project.
Moreover, as a consequence of the demonstrated utility of early season monitoring of spore presence in vineyards, a private company in the disease diagnostic industry (AL&L Crop Solutions Inc.) is now providing quantitative Real Time PCR testing for the grapevine powdery mildew pathogen *E. necator*.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

One negative was in having to return money. UC Davis ran into a problem with trying to get money to cooperator (Len Coop) at OSU then had to return it without fulfilling this obligation to him. Better tabs on the money should have been kept as time was winding down. Also, UC did not anticipate the non response from table grape growers. The fact that table grape growers have production goals set with inputs finalized before the season, make them pretty nonflexable. Thus, project staff will work the few that will work with UC to see if use of the model can be increased. This project should probably have been set for 5 years due to a problem getting table grape growers on board with the survey and overall study. The secretive nature of this group made it possible to only work with a few growers. With the purchase of the weather stations project staff will continue to work with them on the use of the model. On the whole this was a very positive experience. UC Davis knows the GT model works well in disease control and reducing fungicide use and the surveys showed a high percent of growers use the model and the challenge to increase the usage will go forward with success. One unexpected outcome of the project was the rapid adoption of the early season spore catch work. With two companies now providing this service to growers and the rapid acceptance of growers and Pest Control Advisor's (PCA) to pay for the service was a welcome surprise. More private companies are expected to become involved in the future.

The goals of the project were realized but extra time would have allowed project staff to further the use of the model in table and raisin grapes. UC will continue the project.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

The following are provided as separate attachments to this report:

- Attachment 1 (includes attachments 1-13)
- Attachment 2 (Broome Poster)
- Attachment 3 (Peduto Poster)
- Attachment 5 (Peduto Talk)

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 41	**Project Title:** Area-wide Biological Control of Diaprepes Root Weevil	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No:** SCB09031	**Date Submitted:** December 2012
Recipient Contact: Robert R. Chan, Office of Research	**Telephone:** 951-827-7986	**Email:** rchan@ucr.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The life history of the Diaprepes root weevil makes this insect a significant threat to many different commodities and systems in southern California (CA). The insect spends most of its life as a larva in the soil feeding on plant roots where it is protected from natural enemies and is very difficult to control chemically. It pupates (transforms to the adult stage) in the soil, the adults emerge out of the soil and are large and active; thus, few predators except birds or lizards will tackle the adults. The only relatively vulnerable life stage is the egg mass, which has proven susceptible to egg parasitoids in Florida and other parts of the world (small stingless wasps whose young eat the eggs). With the end of the State-run eradication program in 2008, improving biological control was considered the best way of dealing with this pest in a cross-commodity fashion. The project's intent was to import the most effective parasitoids that could be identified into CA and release them for biological control, i.e. via classical biological control. Under this scenario, the absent natural enemy is imported, released where the pest was newly introduced (i.e. southern CA), and it is hoped pest levels will be reduced as much as possible, thus reducing pesticide use for this new pest insect.

As described below, the project made excellent progress importing the species of parasitoid that is most effective in Florida attacking Diaprepes eggs (*Aprostocetus vaquitarum*) but had a very difficult time with permits for the other species planned for import. Chill-termination of Diaprepes eggs was also studied – the idea of subjecting them to limited bouts of cold temperature so that they will not hatch, but are suitable for parasitoids to attack. Good progress was made on this objective, and it is important so that Diaprepes eggs can be made available for extended periods of time for rearing parasitoids, rather than only when there are egg laying adult Diaprepes.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Objective 1.

- *Ship parasitoids from the University of Florida to the University of California, Riverside (UCR) Quarantine under an approved federal permit,*
- *An authorized Quarantine officer (Dr. Serguei Triapitsyn or Dr. Imad Bayoun) inspects each shipment,*
- *Live insects are transported under an approved state permit to release sites, and*
- *Release insects using (a) field cage releases or (b) open field releases*

When submitting the proposal to conduct this work, the target was to import and release 3 parasitoid species over the duration of the project. This seemed reasonable because permits were in hand allowing shipment of *Aprostocetus vaquitarum*, *Haeckeliana sperata*, *Fidiobia dominica*, and *Fidiobia* sp. (a *Fidiobia* species different from *F. dominica* which had not been named yet was the target of interest) from Florida to UCR Quarantine as well as CA release permits for the first two species. However, everything changed when USDA/APHIS (Animal and Plant Health Inspection Service - the federal agency that permits shipments and releases) changed their policy so as to require detailed host specificity testing prior to allowing release of biological control agents, even if they had previously been released in another U.S. state. It is ironic that even though UCR had an approved *H. sperata* permit allowing CA field release, this permit was not renewed. Completely new and unanticipated Quarantine studies were required before UCR could apply for permit renewal. APHIS sent UCR a list of 22 weevils that have been imported into various parts of the U.S. for control of various weed species. APHIS' concern was the possibility that one of these beneficial weevils would be negatively affected by the weevil egg parasitoid UCR wanted to import and release.

UCR spent substantial time and effort trying to conduct the required host specificity testing for *H. sperata*. After discussion with a number of experts, the list of 22 weevil species was reduced down to 10 key species that were most important and would likely be sufficient to obtain a permit. Dr. Jorge Pena spent considerable time and effort testing 4 of these species in Florida. Dr. Kris Godfrey grew a number of the weeds that are needed to rear several of these weevils, and helped in arranging for field collections of the weevils for shipment under permit to UCR Quarantine (state permits were obtained allowing shipment of 5 of these weevil species from collection areas in CA as well as a shipment permit for a 6th species that USDA/ARS had only in lab culture in Albany, CA). Dr. Pena made 22 shipments of *H. sperata* from Florida to Quarantine that were used in host specificity testing. To summarize about 1.5 years of effort, UCR finally came to the realization that it would not be possible to obtain a permit for *H. sperata* within the time frame for this project – this would likely have taken another 2-4 years of sustained effort. These weed-infesting weevils are very difficult to work with, as are the weeds that they attack (many attack only a few weed species and a specific plant part such as the seed head).

Luckily, *H. sperata* was the #2 priority on the project's list; the most effective parasitoid in Florida and the #1 target of UCR's research was *Aprostocetus*. Over the duration of this project, Dr. Pena made 99 shipments of

Aprostocetus to Quarantine totaling roughly 45,800 insects. Releases were made on a total of 40 different properties in Encinitas, La Jolla, Long Beach, Newport Beach, and Rancho Santa Fe, CA. Releases were made on a total of 97 dates (how many wasps were released at each site each date varied quite a bit depending on where the most weevils had been seen and how many wasps were available on that date).

One of the methods used with *Aprostocetus* was a release into a closed bag with Diaprepes eggs. Basically, UCR would pick out a good host plant, collect Diaprepes adults, seal them in the bag to lay eggs, and then later add *Aprostocetus* females (after removing the Diaprepes adults). The idea was to then open the bag close to when the wasps reached the adult stage so that they could fly out and attack other Diaprepes egg masses. When UCR destructively sampled bags of this nature to see how well it worked (done with 28 bags total), an average of 9.8 wasp pupae per bag were obtained using an average of 3.5 adult wasps per bag (this nearly 3-fold increase was considered good given that the wasps had reproduced under field conditions and thus, UCR was able to release very young adult wasps).

Following field release, signs of parasitoid establishment in the field were looked for. Extensive searches were made on 8 dates in Newport Beach and 5 dates in Encinitas / Rancho Santa Fe – a total of 464 Diaprepes egg masses were collected from the field and examined. In total, 9 *Aprostocetus* pupae were recovered in the field from field collected egg masses (two on September 21, 2011, one each from an egg mass on *Hibiscus* and *Raphiolepsis indica*, and seven on October 26, 2011, one and six from two *Phoenix roebellini* plants). UCR is quite encouraged by these recoveries. In biological control work it is often several years before recoveries are made. The true test of this release work, however, will be how many *Aprostocetus* are seen in future years and to what degree they help control Diaprepes weevil (the project ended June 2012 prior to the 2012 Diaprepes egg laying season started).

The third parasitoid initially targeted in this research was one of several *Fidiobia* parasitoids. Dr. Pena originally had a colony of *Fidiobia dominica* in Florida that had been collected from the island of Dominica. Unfortunately, this parasitoid culture was lost in Florida before UCR could start working with it. A follow-up search for this insect in Dominica was unsuccessful.

Dr. Pena then heard about *Fidiobia* n. sp. (a new, undescribed species) that was reared commercially in Columbia for biological control of the eggs of citrus weevil, *Compsus* sp. Pena contacted the governmental institute CorpoICA, and with the help of one of its entomologists, filed the paperwork to be presented to the Ministry of the Environment. However, this paperwork needed to be approved by CorpoICA's Genetic Resources office and the person in charge refused to push forward the paperwork because he considered the commercially produced *Fidiobia* to be a Colombian genetic resource. A new APHIS PPQ (Plant Protection and Quarantine) permit was issued recently to import parasitoids of citrus weevils into the Florida Quarantine facility. The permit is valid for 4 years and Dr. Pena plans to continue working on trying to obtain this insect.

Having been frustrated in trying to obtain two *Fidiobia* species from outside CA, then having to conduct lengthy host specificity studies, UCR's attention turned to the previous report of a weevil egg parasitoid in CA. In the late 1980's *Fidiobia citri* was reported to attack Fuller rose beetle eggs in CA. Pest control advisors were contacted, and in January of 2012, the insect was found in a Valley Center citrus grove. UCR made a collection and ever since have been rearing it in the laboratory on Fuller rose beetle eggs. The female wasp lays her egg inside a Fuller rose beetle egg and is quite small. Unfortunately, although the females show great interest in

Diaprepes eggs, an oviposition event was never observed, and no offspring resulted when the adult parasitoids were left with Diaprepes eggs for an extended period of time inside Quarantine.

Objective 2.
Conduct studies to determine appropriate temperature regimes and length of exposure for chill-termination of Diaprepes eggs.

The objective was to develop a method of "chill-terminating" Diaprepes eggs so that the eggs could not hatch, but remained suitable for attack by egg parasitoids and predators. This concept was based on research by Roger Leopold and collaborators at the USDA/ARS Laboratory in Fargo, North Dakota. The Chen and Leopold (2007) method for chill terminating glassy-winged sharpshooter eggs involves 5 days of storage at 2°Celsius (C) to "terminate" the eggs, and they then can be held for up to 70 days at 10°C and are suitable for parasitism by the internal parasitoid *Gonatocerus ashmeadi*. Such a method for storing Diaprepes eggs would have two obvious advantages: (1) parasitized eggs taken to the field would be safe, i.e. Diaprepes eggs would not hatch if any eggs were not parasitized and (2) Diaprepes eggs could be collected and stored for longer periods of time before they were used to maintain colonies or parasitoids were released in the field.

To summarize a substantial amount of research, chill-terminating at 2°C was found to be too cold for Diaprepes eggs to hold up well, but 5°C for 5 days appeared to work very nicely. UCR held 2507, 3447, and 2838 eggs at 5°C for 5, 8, or 11 days and obtained no egg hatch, whereas 97.9% of 2115 eggs held at room temperature hatched. This method could be very useful for future Diaprepes parasitoid research.

Objective 3.
Outreach to progressively increase as the project progresses. Hold regular meetings of the Advisory Committee, which includes representation from the citrus, ornamental nursery, avocado, and other industries, the San Diego Agricultural Commissioner's office, the San Diego Farm Bureau, and members of the research team.

UCR consistently met quarterly via conference call and received excellent input from the advisory committee. UCR especially appreciated the substantial input from Tracy Ellis and David Kellum of the San Diego Agricultural Commissioner's office, Janet Taylor of CDFA, and Janet Kister of Sunlet Nursery who were quite active participants. Project outreach was accomplished by each of the project participants as well as a number of the members of the Advisory Committee. Jim Bethke and John Kabashima took the lead in extending information to the ornamental and nursery industries; Joseph Morse to the avocado industry; and Gary Bender, Kris Godfrey, and Joseph Morse to the citrus industry.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

For objective 1, the expected outcome was to import, evaluate, and release 3 parasitoid species. As detailed above, early during the research, USDA/APHIS made a major change regarding the amount of host specificity data that would be required before authorizing a permit allowing parasitoid release. UCR was caught by surprise when APHIS would not renew the *H. sperata* release permit and instead, wanted us to run host specificity studies on 22 weevil species. Considerable time and effort was spent trying to do these requested studies, but after 1.5 years of sustained effort, UCR realized this would not be possible. Given this experience, it would not be feasible to release the third species (one of the *Fidiobia* species) because again, extensive host specificity testing would be needed before release would be allowed.

UCR was able to release only 1 species (*A. vaquitarum*) due to permit changes but also imported and evaluated *H. sperata*, and evaluated the native *F. citri*. So UCR accomplished 3/3 evaluation goals, 2/3 of import goals but only 1/3 release goals. The evaluation criteria for releases were (a) percent parasitism of Diaprepes eggs in controlled studies, (b) the percent of egg masses in release and surrounding areas that are parasitized, and (c) the length of time parasitoids can be found after the last release. In controlled laboratory studies, 52.5%, 63.2%, and 66.7% of female *A. vaquitarum* parasitized a Diaprepes egg mass when provided 1, 2, or 3 egg masses, and laid 14.2, 9.9, and 14.0 eggs per wasp female, respectively. In these lab studies, % parasitism is not really the appropriate statistic, as this would vary greatly depending on how many female wasps one exposed to a certain number of Diaprepes eggs. Total eggs laid per female wasp was 53.4 (range 19-124) and female wasps lived an average of 15.2 days. This wasp is really more of a predator than a parasitoid (wasp eggs are laid inside the egg mass but external to the egg) and each wasp larvae consumed an average of 2.6 Diaprepes eggs to complete its development. For *A. vaquitarum,* % field parasitism near the release area (criteria b) was 9 parasitized egg masses out of a total of 464 egg masses collected over 13 collection dates July 23, 2010 to June 12, 2012. Including all egg masses, % parasitized egg masses was 9/464 = 1.94%. The first recovery was made September 21, 2011, after 1.5 years of releases (first release March 31, 2010) so one should largely discount the field egg masses assessed early during the release program. Including egg masses collected only after the first recovery, % parasitized egg masses was 9/158 = 5.69%. With respect to *A. vaquitarum* and criteria (c), the last parasitoid was recovered October 26, 2011. One must take into account the field biology of Diaprepes in evaluating this criteria – Diaprepes females lay their eggs in coastal southern California mostly July-October each year and one would expect field parasitoid levels to peak towards the end of this time period (i.e. wasp levels would start out low and build progressively as more egg masses are available later in the year). Given that the project ended June 2012, it is not at all a surprise that the few Diaprepes eggs masses UCR were able to find early in 2012 (before the project ended) were not parasitized. To summarize the *A. vaquitarum* work, a tremendous amount of effort was spent importing and releasing this species (the #1 most effective species based on Florida work). Dr. Pena sent 99 shipments to CA containing a total of 45,800 insects, and UCR believes with an outstanding success – i.e. the species was recovered following release.

Space does not allow a full listing of all laboratory work done with *H. sperata* and *F. citri*. *H. sperata* has a lower developmental threshold of 11.3°C, and development from egg to adult occurs after 279.7 degree days above this threshold. *F. citri* is a tiny internal egg parasitoid of Fuller rose beetle eggs, *Naupactus godmani*. Adult females lived an average of 19.7 days in the lab (range 4-41, n=57) and males 13.6 days (range 3-46, n=27).

For objective 2 (chill termination research), UCR proposed that success would be measured by (a) hatching ability of Diaprepes eggs after exposure to the chill termination regimen and (b) acceptance of chill-terminated egg by parasitoids, i.e. oviposition rate per wasp female, number of progeny produced per egg mass, sex ratio of parasitoids produced, and length of time adult parasitoids survived. As detailed above, the chill termination method fulfills criteria (a) completely (0% hatch), but *Aprostocetus* females did not appear to accept chill terminated eggs. Future research should determine if internal parasitoids would accept them (as noted, *A. vaquitarum* is an external parasitoid/predator).

Objective 3 dealt with outreach conducted by project participants over November 2009 – June 2012 including quarterly conference calls with project participants and the Diaprepes advisory committee. All quarterly meetings were held (either in person or via conference call) and a substantial amount of outreach was accomplished over the duration of the project.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The Diaprepes root weevil could have major impacts on the ornamental nursery, citrus, and avocado industries in CA. UCR hopes the *Aprostocetus* releases have resulted in the establishment of this biological control agent, and that it will have a significant impact in reducing the severity of Diaprepes below what it would be without the presence of this parasitoid.

There are 4 major stakeholder groups (1-4 below) who benefited from the information on Diaprepes root weevil biology and management in California, biological control of this insect, and the research that was done in addressing this problem. A good reference for impacts of Diaprepes root weevil on Groups 1, 3, and 4 is the Jetter and Godfrey (2009) article (see Attachment 1).
Total estimated # of stakeholders: ca. 672 + 763,023 + 3,000 + 150 = 766,845 stakeholders.

Group 1. Commercial nurseries in the area that might be impacted by regulations governing intra- and interstate shipment of plants if Diaprepes root weevil was found on or near their property.

There are approximately 4,969 commercial nurseries in California and the market value of sales is $3.65 billion (USDA NASS 2007 census). Based on data obtained January 11, 2013 from the County of San Diego Department of Agriculture, Weights and Measures, San Diego County has 875 licensed nurseries at a total of 1,617 locations (a total of 672 production nurseries at 904 sites; the rest are retail nurseries).
Total estimated # of stakeholders: ca. 672 (conservatively counting only the production nurseries).

Group 2. Backyard owners of citrus, avocado, and other plants affected by Diaprepes root weevil.

Data in the left 4 columns of Table 1 below are from the U.S. census web site for coastal counties of California where it seems likely Diaprepes root weevil will eventually spread. Of the number of housing units, the project team estimated conservatively that 20% are private homes (occupied by either the owner or a renter). Of those, the project team estimated that 50% of the homes have at least one backyard citrus tree. These estimates are based on the CA Department of Food and Agriculture's (CDFA) estimate that 60% of backyard homes in the Los Angeles area have at least one citrus tree. These estimates were made via visual inspection by the CDFA recently to determine how many backyard citrus trees would need to be treated for Asian citrus psyllid control in the Los Angeles area if the eradication program were to continue in that area.
Estimated # of stakeholders: ca. 763,023.

Table 1. Data from the U.S. Census web site

County	Population	Housing Units	Persons/ household	Number of homes 20% private homes	50% w citrus
Los Angeles	9,889,056	3,449,273	2.99	862,318	431,159
San Diego	3,140,069	1,168,679	2.79	292,170	146,085
Orange	3,055,745	1,050,889	2.99	262,722	131,361
Ventura	831,771	282,505	3.03	70,626	35,313
Santa Barbara	426,878	152,839	2.84	38,210	19,105
Totals	17,343,519	6,104,185		1,526,046	763,023

Group 3. Commercial avocado growers near the Diaprepes infestation area and as the weevil spreads.

The California Avocado Commission estimates there are roughly 5,000 commercial avocado growers in California, many of them in the region near coastal areas of California in San Diego, Orange, Los Angeles, Ventura, Santa Barbara, and San Luis Obispo counties (perhaps 2% of the acreage is in the San Joaquin Valley and would be much less likely to be affected; also acreage in Riverside county which is warmer and further from the coast would less likely be affected). It seems likely that Diaprepes root weevil will eventually spread to all of these areas except the San Joaquin Valley and Riverside County. Diaprepes root weevil has not appeared as a pest of the limited acreage of avocados in Florida and the project team believes this may be because commercial avocados in Florida on grown on very rocky ground where weevil larvae do not do well in the soil. Greenhouse trials inside Quarantine in California show that larvae can survive on avocado roots but not as well as on citrus. If populations of Diaprepes became problematic on commercial avocados in California, they could be a serious problem – Phytopthora root rot is the number 1 pest problem on California avocados and Diaprepes larval feeding is known to make root rot much more severe.
Estimated # of stakeholders: ca. 3,000.

Group 4. Commercial citrus growers near the Diaprepes infestation area and as the weevil spreads.

Given the short amount of time for this response, the project team could not provide accurate data on the number of commercial growers in the coastal areas of southern California. However, a rough estimate is provided. Most of the commercial citrus acreage in California is now in the San Joaquin Valley (ca. 75%). Remaining growers in coastal areas most likely to be affected by the spread of Diaprepes root weevil are in San Diego and Ventura counties.
Estimated # of stakeholders: ca. 150.

It is very difficult to quantify with any precision the impact this project has had economically; however, the team has done its best by taking the following 3 approaches below:

Approach 1. The project helped justify continued intra- and interstate nursery shipments out of San Diego County.

According to the 2011 Crop Statistics and Annual Report from the County of San Diego Department of Agriculture, Weights and Measures, Nursery and Cut Flower Products in the County were worth \$1.092 billion in 2011. San Diego County has by far, more nurseries than any county in the nation. Had Diaprepes established in San Diego nurseries, each infested nursery would have been required to treat with pesticides in one fashion or another before being allowed to ship – the total use of pesticide for this purpose would have been very, very large. Moving towards Diaprepes biological control was important not only for the industry, but also for the public and municipalities to reduce the amount of pesticides that would have been used to protect fruit trees and landscape plants.

Economic impact – consider an impact on 0.1% of nursery shipments for a <u>single year</u>: 0.1% of \$1.092 billion = **\$1.092 million**.

Approach 2. Political impact – the project helped justify discontinuing eradication.

The California Diaprepes eradication program run by the CDFA cost approximately \$4.9 million in 2008-2009, and was discontinued in 2009 largely for financial reasons as the state was short on funds due to the economic downturn. In part, the urgency for this project addressed the following: if eradication could not be continued, it was worthwhile using whatever other approaches might work to slow the spread of Diaprepes root weevil in California and mitigate its impact. Biological control was considered one of the few feasible means of slowing the spread and mitigating the impact of the weevil could have if it was no longer feasible to treat chemically and maintain a quarantine. Biological control efforts conducted were examined on this weevil in Florida and worked on the most effective biological control agents that had been identified. *Aprostocetus* was largely focus upon because the project team already had a permit, which allowed its importation into California and release; it had been the most successful classical biological control agent identified in Florida.

Economic impact – the project in part justified CDFA not continuing the eradication program. Assuming the total eradication costs over the next 5 years might have been similar to the one-year cost in 2008-2009 (a quite conservative estimate), the savings to California taxpayers was ca. **\$4.9 million**.

Approach 3. Analogy to the situation in Florida.

A rough estimate of the impact of Diaprepes root weevil in Florida is $70 million in annual damage (see Attachment 2). If you assume that the Diaprepes Specialty Crop project better informed the public, nurseries, citrus and avocado growers, and county and state officials about the impact of Diaprepes root weevil such that greater efforts were taken to curb the spread of this insect. Also, assume that the impact of this weevil in California will eventually be 50% of its impact in Florida and that the biological control program delayed the spread of Diaprepes root weevil in California by 6 months. These seem like quite conservative estimates.

Economic impact – $700 million/year in FL x 50% of this impact in CA x 0.5 year delay = **$175 million**.

Overall estimated economic impact: The 3 approaches above can be used as either a range (i.e. the impact is somewhere between $1.09 and $175 million) or another consideration could add the 3 types of impacts together (i.e. the impact is ca. $181 million).

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

A major problem ran into with this project was that USDA/APHIS completely changed their perspective on granting permits allowing the release of beneficial parasitoids. There was little advance notice of this change and they now require extensive and expensive host specificity testing before allowing the release of these species. One of the more important accomplishments of this project was to release *Aprostocetus vaquitarum* in California before these changes would have made it extremely expensive to obtain a permit to do so.

What has the project team learned that would be of help to other researchers continuing this type of work?
(1) The present host specificity requirements allowing field release of beneficial parasitoids are daunting and UCR suggests researchers carefully budget the cost and time needed to accomplish the work required under the new regulations, especially if the parasitoid might be able to impact a beneficial species (such as the weevil biocontrol agents ran into with no advance notice).
(2) *Aprostocetus vaquitarum* appears to be an excellent biocontrol agent for Diaprepes, and future field monitoring should tell whether this species is established in CA and how well it is controlling this important pest (if it has, the funds spent on this project have been fully justified).
(3) Given the new regulations, work on *H. sperata* and *Fidiobia* spp. can likely not be justified unless new information surfaces suggesting they are very effective – UCR's lab work suggests they may not be.
(4) For internal parasitoids, the chill termination protocol developed could tremendously assist in Quarantine rearing and then mass rearing by insectaries that wish to release these species.
(5) UCR's field research pins down when Diaprepes adults and egg masses are present in the field in coastal areas of southern CA (to date this insect has not spread to interior regions). This work is presently being prepared for publication and will be of substantial assistance to future Diaprepes biocontrol efforts.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

A number of publications are being worked on as a result of this project, but will not be available until after the grant period.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 42	Project Title: Refining chemical control of vine mealybug to manage resistance, enhance natural enemy conservation and promote integrated control	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09032	**Date Submitted:** December 2012
Recipient Contact: Nilima Prabhaker	**Telephone:** 520-316-6353	**Email:** nilima.castle@ucr.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The vine mealybug [VMB, *Planococcus ficus* (Signoret)] is a grape pest of exotic origin that was first discovered in the Coachella Valley of California in 1994. It spread rapidly to other grape growing regions of California on grapevine nursery stock, with localized spread occurring by natural dispersal and contaminated farm equipment. Now established in 21 counties, VMB represents a serious threat to vineyard owners throughout California as wine, raisin and table grapes are all vulnerable to VMB infestations. The pervasiveness of VMB in California mandates that effective and sustainable management strategies be developed. Chemical control is a key element of most pest management programs for the quick and usually effective results it delivers. But chemical control is also an approach in which indiscriminate and prolonged use can create more problems than benefits. The key to sustainable integrated pest management programs (IPMs) is to optimize and diversify chemical control so that the full potential of each treatment is attained and the total number of treatments required for effective control is minimalized.

Recognizing the need to obtain better information on insecticidal controls of VMB, the overall goal of this project was to identify a suite of selective, reduced-risk insecticides that work in concert with biological control to suppress VMB populations through enhanced conservation of natural enemies. Many of the newer insecticides that have unique modes of action are highly selective because they target specific biological processes in particular insects. This means that treatment of target pests such as VMB may have limited impact on other beneficial organisms such as insect predators and parasitoids. But to determine the impact that candidate insecticides or insecticide regimens have on VMB and its natural enemies requires intensive and replicated studies in the field. There is only limited field data on many of the newer insecticides that have been registered recently for use against VMB. Thus, the findings from the current study will add to this limited body of knowledge and ultimately provide growers with a more complete set of guidelines for managing VMB in vineyards.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activities for this project centered on five field trials conducted in Kern County (Co.) table grape vineyards in 2010-11. This project originally planned for trials to also be carried out in Fresno Co., but difficulty in locating grower cooperators with VMB-infested vineyards resulted in greater attention being given to Kern Co. field sites. Even in Kern Co., however, VMB infestations were highly variable with three of the five field sites characterized as lightly infested and the other two sites as heavily infested. VMB infestation patterns within vineyards are typically highly aggregated, meaning that some locations within vineyards have heavier than average numbers of VMB, while other locations will be much lighter or uninfested. For lightly infested vineyards, this type of spatial variability is even more pronounced and may be represented by only a few small foci of VMB in a vineyard. This was the situation in the three lightly infested vineyards that were included in this project. Thus, comparison of insecticide treatment regimens is less certain when fewer than half of the treatment plots in the experimental field design are infested with VMB, and then only lightly infested at that. Nevertheless, experimental plots were set up in February each year when grapevines were still dormant with no above-ground activity of VMB, and therefore no way to determine infestation levels in advance. The same five treatment regimens with four replications per regimen were used at all five trial sites. The timing of individual treatment applications within each regimen varied according to seasonal timing as well as perceived phenological states of VMB. For example, the organophosphate insecticide Lorsban® was included in Regimen 1 (representing the grower conventional approach), but is required to be applied prior to budbreak in late winter. With respect to phenological states of VMB, the insect growth regulator Applaud® was always applied in early spring when it was assumed that a large proportion of the total VMB population in a vineyard would be represented by early immature stages soon after hatching of egg clutches. As a chitin synthesis inhibitor, Applaud interferes with the molting process in immature insects, and so is most effectively used soon after spring egg hatch.

The most stringent test of each insecticide regimen's capacity to control VMB occurred in the two heavily infested field trials. Although suppression of VMB occurred with all four treatment regimens (no. 5 was the untreated control), there was only one regimen, the Movento® treatment, which completely suppressed VMB and required no additional treatments to maintain economic control. This finding reinforces what growers are already learning about the exceptional performance of Movento. Another important finding was the lackluster performance of the neonicotinoid insecticides Admire Pro® and Platinum®. This finding is important because Admire Pro (or other generic imidacloprid products) is used routinely by growers and Pest Control Advisors (PCAs) to combat VMB, but with uncertain impact. Based on measurement of imidacloprid concentrations in grapevine tissues through the growing season, insufficient amounts of imidacloprid were being taken up by grapevines at four of the five trial sites. The same was true for the Platinum treatment, helping to explain why VMB suppression was not greater in plots treated with these two insecticides.

Personnel at the University of California Cooperative Extension (UCCE) office in Kern Co. were mostly responsible for VMB sampling, with the USDA-ARS cooperator taking care of analytical lab tests.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

To carry out field trials successfully requires planning, execution, and analysis as well as personnel coordination to insure that project goals are achieved. Meetings held between Principal Investigators (PIs) and cooperators early in the project were critical to developing an experimental approach that would yield strong results. Chief among topics was which insecticides should be included in the different treatment regimens, limiting the choices to newer, more selective insecticides. The narrower spectrum of activity of selective insecticides generally improves compatibility between chemical and biological control and potentially results in more complete integrated control, an important goal of this project. Another goal established for this project was to improve knowledge of the activity profiles of neonicotinoid insecticides included in the study. The neonicotinoids, especially imidacloprid, have been relied upon frequently for VMB control, but often with uncertain results in terms of impact on VMB infestations. The results from this project indicated that a consistent suppressive effect occurs, but that the magnitude of the effect is limited and may be influenced by soil type. Tissue samples collected every two weeks through the growing season and tested for imidacloprid concentrations showed a relatively slow uptake that peaked in June before gradually declining. However, peak concentrations varied among field sites as did soil texture, suggesting a link between soil type and uptake concentrations of imidacloprid in grapevines. Soil texture analysis indicated that imidacloprid uptake occurred at a higher rate from soils with higher clay content compared to more sandy soils. This insight is being studied in a new project that is looking more intensively at factors that influence the uptake and distribution of four neonicotinoid insecticides in grapevines. A better grasp of the activity profiles of insecticides applied to vineyards will lead to more efficient use of insecticides and avoid over treatment of follow-up applications when none are necessary.

The overall goal of this project was to improve existing IPM programs for VMB by experimentally identifying alternative insecticide use regimens that feature selective insecticides for control of VMB, while also fostering greater biological control. Although mere replacement of one set of insecticides with another may not seem like much improvement, a change to newer insecticide chemistries that are highly effective against VMB while having limited impact on beneficial organisms that naturally control VMB represents significant progress. The measures of success using lower risk, alternative chemicals included 1) obtaining VMB control equal to or better than the current insecticides, 2) reducing the average number of applications per vineyard and the average amount of insecticide per acre relative to current levels, 3) increasing the densities and/or diversity of beneficial insects relative to those present under current insecticide use regimens, and 4) observing no increase in resistance to low-risk insecticides relative to the current insecticides. Based on the performance of Movento, it can be clearly stated that for success measure item 1, control of VMB was vastly improved relative to the grower standard regimen, and for item 2, reducing the number of seasonal insecticide applications to just one represented a tremendous improvement. Toxicological bioassays showed for item 4 no increase in resistance to any insecticide chemistry. The one uncertainty was item 3 in which evaluations of beneficial insects in the various treatment plots were inconclusive, probably due to the relatively small plot sizes.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Wine, table, and raisin grapes are a multi-billion dollar industry in California, all under threat of VMB. There are numerous commodity groups representing the three types of grape production that can all benefit by the research findings of this project. There are also the individual growers and PCAs that will benefit by learning of the superlative performance of Movento in this study, but also by being cautious with their applications of imidacloprid and other neonicotinoids. Additional research in the new project will soon add more information on particular soil and other conditions such as grapevine age that are more or less conducive to neonicotinoid applications.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

A lesson already learned, but reemphasized in this project, is the uncertainty that can underlie a field trial when it is conducted in a commercial vineyard. Growers must be reassured that research activities undertaken in their vineyards will not lead to damage in excess of what they would normally expect. Prior assurances given to growers ahead of this project required that if VMB infestations became too heavy anywhere within the experimental area that clean-up treatments would be applied. This unfortunately prevented more than one trial from being carried out longer and causing a loss of data points midway to late in the trials. In another instance, a grower over-treated the experimental plots with imidacloprid, effectively ending any further data collection. In a suggestion to other field researchers that depend on cooperating growers, make sure that a regular line of communication is maintained so that the grower remembers that you are there and knows what you are doing so as to lower the chances of accidental intervention.

One of the unexpected outcomes was the poor uptake of imidacloprid by grapevines relative to other crops that have been investigated. Better performance was anticipated for imidacloprid, but the lack thereof has spawned a new study that will intensively investigate the factors contributing to uptake of neonicotinoids in grapevines.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attachment – Insecticide Treatment Data

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 43	**Project Title:** Acquisition of a Variable-Pressure Scanning Electron Microscope (VP-SEM) to enhance diagnostics of pests affecting Specialty Crops	
Grant Recipient: California Department of Food and Agriculture, Plant Pest Diagnostics Branch	**Grant Agreement No:** SCB09050	**Date Submitted:** December 2012
Recipient Contact: Stephen D. Gaimari	**Telephone:** 916-262-1131	**Email:** stephen.gaimari@cdfa.ca.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The purpose of this project was to acquire a Variable-Pressure Scanning Electron Microscope (VP-SEM) for the Plant Pest Diagnostics Branch (PPD) of California Department of Food and Agriculture (CDFA), for improving the diagnostics capabilities of all five laboratories (Botany, Entomology, Nematology, Plant Pathology, Seed Botany) in serving the needs of California specialty crop agriculture. Unlike conventional SEM, VP-SEM works under a very low vacuum, so does not require any pretreatment (e.g., dehydrating, chemical fixing, coating) of samples, so the processing time per sample is significantly shortened. A wider variety of specimen types (e.g., in fluid, live tissue, cultures, etc.) can be analyzed, and if necessary can still be cultured, grown-out, analyzed for DNA, or further examined. The very large capacity chamber allows large samples to be dealt with without disarticulation, or to view pests (e.g., pathogens, nematodes) *in situ* on intact plant tissue. The large sample plate allows numerous samples to be viewed in one session, without needing to bring down the vacuum and voltage to load a new sample. All of these make the SEM related diagnostics more efficient and faster, and allow further analysis of specimens after SEM analysis is complete.

Understanding biological structure at very high magnification and resolution is an important aspect of the identification of plant pests and diseases. Conventional SEM had been one of the vital tools for the scientists of PPD to provide timely and accurate diagnostics of plant pests affecting specialty crops to our clientele. SEM provides a level of magnification and resolution that is necessary to make species-level determinations for many pest species where optical microscopy would not be sufficient. For example, egg masses of leafhopper species (including glassy wing sharpshooter, or GWSS – the main vector of Pierce's Disease in grapes) have powdery wax coatings laid down by the egg-laying female to protect their eggs. These brochosomes, as they are called, are variable in their morphology among species, and many, including GWSS and other pestiferous leafhoppers, can be readily identified by these structures alone. Most leafhopper submissions from grape growers and other clientele are only egg masses, which are identical under optical microscopy, so their accurate identification requires proper viewing of the brochosomes. Other examples include various fungal pathogens, seeds and nematodes.

The process of identifying plant pests at PPD has been greatly advanced using the newer technologies in SEM, in our case the VP-SEM purchased under this project. Previously, the process of using conventional SEM for identifying plant pests and diseases has required a long preparatory phase prior to specimen viewing, including full dehydration and desiccation (a long process in itself, under carbon dioxide in a critical point drier), chemical fixation, and coating with an electrically conductive material (gold or platinum) using a high-vacuum sputter coater. Once under high vacuum and voltage in the SEM chamber, a high degree of technical expertise is necessary to manually adjust settings to get an image from which the necessary information can be extracted. Depending on fragility of the specimen, this process can cause collapse or mechanical deformation, rendering it unidentifiable or causing misinterpretation, which is a particular problem for making critical identifications for CDFA. After conventional SEM examination, the specimens are useless for any other analysis due to being chemically fixed and coated with metal; this removes our ability to use DNA analysis to determine points of origin and introduction pathways, for example. Additionally, due to sample charging (caused by the conductive material accumulating a higher charge than the ground), conventional SEM images can have artifacts that render them unusable.

The current technology of VP-SEM allows the pre-viewing process of older conventional systems to be completely avoided, because the low-vacuum settings allow specimens to be viewed at high resolution and magnification without dehydrating, desiccating, chemically fixing, or coating specimens. In fact, specimens can be viewed as submitted for identification, whether dead or alive, wet or dry, large or small, soft or hard, allowing study of specimens in their natural hydrated state, thus providing more accurate data on the true form of the biological structures so important for identification. VP-SEM also allows for very rapid workflow (which is critical in emergency and high risk identifications), as specimens can be dealt with very quickly, including viewing multiple samples per session on a large plate, without needing to power down and remove the vacuum and voltage to load a new sample each time. This allows emergency response efforts to be more quickly coordinated and implemented based on diagnoses. In addition, after a specimen is viewed under low pressure, it remains unaltered and can be further analyzed as necessary using other methods (e.g., optical microscopy, tissue culture, germination, DNA analysis, dissection, etc.) that would not be possible if the specimen was desiccated, fixed and coated. VP-SEM also greatly advances the ability to tackle problems in diagnostics as they come up, allowing for differentiating species that are potential or actual pests of California's many specialty crops, using characters never considered under optical microscopy, including use of soft tissues and textures, egg morphology, larval arthropods and nematodes, morphology of specialized structures, microstructures of plants such as trichomes, ovules, and pollen, and fungal pathogens such as rusts and mildews.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

The major project goal was to acquire a VP-SEM for the Plant Pest Diagnostics Center (PPDC), in support of the diagnostics program serving California's specialty crops. The goal for the use of this VP-SEM was to significantly increase the PPDC's ability to provide timely diagnostics services to stakeholders.

After manufacture, the instrument was delivered in August 2010 and installed in October 2010. Pressurized gas (high purity, >99%, nitrogen) required to operate the pneumatic valves and vent and purge the VP-SEM, and a two-stage pressure regulator were also purchased. Six two-hour training sessions by a Tescan engineer were conducted for 20 PPD staff members. The first session was slightly longer for three staff members to receive maintenance training to learn administrative functions, filament replacement, and routine up-keep. Additional training was provided in November 2010 by a Tescan engineer, with 3 two-hour straining sessions for 12 PPD staff members, five of which were new training, and seven of which were additional training for low-vacuum and other special applications. Since installation and training, the VP-SEM has been in general near-daily use in PPD in support of the diagnostics programs, significantly increasing diagnostics productivity and speed.

Time for analyzing samples using the new equipment has greatly enhanced the ability to make rapid identifications for those samples requiring SEM, e.g., egg masses of sharpshooters affecting grapes, certain fungal pathogens, nematodes, etc. In the past, it was a long procedure requiring dehydration of specimens, coating specimens, and viewing them one at a time. The current system allows multiple samples to be loaded at one time, moving from one to the next in rapid succession, with the click of a button. An accessory control panel was purchased to fully control the microscope and provide very fast access to the VP-SEM functions and enable the user to control advanced VP-SEM functions and stage movements in all directions. This allows for faster and more precise examinations of specimens submitted to PPD for diagnosis. After many hundreds of samples have been run through this new system, time required per sample has been cut by up to 75%, due to shorter preparation time, being able to load multiple samples without powering down the machine, and the user-friendly computer and control panel interface. These samples have remained available for further study, because use of the VP-SEM does not alter them in any way. Additional training has been provided by Tescan engineers, and PPD employees have successfully troubleshot problems without incident.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The VP-SEM and associated supplies and accessories continue to be utilized on a routine, near-daily basis in aid of PPD's diagnostics programs in support of California's specialty crops. This indispensible tool allows PPD to serve California's specialty crop industry much more quickly and efficiently than prior to acquisition of this equipment. Samples are processed and diagnosed 75% more quickly than before.

The old conventional SEM required a long pre-process to get a sample ready for SEM. This included dehydrating the sample (a multistep, 1 to 2 day process), mounting it on a stub, and coating the sample with a sputter coater. Once the processed sample is put in the SEM, to get to an adequate image for diagnostics would take a minimum of 30 to 40 minutes. Each sample had to be put in the SEM separately (i.e., one at a time), so any additional sample would take another 30 to 40 minutes. The VP-SEM purchased under this grant removes the necessity for the pre-process, because it can be run at low voltage and low vacuum. Therefore, that entire time period is gone. For the VP-SEM, processing entails only mounting the sample on a stub, then it is ready for analysis. For the VP-SEM, the sample stage is put in, and it takes about 15-20 minutes to get an adequate image for diagnostics. But note, a 7-stub stage is being used, so samples 2, 3, 4, 5, 6, 7 will take only 10 minutes each. To do 7 samples in the old SEM would take a minimum of 3.5 to 5 hours, whereas in the new VP-SEM, 7 samples would take 75-80 minutes. For a single sample, it takes half the time at the VP-SEM, but the entire pre-process time of the old SEM is removed.

The intended use of the VP-SEM was to advance the diagnostics capabilities of PPD, allowing: 1) higher throughput of samples, by viewing multiple samples at a time and avoiding the long preparatory period for conventional SEM; 2) *in situ* viewing of samples in a variety of media, e.g., on a culture plate or leaf surface, or in fluid; 3) non-destructive sampling, so samples can be further analyzed using DNA methods, culturing, dissection, and proper preservation; 4) avoidance of collapse, mechanical deformation, or artifacts of samples that are problematic in conventional SEM sample preparation, e.g., through dehydration, chemical fixation, coating. All of these uses have been realized, and are continuing to provide benefit for California's specialty crop agriculture.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Beneficiaries include the specialty crop industry of California, pest prevention programs of CDFA, County Agricultural Commissioner's, University of California Cooperative Extension, US Department of Agriculture, California's domestic and foreign trading partners, and the general public. This project has direct impact on the entire California specialty crop industry, from the standpoint of increased throughput of samples submitted to PPD for identifications that require SEM. The impact is felt in the more rapid identifications from PPD for many pests and diseases. More rapid and efficient identification allows more rapid response, including survey, control and eradication efforts, halting spread of pests and diseases, and preventing entry of pests and diseases at border stations. VP-SEM allows samples to be viewed immediately, in any state, even alive, which was not possible using the older technology. More rapid identifications have economic impacts from the standpoint of implementing control measures earlier, before a pest or disease situation has spread too far. By enhancing PPD diagnostics capabilities, problem pests can be controlled or eradicated before they had the chance to affect specialty crops, regardless of the origin of any given sample.

The potential impacts are directly linked to the speed with which a diagnosis can be made. These impacts are quantifiable relative to the necessary response from the beneficiaries. For example, the faster the sample submitter (e.g., CDFA, US Department of Agriculture, County Agricultural Commissioner's Offices, industry groups, or growers) knows the identity of the sample submitted, the faster the problem can be mitigated. This is true for all labs in the Plant Pest Diagnostics Branch (Entomology, Plant Pathology, Nematology, Seed Science, Botany) for samples requiring SEM. For entomology, several critical programs depend on VP-SEM to identify certain pests, including GWSS (glassy wing sharpshooter) egg masses, and immature stages of LBAM (light brown apple moth) and EGVM (European grapevine moth). The industries primarily affected by these three pests include the grape and wine industries, the berry and stone fruit industries, and nursery industries. In addition, various other identifications benefit from SEM imaging to separate certain closely related species. For Plant Pathology, mycology (fungal) samples are often submitted for identification where it is necessary to look at fruiting structures to separate closely related species, and for characterizing the morphology of new pests or new species. Because of the numbers of unknowns (i.e., outside the major survey programs) submitted from any specialty crop, this tool allows for faster identifications, and sometimes recognition and characterization of newly introduced pathogens. For Seed Science and Botany, with submission of samples from seed producers and the seed industry for various specialty crops, the enhanced ability to make accurate and quick identifications is highly beneficial. For the Nematology laboratory, SEM is critical for submitted nematode samples from specialty crops for identifying unknown specimens and for characterizing the morphology of new pests or new species. All specialty crop industries benefit from faster identification times, with economic benefits quantifiable only relative to their need to mitigate pest problems.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The purchase and installation of the VP-SEM equipment took longer than expected due to the procurement process taking longer than expected and the need to move the existing equipment before the VP-SEM equipment could be installed.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

None.

Project 44 – Regents of the University of California, Davis - (UC)

Final Performance Report

Project Title

Development of an Integrated Pest Management Program (IPM) for Vole Control in Artichokes

Project Summary

California meadow voles, *Microtus californicus*, are the primary vertebrate pest in artichoke fields around Castroville, California. For years, the main control method for voles was chlorophacinone treated artichoke bracts. However, in 2001, artichoke growers began to notice an uncharacteristic increase in vole populations. In response to this, a research project was conducted to develop baiting strategies for voles in artichokes with the hope that improved baiting strategies would address the increased populations. This study indicated that the Castroville vole population had become resistant to chlorophacinone.

Faced with vole populations that are resistant to chlorophacinone, the artichoke growers, United States Department of Agriculture and researchers worked to develop and register zinc phosphide for use on artichoke bracts. However, this baiting strategy has not proven to be as efficacious as was anticipated. This is of particular concern as growers are faced with the possibility of losing the chlorophacinone treated bracts due to resistance, while zinc phosphide treated bracts may not be accepted at a level high enough to effectively control voles in a field setting. Without a comprehensive control program, growers will continue to suffer increasing losses, extensively damaging the artichoke industry in California.

Nearly 100 percent of all artichokes grown commercially in the United States are grown in California. While artichokes are a small industry compared to other crops (e.g., broccoli, grapes, lettuce), they add over $50 million to the economy of the State. Approximately 75 percent of the State's total acreage lies within Monterey County. There is nowhere else in the world with such a concentrated area of production, consistently yielding nearly four million cartons of artichokes every year. Without effective control methods, growing artichokes may become unprofitable. To assess control effective methods for indexing populations must be available. Traditionally, chewing indices using artichoke bracts have been used to assess population status. However, using artichoke bracts as a chewing index may bias results given that toxicants are applied on these same bracts. Therefore, developing less biased indices should provide more accurate and precise results on efficacy trials of registered toxicants such as, chlorophacinone treated bracts and pellets and zinc phosphide treated bracts. Additionally, other alternatives to toxicants may provide effective control, which may alleviate some of the resistance to chlorophacinone currently seen in voles in the Castroville area. Some of these alternatives include cultural practices such as, disking, removing aboveground vegetation during non-production periods (chopping) and exclusionary fencing. A combination of these approaches should ultimately allow the UC to develop an IPM approach to more effectively control voles in artichokes.

Project Approach

The UC developed and tested indexing methods to determine the efficacy of a number of control programs for voles in artichokes. It was found that using wax blocks was far superior at indexing vole activity than were artichoke bracts. Each size of the sampling grid tested (4 x 4, 5 x 5, 6 x 6) and produced quality index values for the populations studied, although for lower populations the larger grid sizes were found to likely be the best. These results allowed for testing the different control methods UC was interested in.

Combinations of cultural practices are often implemented that have the potential to substantially reduce vole populations within artichoke fields. These practices include chopping artichoke plants to ground level and disking up old fields. Every year, artichoke plants are chopped down to ground level during the non-production period (usually summertime). This removes all cover and most food sources for voles in artichoke fields. However, the level of vole activity in chopped fields had never been assessed. It was found that chopping artichokes significantly reduced vole populations (2010: index value pre-chop = 25.2, index value post-chop = 2.5, $P = 0.05$; 2011: index value pre-chop = 10.7, index value post-chop = 3.1, $P \leq 0.001$), indicating this is an effective method for reducing vole activity in artichoke fields. After growers chop artichoke fields, they then fumigate the remaining vole burrows with aluminum phosphide. Tests of the efficacy of this fumigation process indicated a further reduction in vole populations post-treatment (2011: index value pre-fumigant = 3.1, index value post-fumigant = 1.3, $P \leq 0.001$). Collectively, these two approaches resulted in a substantial reduction in vole populations. This was further strengthened by telemetry data collected on radiotransmittered voles, it was found that 100 percent of all radio transmittered voles ($n = 20$) either died or left artichoke fields after chopping and aluminum phosphide treatments. Disking was very successful at removing voles from artichoke fields (2010: index value pre-disking = 3.3, index value post-disking = 0.3, $P = 0.08$). Disking is only done when a field is taken out of production and is going to be replanted to new artichoke plants, which is only done every five to 10 years. When possible, disking can substantially reduce vole activity in artichoke fields.

Exclusionary fencing is another approach that could substantially reduce vole activity in artichoke fields. Late this spring, UC constructed two forms of exclusionary fencing around two separate fields of artichokes. One form of fencing was a combination of black plastic mesh and aluminum flashing. This approach is solely meant to exclude voles from fields. The other fencing design was a combination fence and trap device. This device not only kept voles from entering artichoke fields, but also captured voles inside the fencing structure. Once captured inside the fencing structure, the voles could then be predated upon by natural predators (hawks, owls, bobcats, raccoons, etc.) thereby encouraging natural predation along the boundary of the artichoke field. This could potentially reduce vole populations in areas adjacent to artichoke fields, thereby reducing the possibility of voles moving into these crops. The UC has only begun testing these devices. These tests will be extended as part of a companion project that extends through March 2012. However, initial feedback from growers suggests the fencing has been quite effective. If so, chopping and aluminum phosphide treatments could be used to remove voles from fields annually, then exclusionary fencing could be used to keep voles from moving back into fields thereby substantially reducing damage to artichoke fields.

Although these approaches may be enough to substantially limit vole damage to many or even most artichoke fields, occasionally, voles will find their way into these fields. Additionally, there may be some situations where fencing cannot be used (e.g., areas where frequent movement of machinery into and out of fields is needed, fields that do not typically house vole populations). For these settings, effective rodenticides will still be the best method for vole removal. Chlorophacinone and zinc phosphide treated artichoke bracts were tested, as well as chlorophacinone pellets (Rozol®) to determine their efficacy in winter and spring seasons. Even with the known presence of vole resistance to chlorophacinone, the chlorophacinone bracts were the most efficacious of the rodenticides used in winter (84% control). The Rozol pellets were somewhat efficacious (61% control), while the zinc phosphide treated bracts exhibited little control over vole populations (13% control). Additionally, efficacy was much higher in winter than in spring (chlorophacinone bracts = 26%, Rozol = 23%, zinc phosphide bracts = 0%), indicating that baiting programs should occur before early March in order to maximize the efficacy of rodenticides. The UC was also able to test out cholecalciferol as a potential alternative to the already registered baits. Initial trials suggested low efficacy (21% control), although these trials were conducted in spring when bait acceptance was low for all baits. Therefore, UC will further test this material in the fall/winter of 2011/2012 through a companion project. If effective, this could provide an alternative rodenticide to mitigate the impact of chlorophacinone resistance in vole populations.

Project cooperators have all contributed to this project. R. Engeman has been directly involved in statistical design and analysis, V. Hornbaker has assisted with data collection and rodenticide registration and background information, while T. Salmon has provided historical background information.

Goals and Outcomes Achieved

1. An index was developed to measure vole activity in artichokes.
2. The UC determined the efficacy associated with chopping, disking and aluminum phosphide treatments.
3. A study was initiated looking at the efficacy of exclusionary fencing at keeping voles out of artichoke fields.
4. Efficacy trials were conducted on rodenticides used to control voles in artichokes.
5. Collectively, these control methods can be combined into an IPM program for controlling voles in artichokes that should yield less damage to artichokes, lower vole control costs and a reduced dependence on rodenticides for vole control.

Potential outcome measures would include long-term reductions in damage to artichokes, long-term reductions in vole control costs and long-term reductions in rodenticide use. Monitoring these long-term outcomes was not part of the study proposal, but would be worthy of investigation.

Goal 1: Develop an effective method for indexing vole populations in artichokes. This was accomplished.

Goal 2: Assess the influence of land-use patterns on vole populations and the effectiveness of cultural practices for controlling vole populations. The UC was able to ascertain the efficacy of a variety of cultural practices. However, UC was not able to determine the influence of land-use patterns on vole populations (see “Lessons Learned” section for more information).

Goal 3: Assess the effectiveness of drift nets for controlling vole populations. This was deemed impractical early on and was replaced by the goal to assess the efficacy of exclusionary fencing at keeping voles out of artichoke fields. This assessment is on-going but early reports suggest it is effective.

Goal 4: Determine efficacy of chlorophacinone treated bracts, zinc phosphide treated bracts and Rozol pellets for controlling voles in artichokes during different seasons. This was accomplished.

Goal 5: Combine methods to develop an integrated approach for controlling voles in artichokes. This was accomplished.

<u>Beneficiaries</u>
Artichoke growers and consumers of artichokes are the primary benefactors of this project. Greater vole control will result in a greater abundance of artichokes and theoretically lower consumer costs. Still, the IPM approach developed for vole control in artichokes could be adapted to fit other commodities where vole populations are a substantial hindrance to crop production.

Vole activity was reduced by 88 percent through chopping and aluminum phosphide treatments. Disking was also highly effective at reducing vole activity (92 percent control). When combined with exclusionary fencing, this should result in substantially lower control costs and damage associate with voles. When such cultural practices are not practical, chlorophacinone treated artichoke bracts are still the most efficacious rodenticide. Rozol pellets provide some reduction in vole activity; zinc phosphide was ineffective in the trials.

Some cultural practices such as chopping and disking already occur, so UC use for vole control will add nothing to overall control programs. However, when used with low-cost fencing, these cultural practices have the ability to substantially reduce vole populations within artichoke fields, thereby increasing artichoke production and lowering control costs. That being said, the development of economic data was not part of this project, so UC has no quantitative data to define this impact.

<u>Lessons Learned</u>
The lesson learned was exclusionary fencing may be a practical and effective method for keeping voles out of artichoke fields and that some growers were open to the idea of using such fencing given the large amount of damage caused by voles. Interestingly, chlorophacinone bracts were still fairly effective at controlling voles in artichokes even with resistant voles present in the population, although the level of control is lower than the target goal of > 90%. Zinc phosphide provided little control. Further use of this rodenticide is not currently warranted for vole control

in artichokes. Collectively, UC was able to develop an IPM program for vole control in artichokes that should be very useful for growers.

The UC was surprised at growers' willingness to utilize exclusionary fencing for vole control. They have not been receptive in the past. The UC was not able to assess the impact of landscape-use patterns (i.e., juxtaposition of habitats) on vole damage to artichokes given low capture rates of voles moving into artichoke fields. Likely, radiotransmittered voles will be required to assess this objective, and is worthy of investigation in a future project.

Contact Person

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Additional Information

Publications will follow.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 45	**Project Title:** Host Specificity Testing of Exotic Parasitoids for Biocontrol of Asian Citrus Psyllid	
Grant Recipient: California Department of Food and Agriculture	**Grant Agreement No:** SCB09056	**Date Submitted:** December 2012
Recipient Contact: Mike Pitcairn Mark Hoddle	**Telephone:** (916) 262-2049 (951) 827-4714	**Email:** Mike.pitcairn@cdfa.ca.gov Mark.hoddle@ucr.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Asian citrus psyllid (ACP), *Diaphornia citri* Kuwayama (Hemiptera: Psyllidae), was first detected in California on August 27, 2008, when it was trapped in backyard citrus in southwestern San Diego County. As of September 2012, populations of this were known from San Diego, Imperial, Los Angeles, Orange, Riverside, and San Bernardino Counties in California. ACP now has a secure foothold in southern California and eradication in urban areas is impossible. Further, surveys have indicated that in Los Angeles County, populations of ACP appear to be free of natural enemies, especially parasitoids that attack nymphs. This natural enemy free space may account for the very high densities often observed in backyard citrus in Los Angeles County.

ACP is viewed as a serious threat to California citrus production because of its ability to acquire and transmit a bacterium which causes a disease known as Huanglongbing (HLB) or citrus greening, an incurable malady lethal to citrus. Uncontrolled populations of ACP in urban areas presents a major threat to commercial citrus production in California for two reasons: (1) high density ACP populations appear to readily immigrate from urban areas towards commercial production zones thereby threatening to establish populations in these relatively un-invaded areas, and (2) these immigrants could eventually carry HLB from urban areas to commercial orchards where it does not currently exist.

The use biological control agents as part of a classical biological control program against ACP in southern California is one tool that can be incorporated into future control programs that will be needed for sustainable ACP management. Host-specific parasitoids that attack the nymphal stages of ACP are perhaps the most efficacious natural enemies available. The establishment of host-specific parasitoids for the suppression of ACP populations, especially in areas where insecticide use will be limited (e.g., organic growers, backyard citrus plantings, and urban ornamentals that can support ACP) could be extremely beneficial not only for reducing pest densities, but also for mitigating HLB spread and infection severity. The natural enemy with most potential for ACP biological control in southern California was determined to be *Tamarixia radiata* (Hymenoptera: Eulopidae) sourced from the Punjab of Pakistan. The citrus growing regions of the Pakistani Punjab have around 70% climate match with major commercial citrus production areas in California. Good climatic compatibility between the natural enemy's area of origin and the intended area of introduction is thought to be important for enhancing the likelihood of natural enemy establishment and impact. In September 2012, the first of five foreign exploration expeditions to the Punjab of Pakistan was initiated, and from these collections *T. radiata* was collected and returned to Quarantine at the University of California, Riverside (UCR) for safety testing.

T. radiata is considered native to Asia (*sensu latu*) and has been reported from India, Pakistan, Nepal, China, and Vietnam. Adult females feed on younger ACP instars killing them, and this process is known as host feeding. Through this combined action of parasitism (around 300 eggs laid before death) and host feeding, a single female *T. radiata* has the potential to destroy approximately 500 ACP nymphs over the course of her lifetime.

This purpose of this project was to conduct the mandatory safety testing for *T. radiata,* a parasitoid of ACP sourced from the Punjab of Pakistan as required by US Department of Agriculture-Animal and Plant Health Inspection Services (USDA-APHIS). Without the completion of these studies to determine the potential host range of *T. radiata* and the threat posed by this natural enemy to non-target species of psyllids in California, USDA-APHIS would not grant permission to release this natural enemy from Quarantine for establishment in California.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

During the lifetime of this grant safety testing for *T radiata* was completed in Quarantine at the UCR. Seven species of psyllid were tested to determine if they would be suitable hosts for *T. radiata*. California has a very rich native psyllid fauna, with 165 species known from the state (this total includes native and exotic species). Because of this large psyllid fauna in California, only a subset of these species could be tested for their suitability as hosts to *T. radiata*. Consequently, multiple selection criteria were used for the selection of representative non-target psyllids for host specificity testing (Table 1).

Host specificity testing for *T. radiata* was conducted under choice and no choice conditions involving sequential and static exposure experiments. Test psyllids were hand placed onto small host plants growing in "cone-tainers" and parasitoids were introduced into inverted vials that enclosed the test plants with psyllids (Fig. 3).

No choice tests followed one of two different sequential exposure programs. In this design test, the first block of *T. radiata* were exposed to either a non-target-psyllid (NTP) for a specified exposure period and then immediately to ACP for a second exposure of the same time. In the second block of *T. radiata* tested under this sequential test plan female parasitoids were first exposed to ACP being moved to NTP. This process for both test blocks of *T. radiata* was repeated on day two. The rationale for this exposure sequence was to determine the predilection of *T. radiata* for ACP and NTP and to determine if first exposure experience of naïve females influenced attack rates on target and non-target psyllid species.

In the static long exposure no choice tests, *T. radiata* females were set up with either ACP or NTP and left for 24 hours before being removed. This experimental design was implemented to determine attack rates on NTP when *T. radiata* was repeatedly encountering NTP and was intended to mimic conditions in non-target habitat should *T. radiata* migrate into areas where ACP would be absent but other psyllid species would be present and encounterable for significant time periods.

Choice tests were conducted whereby *T. radiata* was exposed to ACP and NTP simultaneously on their respective host plants and allowed to forage and choose amongst psyllid species for attack.

In the environmental test conditions in quarantine, the ACP rearing room that held double-caged colonies of this insect on *C. volkmeriana* was maintained at 30°C, 40% relative humidity (RH) and 14: 10 L: D photophase. The host range testing room was initially set at 30°C temperature, 40% RH and 14: 10 hour photophase. However, because *Dichlidophlebia fremontiae* nymphs in all the treatments (including controls) died during tests, it was suspected that 30°C was too high a test temperature (this psyllid species was collected from Wrightwood, a cooler region at 6,000 ft in the mountains of San Bernardino County). Consequently, the temperature was reduced to 27°C for all experiments and 40% RH and 14: 10 L: D photophase.

A single mated adult female *T. radiata* (2-3 days of age) was introduced into a test cage for a 4 hour exposure period in sequential no choice (T1, T2) and choice tests (T3) or for 24 hours in prolonged exposure (T5) no choice tests. Naturally occurring mortality of psyllids under prevailing experimental conditions was assessed with control treatments (T4) where test psyllids were set up in an identical manner but were not exposed to *T. radiata*. Experiments were set up as complete blocks that were repeated over time for 10 replications for each test species and exposure scenario.

Female *T. radiata* were first introduced into either an ACP cage (T1) or non-target psyllid (NTP) cage (T2). After a four hour exposure period, the same female was transferred to a new NTP cage (T1) or a new ACP cage (T2) that had had no previous *T. radiata* exposure for a further four hour. At the end of this eight hour exposure period, females were removed from cages in a ventilated 2 ml O-ring vial provisioned with a droplet of honey and rested overnight for 16 hours until the next day. The same test sequences were repeated for female *T. radiata* the following day.

For choice test (T3), ventilated inverted vials were removed from cone-tainers to expose test psyllids on their respective host plants. Cone-tainers were then placed inside a screened cage and then a test *T. radiata* female was introduced. After the four hr exposure time, *T. radiata* was removed from the test arena and ventilated vials were replaced over each individual test plant and its psyllids.

For control (T4), one set of five ACP or five NTP on their respective host plants in cone-tainers were set up and maintained in a manner identical to that for psyllids exposed to *T. radiata*. Control psyllids of each test species were not exposed to *T. radiata*. Control psyllids provided estimates of naturally-occurring mortality that was due to the process of setting up psyllids on seedlings in containers and subsequent maintenance in quarantine under prevailing standardized rearing conditions to determine developmental fate (i.e., death from unknown causes or development to adult psyllids).

Prolonged no-choice exposure test (T5) was a static, no choice test run for 24 hours that aimed to evaluate whether *T. radiata* females would attack NTP under an exposure period longer than four hours. Attacks on NTP were hypothesized to be possible under longer exposure times either because females were not time limited or the motivation to oviposit during this period nullified host selection preferences and less suitable hosts would be attacked.

All test cages were observed twice to record psyllid developmental outcomes. The first observation was 4-6 days post-exposure to *T. radiata* and the second observation was 10-12 days post-exposure to parasitoids. Records were taken of the number of adult psyllids that successfully emerged, psyllid nymph mortality, and number of *T. radiata* that emerged from hosts for each treatment.

A total of seven non-target psyllid species were tested for suitability as hosts to *T. radiata*. Psyllid species that were successfully tested using the four test protocols described above were: (1) *Acacia farnesiana* psyllids (*Heteropsylla* sp.) (289 nymphs exposed to *T. radiata* for host feeding and parasitism); (2) *Prosopis glandulosa* psyllids (*Heteropsylla texana*) (299 nymphs exposed); (3) *Rhus ovata* psyllids (*Calophya californica*) (286 nymphs exposed); (4) potato/tomato psyllids (*Bactericera cockerelli*) (299 nymphs exposed); (5) olive psyllids (*Euphyllura olivina*) (300 nymphs exposed); (6) *Fremontodendron californicum* psyllids (*Dichlidophlebia fremontiae*) (300 nymphs exposed); (7) Scotch broom psyllids (*Arytainilla spartiophylla*)
(280 nymphs exposed).

Parasitism by *T. radiata* of non-target psyllid nymphs was observed for just one of the seven species tested, the pestiferous potato/tomato psyllid, and parasitism rates were very low (2-6%). In comparison, parasitism of ACP by *T. radiata* across trials ranged 5-38% and averaged 20% across all test strategies. Because of these low parasitism rates and the existence of a strong guild of resident native species of parasitoid and generalist predators in California (Butler 2011), it is highly doubtful that *T. radiata* will establish populations on this host and become a major mortality factor of this pest post-release from Quarantine.

Mortality attributed to unknown causes of non-target psyllid nymphs following exposure to *T. radiata* was observed. Non-target psyllid mortality is suspected to be a combination of naturally-occurring mortality, unconfirmed host feeding events by *T. radiata* and possible dislodgement and abandonment of host plants by nymphs due to disturbance by foraging parasitoids, and unsuccessful parasitism attempts that resulted in host death.

The results of this work were summarized in a 60 page Environment Assessment Report (EAR) that was submitted to USDA-APHIS for review on November 15, 2011. The results of completed studies concluded that the Pakistani strain of *T. radiata* posed no undue Environmental risk to California. It was recommended that this highly host specific parasitoid should be approved for release as part of a biological control program targeting ACP. On December 7, 2012, USDA-APHIS issued a permit authorizing the release of *Tamarixia* from Quarantine for establishment in California for the biological control of ACP. On December 20, 2011, 186 female *Tamarixia* and 95 male *Tamarixia* were released in the Biocontrol Grove at UCR. Prior to release, parasitoids were tested using DNA analyses to ensure that they were free of the bacterium that causes HLB. All tests were negative for HLB indicating that the parasitoids were free of this bacterium.

Several presentations have been given on this project, as well as a journal article (Pakistan Entomologist 34: 1-5) and a trade magazine article (Citrograph 1: 30-33). In addition, the results of this project were reported in several media interviews, including National Public Radio, the Los Angeles Times, the New York Times and Science Magazine. See Final Report Appendix for detailed Project Outreach activities (Project 45).

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The following activities have been completed:

1) *Safety Testing in Quarantine:* Host specificity testing for *T. radiata* has been completed.
2) *Preparation of Environment Assessment Report:* A 60 page EAR was prepared and submitted to USDA-APHIS on November 15, 2011 and on December 7, 2012 USDA-APHIS granted permission to release *T. radiata* from Quarantine for biological control of ACP in California.
3) *Parasitoid Releases and Recoveries: Tamarixia* releases were initiated on December 20, 2011 and by August 2012 UCR and the California Department of Food and Agriculture (CDFA) had released this parasitoid at approximately 40 different field sites, more than 10,000 parasitoids had been released from Quarantine. About 20% of total release sites have evidence of activity by *T. radiata*. Recoveries have been made in Azusa, Bell Gardens, Ontario, and San Bernardino. Molecular analyses have confirmed that the *Tamarixia* recovered from field sites is of Pakistani origin and was released as part of this project. There is evidence from at two field sites, indicating that *Tamarixia* has moved 20-65 m onto ACP infestations of its own volition.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The outcomes of this project will have important applications to California's organic and conventional citrus growers, and homeowners. In 2007, the CDFA estimated organic citrus growers farmed approximately 10,000 acres across 30 counties and was worth about $69 million. Industry estimates that organic citrus production has been increasing annually at 7-12%. San Diego County, an area with ACP infestations, has the largest concentration of organic growers, around 345 farms, which manage 25% of California's organic citrus acreage. Conventional citrus was valued at $1,057,206,000 (total acreage – 251,500) by the CDFA in 2007. Organic farmers have no scientifically-derived management strategies to combat ACP. The establishment of *T. radiata* in California has provided an extremely important tool for sustainable ACP management. The potential economic impact will be considerable; without this work T. radiata from the Punjab of Pakistan would not have been eligible for intentional release in California. Lower ACP densities because of natural enemy activity will reduce the possibility of citrus orchards developing HLB infections. Further, UCR anticipates flow-through economic benefits from successful ACP control because reduced populations will minimize ACP migration threats from urban citrus and organic orchards to conventional citrus orchards. Consequently, lower ACP pressure in citrus will greatly assist the development and implementation of area-wide management programs for ACP in California. Further, this density reduction because of *T. radiata* has the potential to reduce the number of insecticide applications required to manage ACP, thereby reducing the disruption to other insect integrated pest management programs in citrus and reducing the risk of environmental and/or human health concerns. Successful integration of biological control into area-wide management programs may also prove very cost effective for all growers.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

This project provided many unique challenges most of which pertained to the establishment of colonies of native California psyllids on difficult to grow and maintain native California plants. The post-graduate researcher overseeing the day-to-day execution of this work achieved remarkable results in Quarantine under very difficult conditions, especially space constraints, and artificial lighting and temperature control issues. Also, the post-graduate researcher developed the highly effective “cone-tainers” for experimental use in Quarantine. These achievements and subsequent outcomes cannot be understated. Consequently, the successful lessons learned from this work will be applied to the next ACP parasitoid, *Diaphorencyrtus aligarhensis*, also sourced from the Punjab of Pakistan for the biological control of ACP in California.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

See Attachment 1 for additional information relating to this project.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 46	Project Title: Cotton Aphid Management in Pomegranate: Slowing the Spread of Citrus Tristeza Virus in the San Joaquin Valley	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09041	**Date Submitted:** December 2012
Recipient Contact: Dr. Larry Godfrey	**Telephone:** 530-752-0473	**Email:** ldgodfrey@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Citrus tristeza virus (CTV) is an aphid-transmitted virus and one of the most important pathogens affecting citrus worldwide. The incidence of CTV has increased significantly in recent years in the eastern San Joaquin Valley (SJV) citrus production area. This increase has threatened commercial production as well as hindered the production of virus-free budwood and citrus research at the University of California Lindcove Research & Extension Center (LREC). CTV incidence is monitored annually at the LREC and was under excellent management. From 1990 to 2006, a total of 45 CTV-infected trees were detected and removed from research blocks at LREC (~1 to 6 trees annually from 2001 to 2006). These values should also be representative of disease occurrence in the neighboring commercial citrus production area. However, the situation began degrading in 2006. In spring 2007, 50 CTV-infected trees were found at LREC and removed. Four of the infected trees were found in the Citrus Clonal Protection Program Foundation block that provides budwood to the citrus nursery industry.

CTV increase has occurred concomitant with an increase in pomegranate acreage in this region. Pomegranates are not a host for CTV; however, pomegranates are the only identified overwintering host for cotton aphid, the primary vector of CTV in California (CA). The production of cotton aphid spring migrants in pomegranates is likely a key component of the aphid-CTV complex affecting citrus. Studies were conducted on the seasonal phenology and life history of cotton aphid in pomegranate and citrus systems, chemical and biological methods of managing overwintering cotton aphids in pomegranates that potentially move to spring citrus, and mapping of pomegranate and citrus production acreage in the eastern SJV so as to evaluate the areas of overlap and those potentially most severely affected.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activities Performed:

Assemble research team with representatives of citrus and pomegranate industries to strategize about project and to finalize research plan.

Meetings were held with representatives and experts from the pomegranate industry (Paramount Farming Company and the University of California [UC] Orchard Systems Farm Advisors) and the citrus industry (Citrus Research Board, Central California Tristeza Eradication Agency, UC Citrus Farm Advisors, and key growers). The project was discussed and research plans altered to better fit these two systems.

Investigate the phenology and life history of cotton aphid: All three aspects of this task were successfully completed.

Monitor populations of sexual stages of cotton aphid study –

Cotton aphid overwintering biology is a key link to understanding/managing this species and in particular reducing the impacts on citrus and CTV spread. Populations of overwintering cotton aphid sexual stages were recorded from 1 foot-long pomegranate twigs collected every 7 to 10 days from eleven locations – four in Tulare County (Co.) near the LREC, two sites in southern Tulare Co., four sites in Kern Co., and one location in Fresno Co. Overwintering aphids were found in all but two locations (no aphids were found in the Fresno Co. location and no overwintering aphids were found in one Kern Co. location [aphids were found in the spring]). Egg deposition occurred in November to December (dependent on location) and egg hatch (occurrence of nymphs) generally took place in mid-February (populations of nymphs were lower and delayed in 2011 compared with 2010). The initiation of the development of the winged aphid stage occurred from ~March 20 to April 10 and appears to be consistent across locations/years.

Movement of cotton aphid from pomegranate to citrus study –

The movement of cotton aphid from pomegranate to citrus was studied using 1) net traps at three locations , 2) water pan traps at two locations, and 3) estimates/counts of the percentage of twigs infested with cotton aphids in pairs of citrus and neighboring pomegranate orchards (four locations), in pomegranates without citrus nearby (3 locations), and in citrus without adjacent pomegranates (4 locations). Populations of aphids on citrus and on pomegranates were detectable most commonly in early April. The flux of aphids into citrus in late March-early April coincides with the occurrence of winged (alate) aphids developing in pomegranates in the area.

Develop and validate a thermal unit model of cotton aphid sexual stages study –

Studies on the developmental response of overwintering cotton aphid eggs and the fundatrix stage (aphids hatching from eggs) to temperature were conducted. In summary, eggs require exposure to a “cold period” to hatch, exposure to 1^0Celsius (C) or 34^0Fahrenheit (F) is too cold with exposure to 6^0C (43^0F) being optimal, and exposure to 6^0C for 60 and 90 days is better for egg hatch than 30 days. After the cold period, for hatching, exposure to 25 and 30^0C (77 and 86^0F) was too warm for optimal hatching as opposed to 13-20^0C. The minimum temperature for development appears to be about -1^0C and ~150 degree-days needed for hatch. For the fundatrix stage, minimum temperature for development is about 3^0C with ~400 degree-days needed for development.

Investigate reduced risk insecticide efficacy on overwintering aphids in pomegranates. This task was successfully completed; however, the studies were done on citrus as described below.
Pomegranates were planted at LREC but aphid populations did not develop on the new trees. Therefore, pesticide trials at LREC were conducted on young citrus trees. During 2010, cyantraniliprole, acetamiprid, spirotetramat and thiamethoxam were screened and all were effective in reducing aphid numbers. During 2011, tolfenpyrad, chlorantraniliprole, acetamiprid and thiamethoxam were tested against cotton aphid on citrus and all four significantly reduced the percentage of infested terminals. Insecticides with high toxicity to *Aphytis melinus* parasitoids (a biological control agent of CA red scale) were acetamiprid, tolfenpyrad, and thiamethoxam. Spirotetramat, cyantraniliprole, and chloranitraniliprole were relatively soft, allowing the parasitoids to easily survive. These results may indicate these same materials could be incorporated with biological control in pomegranates.

Investigate non-chemical management of cotton aphid in pomegranates – Both aspects of this task were successfully completed.
Use of pheromones for monitoring populations of sexual forms such that the opportunities for mating disruption as a management means can be assessed –
Studies were done on the use of pheromones for aphid monitoring from November to March in 2010-11 and 2011-12. Sexual stage aphids utilize two components, nepetalactone and nepetalactol, as their pheromone with each aphid species having a specific ratio (or single component) of these two compounds. In 2010-2011, there was a slight advantage for both pheromone components being present (a 1:1 ratio) but the differences were slight. In 2011-12, a different trap was used compared with the previous year and the results were more clear-cut. There was a clear advantage for the 1:1 ratio of nepetalactone and nepetalactol compared with the single component and the no pheromone treatment. The next step is to examine various other ratios (besides 1:1) of the two components.

Incidence of biocontrol so the need and opportunities for increasing the diversity of biological control agents can be assessed –
Parasitoids were sampled from six sites near LREC that had pomegranates next to citrus. Sampling was conducted from in May 2010 to June 2012. The twigs were examined and the numbers of apparently healthy aphids, mummified aphids, emerged mummies, and “fuzzy” aphids (aphids infected with a fungus) were recorded. Intact mummies were placed in gelatin capsules to allow for parasitoids to emerge.

Parasitoids, primary (parasitoids of aphids) and/or secondary (parasitoids of the parasitoids) were recovered at all sites. In 2010, a typical pattern of aphid parasitism was seen with large numbers of parasitoids collected in the spring and fall when cotton aphid densities were the largest. The proportion of primary to secondary parasitoids demonstrated a typical pattern for time of year in this area with secondary parasitoids peaking slightly later in time than their hosts, the primary parasitoids. The *Aphelinus* species (sp.) parasitoids recovered in 2011 and 2012 are the progeny of parasitoids released in these blocks in 2007 and 2008. The taxonomists are still debating the best species name for this parasitoid. This parasitoid does well under warmer weather conditions than the native aphid parasitoids, *Lysiphlebus* and *Aphidius* sp. These recoveries are proof that this exotic parasitoid has established, albeit in low numbers, in the area.

Map pomegranate and citrus acreage in SJV; determine areas of high risk.
The distribution of pomegranate and citrus production (mapping acreage) was conducted in the southern SJV. Data were obtained by three methods: 1. acquisition of data from County Agriculture Commissioners, 2. corporate farming, and 3. field surveys for commercial pomegranate sites based on section-level reports to the Department of Pesticide Regulation. Orchards ranging from 0.25 to 1,734 acres were indentified. The completed survey included 268 square miles, 406 individual fields, and 29,935 total acres. An analysis of citrus proximity to pomegranate (219,132 total acres) in an area in northern Tulare Co. showed that at the 0.5 mile distance from pomegranate, 51,595 acres of citrus are impacted (24%), ranging to 86,655 (40%) at 1 mile, and 146,442 acres (67%) at 2 miles.

Extend results to citrus and pomegranate industries – Completed with more efforts in progress.
Results were extended to the scientific audience and to the involved industries. Results have been discussed with the citrus industry (Grafton-Cardwell) and the pomegranate industry (L. Godfrey). Presentations were given at the UC Davis Pest Control Advisers (PCA) Conference (L. Godfrey), the Entomological Society of America (L. Godfrey), and the UC Division of Agriculture and Natural Resources (ANR), Integrated Pest Management (IPM) meeting (L. Godfrey, Grafton-Cardwell, Lynn-Patterson). Grafton-Cardwell is writing an insect section for the Pomegranate component of the UC Pest Management Guidelines (http://www.ipm.ucdavis.edu/PMG/selectnewpest.pomegranate.html). Pest Management Guidelines form the basis for the recommendations from UC for managing pests on various crops. Once a draft is written, this document will undergo a university review process, thus the final document will be forthcoming. The pomegranate industry has started conducting a winter meeting and UCD is attempting to get on that agenda.

Review annual results, modify studies, and strategize for next year – Completed

Prepare reports and web site updates – Completed with more efforts in progress.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

<u>Activities:</u>

Investigate the phenology and life history of cotton aphid.
Information was collected on the overwintering biology of the cotton aphid in pomegranate. The timing of egg hatch and development of the spring migrant stage were observed. This winged stage is critical for the CTV disease transmission to citrus. The research documenting the timing of flights has helped to fine-tune and minimize insecticide treatments avoiding disruption of the IPM program in the orchards surrounding LREC. The laboratory studies in this area will be useful for predicting the occurrence of this life stage using temperature as the driving force. Weather station data are available from the area (or small affordable units are available); validation studies are needed link the laboratory data to the field situation.

Investigate reduced risk insecticide efficacy on overwintering aphids in pomegranates.
In the fall of 2008, a program was instituted by the Tulare County Pest Control District of treating with pesticides for aphids during the spring flush (March) and fall (September) flush in a 1-2 mile radius around LREC. The spring treatment is a foliar application of acetamiprid and the fall treatment a systemic treatment of imidacloprid. This treatment regime has successfully reduced the incidence of CTV-infected trees at LREC from 83 trees in 2008 to 12-20 trees during 2010-2012 and in 2012 there were no infected trees in the foundation block. The surveys of aphids by UC Davis' research team indicate that aphid populations have been greatly reduced, but not completely eliminated by these treatments. Surveys of CTV incidence by the Central California Tristeza Eradication Agency in a 1 mile radius around LREC indicate that the incidence of CTV is about the same (3.5 to 3.9% infected trees in 2010 and 2011), indicating that aphid control is slowing the spread of CTV. The studies done under this project have been useful for determining effective treatments in the short-term and for the long-term.

Investigate non-chemical management of cotton aphid in pomegranates.
Aphid pheromones shows promise for future management tools for the overwintering cotton aphids. This aspect has not reached a usable stage yet as more research is needed to determine the optimal pheromone blend and to devise ways to utilize this technology. The surveys of parasitoids revealed a species that was brought to CA, reared, and released ~5 years earlier but not had been previously recovered, i.e., proven to have survived. This species could fill an important niche for biological control during the hot summer period when native parasitoids are ineffective.

Map pomegranate and citrus acreage in SJV.
Based on acquired Geographic Information Systems (GIS) data and ground-truthing, the areas of most concern, i.e., overlap between citrus and pomegranates, were identified. The distance that spring migrant cotton aphids can travel is unknown, but even using the most conservative estimate for crop proximity (0.5 mile), ~52,000 acres of citrus in this northern Tulare Co. area are potentially impacted (24%).

Extend results.
Results were extended to scientific and grower communities. Progress is being made on updating appropriate web-based information.

The stated goals of this project in the Expected Measurable Outcome and Performance-Monitoring Plan were to develop and refine management techniques through improved knowledge and management of the key insect vector, the cotton aphid, and to reduce CTV incidence to below 5% in the surrounding area and 0% in the foundation block at LREC. It is UC Davis' belief that these goals have been accomplished.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The California citrus and pomegranate industries will receive the most immediate benefits from this work. Growers of fresh market pomegranates benefit from better management of cotton aphid. Cotton aphids on pomegranates produce honeydew that allows sooty mold production and reduces the quality of this specialty crop. The feeding of the aphids on the leaves may also reduce pomegranate productivity, but this has not been fully evaluated. Pomegranate acreage in California is approximately 30,000 acres and increasing so improved management of this pest will improve profitability. Citrus growers that are near pomegranates benefit from the reduced densities of aphids as well, which move into citrus in the spring. The University of California, Davis data shows that 2,554 blocks of citrus are within 1 mile of pomegranates in the San Joaquin Valley (SJV) or a total of 53,338 acres of citrus. Lower number of aphids translates to lower spread of citrus tristeza virus, which is most important for citrus production on sour orange rootstock (~10-15% of the 230,000 citrus acres in the SJV). The sour orange rootstock is susceptible to even mild strains of citrus tristeza virus. The rest of the acreage is susceptible to severe strains of citrus tristeza virus, which are less frequent, but still important and minimizing cotton aphid populations is nevertheless a key component of management. Citrus tristeza virus can be extremely damaging including quick decline, seedling yellows, and stem pitting, which are different syndromes caused by isolates of the tristeza virus.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Conducting research in multiple systems, research areas, geographical areas and Principal Investigators always presents challenges. There were several examples of interesting, useful results but nothing totally unexpected.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

None.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 47	**Project Title:** Refined Management of Arthropod Pests of Mint to Improve Sustainability and Protect Water Quality	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** No. SCB09009	**Date Submitted:** December 2012
Recipient Contact: Larry Godfrey	**Telephone:** 530.752.0473	**Email:** ldgodfrey@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

In California (CA), ~4,000 to 5,000 acres of peppermint are grown in the northeastern counties of Shasta, Lassen, Modoc, and Siskiyou with an annual value of ~ $5 million. This specialty crop is grown for its essential oils, used in manufacturing of personal care products, confectionary flavoring, as well as insecticide products. The twospotted spider mite (TSM) commonly attacks mint. Feeding damage can have a negative impact on oil yield and quality; however, this impact is not fully understood. Effectively managing spider mites requires that pest control advisors and growers have a monitoring method to efficiently and accurately determine if and when treatment is necessary. Spider mite monitoring techniques and treatment thresholds were developed at Oregon State University in the mid-1990s for mint grown in the Pacific Northwest (NW). This project investigated spider mite management methods for California conditions.

The mint root borer (MRB) is a key lepidopteran pest on mint causing substantial yield and stand losses. Damage results from the larvae feeding on the rhizomes of the mint plants. MRB is the target of considerable use of organophosphate (OP) insecticides, chlorpyrifos and ethoprop, as well as several, recently-registered, reduced risk (RR) insecticides. The Klamath Basin and associated National Wildlife refuges and waters, as well as the pristine trout streams of the Fall River Valley are two of the most valued and scrutinized areas statewide in terms of agriculture and environmental interactions. The use of OP insecticides and the miticide, Omite® (propargite), are especially problematic in these mint production areas given the sensitivity of their environment and watersheds to insecticide contamination.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activities Performed:

1) Assembled advisory panel.

2) Requested plot space from the University of California Intermountain Research and Extension Center.

3) Investigate and validate the spider mite management methods developed in the Pacific NW for California conditions.
a. Sampling of mite populations to make management decisions.
Work accomplished. Mite populations tend to aggregate within fields. Within-plant distribution of mites, i.e., the percentage of mite-infested leaves in the top, middle and bottom strata of mint plants, during the growing season was not aggregated. The University of California, Davis' (UCD) presence / absence and enumerative sampling models indicate that at a mean of 5 mites / leaf, ~23 leaves per seven locations per 40 acres, provides a sufficient sample number to estimate mite density. These findings are an improvement to the Pacific NW sampling model which recommends 45 leaves per 14 locations per 40 acres.
b. Mint yield loss relationship from mite infestation.
Work accomplished. There is a relationship between spider mite density and yield loss, and winter-kill. Results from analyses of oil quality data suggest that there is not a strong relationship between mite density and oil quality. Results have exceeded the measurable outcome expectations. UCD has substantially improved the Pacific NW sampling model for CA conditions. Yield data indicates that mint can sustain considerable populations before oil yield and quality are adversely affected. However, at this time UCD does not recommend increasing the treatment threshold of 5 mites / leaf.

4) Study the use of releases of predatory mites for spider mite management in mint in CA.
a. Investigate species composition of naturally occurring predatory mites (if any) in mint.
Work accomplished. Predator mites present were identified as *Neoseiulus fallacis*. This is the dominant predator mite species in CA mint fields. It was present in all the fields sampled; however, at very low numbers.
b. Investigate releases of predatory mites (obtained from an insectary) for management of spider mites in mint.
Work accomplished. *Neoseiulus fallacis* were released at ~2000 mites per acre. Releases were conducted when spider mite densities reached 20% of leaves w/1 mite, 20 % of leaves w/≥ 5 mites, 40% of leaves w/1 mite, and 40 % of leaves w/≥ 5 mites. There was not a strong relationship between predator mite releases and spider mite control. Results have met the measureable outcome expectations. UCD better understands what predator mite species are present. However, the role that insectary-reared predator mites play in spider mite control is not fully understood at this time.

5) Investigate the seasonal life history of mint root borer in CA and the applicability of the population model developed in the Pacific NW for CA conditions.
Work accomplished. Dates at which biofix (beginning date of first sustained seasonal moth flight), peak flight, and 90% flight were determined for each of the three production areas. The occurrence of biofix, peak flight, and 90% flight under CA conditions differs from the expected dates predicted by the Pacific NW model.

6) Study the effectiveness of reduced risk insecticides for management of mint root borer in CA.
Work accomplished. Experiments were conducted in commercial mint fields located in Big Valley (site 1) and Tulelake (site 2). Thirteen treatments were applied at each site in 2010 and 2011. Efficacy was evaluated by taking soil samples (1-ft^2 x 3in deep) and recovering larvae using Berlese funnels. Too few larvae were collected in Berlese funnels to definitively evaluate the insecticide treatments. However, Coragen® (as well as

Voliam Flexi®) contains chlorantraniliprole, a reduced risk active ingredient that is very effective against moth larvae feeding belowground. Results of activity 4 have met expectations; understanding of the MRB life cycle under CA conditions has improved. This has considerable implications for improving the use of reduced risk insecticides through optimizing application timing. UCD did not meet the full expectation of activity 6 due to the low number of larvae extracted from the soil samples.

7) Extend results to growers and mint industry through appropriate outlets.
a. Field days.
Work accomplished. UCD presented at three Field Days.
b. Indoor meetings.
UCD presented four indoor meetings.
c. Professional Meetings, Entomological Society of America.
UCD presented three poster and two oral presentations.

8) Summarize overall project; develop Pest Management Guidelines for the University of California Integrated Pest Management (IPM) web site (www.ipm.ucdavis.edu) and develop written material.
Work accomplished. UC IPM Production Guidelines for twospotted spider mite and mint root borer. Journal of Economic Entomology, Enumerative and binomial sampling of *Tetranychus urticae* (Koch) (Acari: Tetranychidae) on peppermint in California. The results of this activity have fully met expectations.

Contributions by Daniel Marcum were instrumental in keeping a strong working relationship with the mint growers of Shasta and Lassen counties. Daniel assisted in data collection, grower meetings and was a major contributor in the writing and edition of the mite sampling article submitted the Journal of Economic Entomology. Rob Wilson played a similar role by developing and maintaining a working relationship the mint growers in the Tulelake area. Rob provided technical advice regarding experimental design and assisted with data collection. Rob reviewed the mite sampling manuscript and provided valuable editorial comments.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Activities:
1) Investigated the spider mite management methods developed in the Pacific NW for CA conditions – sampling of mite populations to make management decisions and mint yield loss relationship from mite infestations.
Goals accomplished: made considerable improvements to Pacific NW mite sampling plan.

2) Investigated the spider mite management methods developed in the Pacific NW for CA conditions – mint oil yield and quality from mite infestations.
Goal accomplished: TSM infestations reduce oil yield; however, not to the degree as previously understood.

3) Studied the releasing predatory mites for spider mite management in mint in CA – investigated species composition of naturally-occurring predatory mites in mint.
Goal accomplished: the predominant predator mite species was identified as *Neoseiulus fallacis*. Low numbers of this predator occur naturally.

4) Studied releasing predatory mites for spider mite management in mint in CA – investigated releases of predatory mites (obtained from an insectary) for management of spider mites in mint.
Goal was not fully accomplished: due to low TSM populations during 2010, the trial was not run. In 2011, UCD found no relationship between predator releases and TSM control.

5) Investigated the seasonal life history of mint root borer in CA and the applicability of the population model developed in the Pacific NW for CA conditions.
Goal accomplished: MRB life history under CA conditions differs from the Pacific NW.

6) Studied the effectiveness of reduced risk insecticides for management of mint root borer in CA.
Goal not fully accomplished. However, the Department of Pesticide Regulation (DPR) pesticide use report data indicates that Lorsban or Mocap were not used in 2010. Based on a verbal survey of peppermint growers, UCD estimates that > 75% of mint growers used Coragen in lieu of Lorsban or Mocap to control MRB in 2011. UCD fully expects this trend to continue.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

All CA peppermint growers that adopt UCD's improved TSM sampling plan will benefit from this project. UCD has published recommendations on the UC IPM Guidelines. A time lag will exist between the publication date and its adoption by growers and pest control practitioners. All growers attending UCD's meetings have expressed interest in adopting the improved sampling plan. DPR pesticide use data indicate that Omite® (propargite), Lorsban or Mocap were not applied in 2010. This trend will likely continue in subsequent years. The local environment and 5,000 – 7,000 local residences benefit from the reduction in the use of these compounds to control TSM and MRB.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Using Berlese funnels to monitor for MRB infestations is ineffective. Traditionally, soil samples are placed into the funnels together. Poor larvae recovery may have been in part due to the soil drying out and trapping larva within the sample. UCD believes that the most effective method is to collect samples just prior to irrigation. Check for larvae by removing the soil from the roots and rhizomes and sift; then place only the roots/rhizome samples in the Berlese funnels. A possible alternative method to Berlese funnels is to use direct feeding damage on rhizomes. This study shows that using the number of damage internodes on 5 rhizomes approximately 10 centimeters each may provide an alternative.

UCD did not expect the difference between the predicted and the observed MRB life-history dates to differ as greatly. UCD was not able to definitively determine if efficacy varied among the RR insecticides tested.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

No additional information.

USDA Project No.: 48	Project Title: Evaluation and optimization of postharvest intervention strategies for the reduction of bacterial contamination in tomatoes	
Grant Recipient: Regents of the University of California, Davis, Center for Produce Safety	**Grant Agreement No:** SCB09051	**Date Submitted:** December 2012
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** (530) 757-5777	**Email:** bfernandez@cps.ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Tomatoes have been implicated in several salmonellosis outbreaks due to possible contamination through bacterial internalization during post-harvest handling. The tomato industry was hit with severe economic hardship as a result of these outbreaks. Despite copious amounts of research directed toward tomato postharvest operations, a void still existed in the operation of tomato fluming operations (i.e., dump tanks). This study was designed to ask basic questions surrounding dump tank operations to provide information to the packinghouse industry to better help guide their decision-making. This project was conducted: (1) to determine the effect of tomato dump tank water management standards on *Salmonella* infiltration; (2) to investigate the correlation among water quality measurement parameters, and assess functional limits where wash water replenishment or replacement is needed; and (3) to determine whether a dry-dump system utilizing an overhead spray rinse with a brush washer was equal to or better than a flume system in removing surface pathogens from the surface to tomatoes. Finally, (4) the information generated was used to develop specific recommendations and this information was disseminated to growers, packers and other stakeholders in several state and national meetings.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Objective 1. Determine the effect of dump tank handling conditions on *Salmonella* infiltration. This objective was broken into two sub-objectives (a) Mapping the distribution of internalized *Salmonella enterica* cells; and (b) Determining the incidence and severity of *Salmonella* internalization as impacted by tomato variety, temperature differential, immersion time, and the post-stem removal time.

Key findings: The incidence and extent of *S. enterica* internalization varied significantly among different locations and/or tissue types. *S. enterica* was only detected in the core tissue segments, especially the segment immediately beneath the stem-scar, and the internalization incidence and populations declined steadily in the core tissue samples with distance from the stem-scar. *S. enterica* was not detected in any of the other internal tissues, including locular cavity, tissues proximal to the blossom end and pericarp tissue samples. Also, the internalization depth of *Salmonella enterica* into tomato tissues was impacted significantly by immersion time. Since the majority of internalized *S. enterica* cells were located within the core tissue segment beneath the stem scar, all follow-up internalization studies used core tissue segment within 2-22 mm below the stem-scar.

Pathogen internalization was impacted by tomato varieties and time interval between stem removal and *Salmonella* suspension immersion. Under the current recommended condition of no more than 2 layers of tomatoes, and no more than 2 minutes of immersion time, tomato varieties and post-stem removal time significantly affected the incidence of *S. enterica* internalization, while temperature differential over the range of -10 to +10 °F had no significant effect. In general, Mountain Spring was less susceptible to *S. enterica* internalization than were Applause and BHN961. Increasing the time interval between stem removal and immersion greatly reduced pathogen internalization in BHN961 and Applause, while it had no effect in Mountain Spring tomatoes. The variety, interactions between variety and post-stem removal time, and interaction between temperature differential and post-stem removal time had significant effects on the populations of internalized *S. enterica*.

The incidence and extent of S. enterica internalization was significantly impacted by the range of temperature differential and immersion time and their interactions. Significantly more severe pathogen internalization was observed with a 15 minute immersion time than a 2 minute immersion time. With 15 minutes immersion time, negative temperature differentials of -10 and -30 °F generated significantly higher Salmonella internalization than did 0 and + 10 °F differentials. However, with a 2 minute immersion time, there was no significant difference for pathogen internalization between temperature differentials from 10 to -30 °F for both varieties. Two *Salmonella enterica* serovars, Thompson and Newport, were used for 2010 and 2011 harvest seasons, respectively. The inoculum level used for 2010 was approximately 10^6 CFU/ml, which was reduced to 10^5 CFU/ml in 2011. Also, due to the limitations in the availability of tomato varieties from commercial farms in Maryland, two sets of tomato varieties were used for 2010 and 2011. To validate the test results from different years, varieties, and *Salmonella enterica* serovars, additional experiments were conducted to evaluate the effect of *Salmonella enterica* serovars, and inoculation levels using high tunnel grown tomatoes (Variety: Applause) in 2011. Test results confirmed that, when immersed immediately after stem-removal, tomatoes have a very high incidence of *Salmonella* internalization, even without temperature differential. This occurs regardless of *Salmonell*a *enterica* serovars or inoculation levels. However, inoculum level of both serovars had a substantial effect on the populations of *Salmonella* internalized with larger populations of *Salmonella* detected inside the tomatoes for inoculum level of 10^6 CFU/ml than for 10^5 CFU/ml.

Objective 2. Determine the correlation among water quality measurement parameters and their associations with dump tank sanitizer efficacy. This study contained several sub-objectives: (a) Packinghouse survey; (b) Correlation among oxidation-reduction potential (ORP), free chlorine, and pH (a measure of the hydrogen ion concentration); (c) Water quality and chlorine concentration changes as impacted by organic load; and (d) Determination of chlorine concentration needed to prevent *Salmonella enterica* cross-contamination during washing.

Key findings: **Packinghouse Survey:** During the survey in Florida, it was discovered that the productivity varied from 120,000 to 180,000 pounds of tomatoes/hour (hr) among three packinghouses, and water temperature was consistently maintained at least 10°F higher than tomato pulp. Tomatoes were dumped into the tank beginning about 0.5-5 hr after harvest, sometimes 24 hr. For these three packinghouses, the residence time of tomatoes in the dump tank was less than 2 minutes. The data from the Florida survey indicates that water quality declined continuously during packing house operations, with a significant increase in total dissolved solids (TDS), chemical oxygen demand (COD) and turbidity over time, which was in line with the observation of the accumulation of dirt and debris. The pH values in these packinghouses were different, ranging from 6.0 to 7.5, and mostly kept stable except periodically for the packinghouse II. The pH in packinghouse II fell to 3.5. Free chlorine and ORP varied widely among different packinghouses, as influenced by the specific parameters of the packinghouse operations: rate of tomatoes washed and the dosage of chlorine in the dump tank. Despite wide variation in dump tank operations and chlorine dosing rates among the packinghouses, all packinghouses maintained at least 25 parts per million (ppm) free chlorine in the dump tanks throughout the period of the visit by the University of Florida researchers.

Relationship between free chlorine, ORP, and pH: The ORP values of chlorinated water decreased with the increase in pH and decrease in free chlorine concentration, but this linear relationship was maintained only when the free chlorine was below 10 ppm. In addition, large variation in ORP readings was observed even at the same pH and free chlorine level. In the presence of high organic load, the free chlorine concentration and ORP readings also gradually changed over time. These findings suggest limitations in using ORP as an indicator for chlorine concentration, especially when the pH control system malfunctions and high organic load accumulates in wash water.

Water quality and chlorine concentration changes as impacted by organic load: Water quality declined rapidly over the continuous addition of tomato extract, as evidenced by the rapid increase in turbidity and COD. This was accompanied by a sharp drop in free chlorine concentration. Interestingly, the ORP readings were quite stable initially, followed by a rapid decline when the free chlorine level fell below 10 ppm. A similar pattern was observed when the wash solution was replenished with Clorox. Furthermore, although the project team was able to restore the free chlorine concentration to around 60 ppm, accomplishing this task required increasing amounts of Clorox with increasing organic load.

Determination of chlorine concentration needed to prevent *Salmonella enterica* cross-contamination during washing: In the absence of chlorine in the wash solution, cross-contamination was noted on both tomato surface and stem-scar of the un-inoculated tomato washed with inoculated tomatoes. No *S. enterica* was detected on any of the tomato surface washed in solution containing free chlorine. However, *S. enterica* was detected in the stem-scar areas on tomatoes washed in solutions containing 0.2 to 5 ppm free chlorine. When the free chlorine concentration was increased to 10 ppm, no *S. enterica* cells were detected in any of the un-inoculated tomatoes. This underlines the critical importance of maintaining sufficient sanitizer concentration to prevent pathogen cross-contamination.

Objective 3. Determine whether a dry-dump system utilizing an overhead spray rinse with a brush washer, is equal to or better than a flume system in removing surface pathogens from the surface to tomatoes. This objective was divided into two sub-objectives: (a) Sodium hypochlorite and sanitizer efficacy studies; (b) Flume and overhead spray comparison study.

Key findings: **Efficacy of sodium hypochlorite (NaOCl) concentrations in overhead spray system:** Significant reductions of *Salmonella* occurred after 15 seconds (s) with NaOCl. At 15 s, 100 mg/L NaOCl achieved a 4.0 ± 1.8 $\log_{10}$ CFU (colony forming units)/ml reduction, which was significantly different from all other concentrations and water. A 3-log10 unit reduction was also achieved by 50 mg/L NaOCl at 30 s and 25 mg/L NaOCl at 60 s. Even water reached a 3-log10 CFU/ml reduction at 60 s. A 5 $\log_{10}$ unit reduction was seen for 100 mg/L NaOCl at 30 s and 50 mg/L at 60 s.

Efficacy of NaOCl, ClO2 (chlorine dioxide), and PAA (peroxyacetic acid) in overhead spray system: After only 5 s, PAA reached a 2.8 $\log_{10}$ CFU/ml reduction of *Salmonella*. Conversely, NaOCl, ClO2, and water each had a 1.9 $\log_{10}$ CFU/ml reduction. All sanitizers reached a 3-log10 unit reduction at 15 s, including water. PAA consistently achieved about a 1-log10 unit higher reduction than the other sanitizers for 5, 15, and 30 s treatment. Increasing treatment time to 30 s did not significantly increase reduction by ClO2 or NaOCl, but did for PAA. At 60 s, average $\log_{10}$ reductions by sanitizers were all significantly higher than water and were not significantly different from each other.

Flume and overhead spray comparison study: The flume water control did not produce significantly different reductions in *Salmonella* depending on spray time, with an average reduction of 1.0 $\log_{10}$ CFU/ml. Flume data was compared to overhead spray NaOCl (100 mg/L) data from the sodium hypochlorite efficacy study. Overhead spray NaOCl treatments of at least 15 s significantly reduced more *Salmonella* from tomatoes compared to flume treatments. At 15 s, NaOCl in the flume and overhead spray had an average reduction of 1.3 and 4.0 $\log_{10}$ CFU/ml, respectively. At 30 s, reduction by NaOCl was enhanced to 5.6 $\log_{10}$ CFU/ml in the overhead spray but only to 3.2 $\log_{10}$ CFU/ml in the flume. Increasing spray time to 60 s did not result in a significantly higher reduction in either system. Concentration of *Salmonella* was tested in the flume. At time 0, *Salmonella* was undetectable in flume water. *Salmonella* was recovered from flume water at an average of 4.5 ± 0.4 $\log_{10}$ CFU/ml after the 15 s treatment and 5.1 ± 0.2 $\log_{10}$ CFU/ml after the 60 s treatment, though these populations were not significantly different from each other. NaOCl (100 mg/L) effectively eliminated *Salmonella* in the flume as populations were undetectable throughout the study.

Objective 4. Develop functional limits that operators can use to ensure that effective sanitizer concentrations and other control parameters are present in the dump tank or spray cleaning system. This will be part of the extension outreach program which will include conducting specialized training on proper washing protocols as support for GAPs/GMPs metrics development and subsequent implementation into food safety systems. The major findings of this project are summarized below. This information has been shared with the produce industry, tomato growers and packers during the Center for Produce (CPS) symposium and several Florida grower meetings. During meetings with Florida growers, both Drs. Luo and Schneider shared their findings on 1) internalization of *Salmonella*, 2) internalization as a function of variety, 3) dump tank conditions, 4) relationship between free chlorine, pH and ORP, 5) potential cross-contamination, and 6) effectiveness of the overhead spray system. In addition to the information sharing at workshop events, both Drs. Luo and Schneider have prepared scientific publications sharing their results with the scientific community (see Additional Information).

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

All goals set forth in the original proposal were met. The outcomes of each of the objectives (and sub-objectives) are:

1) Internalized *S. enterica* cells were found only within tomato core tissue segments immediately underneath the stem-scars. The internalization incidence and populations of *S. enterica* declined in the core tissue samples with distance from the stem-scar.
2) The incidence of *S. enterica* internalization was a function of tomato variety, post-stem removal time, and immersion time, as well as the interaction between tomato dump tank temperature differential and immersion time.
3) Three large packinghouses in Florida were surveyed in 2010 and 2011. It was observed that water quality declined continuously during packing house operations, with a significant increase in chemical oxygen demand (COD) and turbidity. Free chlorine and ORP vary largely among different packing houses, as influenced by the specifics of the packing house operations, including the rate of tomatoes washed, and the dosage of chlorine into the dump tank etc. However, all of them maintained at least 25 ppm free chlorine in the dump tanks during visits by the project team.
4) Laboratory simulation studies indicate that there is a relationship between free chlorine, pH and ORP in water containing a typical organic load. In general, ORP decreases with the increase in pH and decrease in free chlorine concentration. However, this correlation was only maintained within a small range of free chlorine concentration, suggesting a limitation in using ORP as a chlorine indicator.
5) Free chlorine is degraded rapidly by organic loads; although free chlorine concentrations can be brought back to the 60 ppm range, increasing amounts of sodium hypochlorite are needed with increasing organic load in the wash solution.
6) Pathogen cross-contamination occurred readily during tomato washing in the absence of free chlorine (or any other sanitizer). Cross-contamination was found on tomatoes washed in solution containing up to 5 ppm free chlorine, but not in the solutions containing 10 ppm free chlorine. This suggests that maintaining sufficient sanitizer concentration in the wash solution is critical to prevent pathogen cross-contamination.
7) The overhead spray system could achieve a 3- to 5- $\log_{10}$ unit reduction of *Salmonella* from tomato surfaces with specific sanitizers and spray times.
8) The overhead spray system could provide benefits over conventional flumes including higher pathogen reduction, and less sanitizer and water use, all of which help to decrease tomato packing costs and keep the tomato industry a viable part of the economy.
9) Dr. Keith Schneider, University of Florida, presented interim research results at the 2011 CPS symposium in Florida, and final research results at the 2012 CPS symposium in California. The 2011 symposium had 249 attendees, and survey respondents rated the relevance of this project to the fresh produce industry as 1.4 (1=very important; 5=very unimportant). The 2012 symposium had 325

attendees and survey respondents rated the relevance of this project to the fresh produce industry as 1.8 (1=very important; 5=very unimportant).

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The direct beneficiaries from this study are the tomato growers and packers. Indirectly, the food retail sector and ultimately the consumer will benefit from this research as well. The lessons learned could impact immediately the growers choosing tomato varieties that are more resistant to *Salmonella* uptake. This work could also direct tomato breeders to examine the traits in varieties tested to possibly engineer even more resistant tomatoes. Work in the area of packinghouse operational parameters has a direct application by providing needed information to packers on their actual chemical usage and its potential antimicrobial impact. Lastly, the information generated from the brush roller studies provides operational guidelines for a commercial-scale system.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Despite the numerous studies that have been performed on tomato postharvest technology, this study was able to offer insight. This study showed varietal differences in *Salmonella* update. The packinghouse surveys demonstrated that packinghouses, though working from the same set of operational guidelines, all had different 'actual' operational levels of sanitizers. The brush roller studies showed that system to be very efficacious as compared to a simulated, conventional fluming operation. In all, the results from this study provide valuable information to the tomato industry.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Publications:
Xia, X., Luo, Y., Yang, Y., Vinyard, B., Schneider, K., and Meng, J. 2011. Effects of Tomato Variety, Temperature Differential and Post-stem Removal Time on Internalization of *Salmonella enterica* Serovar Thompson in Tomatoes. Journal of Food Protection. 2012. Vol. 75, No. 2, 2012, Pages 297–303.
Chang, A.S., and Schneider, K.R. 2011. Evaluation of Overhead Spray-Applied Sanitizers for the Reduction of *Salmonella* on Tomato Surfaces. Journal of Food Science (submitted).

Presentations:
Keith Schneider: 2nd Annual CPS Produce Research Symposium. Session I, Postharvest Approaches to Minimizing Pathogen Contamination. June 28, 2011, Orlando, Florida.
Keith Schneider: 3rd Annual CPS Produce Research Symposium. Session IV, Wash Water and Process Control. June 27, 2012, University of California, Davis.

Other:
The final research report written for the CPS Technical Committee is posted on the CPS website https://cps.ucdavis.edu/grant_opportunities_awards.php
The final research report and publications resulting from this research will be included in the CPS Global Research Database https://cps.ucdavis.edu/global_research_database.php

Project 49 – Regents of the University of California, Davis - Center for Produce Safety (CPS)

Final Performance Report

Project Title
Reducing Tomato Contamination with *Salmonella* through Cultivar Selection and Maturity at Harvest

Project Summary
Contamination of vegetables with human enteric pathogens most likely occurs both pre- and post-harvest (even though routes of infection and sources of pathogens in the production environment are still a matter of discussion). The goal of this project was to contribute to the development of strategies for improving produce safety without imposing further regulatory burdens or additional costs on producers. The focus was to test the possibility that there already exists commercial tomato varieties that might differ in their "susceptibility" to contamination with *Salmonella*. If such cultivars or genotypes already exist, future efforts could be made to develop more resistant varieties so as to minimize the contamination of produce with *S. enterica*, much as breeders select for disease-resistant crops varieties. Such future breeding efforts require an easy screen. However, because *Salmonella* contaminates plants without causing visible symptoms or damage during colonization and spread, the selection of "*Salmonella* resistant" plant genotypes is less than straightforward. The first step to really solving this problem was to identify those bacterial genes that are crucial to the ability of *Salmonella* to contaminate and persist in tomatoes. Then test whether the corresponding *Salmonella* gene reporters could be used for a direct and straightforward screen of the existing tomato cultivars or maturity stages for those that may be less susceptible to contamination with *Salmonella enterica*.

The overall objective of this proposal was to test whether it is possible to identify a cultivar and fruit ripeness stage (or their combination) that may be less susceptible to contamination with *Salmonella* or less conducive to the growth of the pathogen.

The proposal had two major goals:

1. To screen for a cultivar in which expression of the majority of *Salmonella* "tomato-specific" genes is strongly repressed.
2. To test the gross phenotype of *Salmonella* multiplication in tomatoes of the different varieties at two maturity stages.

Based on the United States Department of Agriculture, Economic Research Service (USDA, ERS) data, the tomato is the most consumed fresh vegetable. In 2009, Americans purchased 18.7 pounds of fresh tomatoes per capita. Throughout this decade, according to the USDA, ERS data, California and Florida led the nation in vegetable and melon farm cash receipts, highlighting the importance of these crops in those states. Florida ranks first or second, (depending on the metric) nationally in the acreage, production and value of fresh market tomato. In 2004, for example, Florida produced about 1.5 billion pounds of fresh market tomatoes valued at more than $500 million. In the 2007 through 2008 growing season, 31,500 acres were under cultivation for the fresh tomato market. Fresh market tomatoes comprise about 40 percent of Florida's fresh market vegetable cash receipts. In Florida, approximately 33,000 workers are directly involved in tomato production and harvest each year. The issues of food safety represent the greatest threat to sustainability and profitability of Florida tomato industry. The USDA, ERS data based on the following June through August 2008 outbreak of salmonellosis caused by *S. enterica* sv. St. Paul, (which was initially wrongly blamed on tomatoes from Florida) the price of tomatoes at the point of first sale dropped from 56.8 cents per pound in June to 25.6 cents per pound in August. This nearly obliterated the tomato industry in the state.

The number of produce-associated outbreaks of salmonellosis is on the rise and is comparable to the outbreaks associated with the consumption of meats and poultry. Furthermore, incidents of salmonellosis caused by *Salmonella* serovars that are commonly isolated from fresh produce have increased by approximately 40 percent based on the Centers for Disease Control data. Despite improvements in Good Agricultural Practice and Best Management Practice, contamination of tomatoes and other produce with non-typhoidal *Salmonella* has resulted in several multi-state and international outbreaks, each causing multi-million dollar damages to the tomato and food industries. This is, perhaps, not surprising considering that in tissues of contaminated tomato fruits, *Salmonella* is capable of building up to high cell numbers, easily reaching 10^5 cells per gram of tissue, levels that are well above those known to cause infections in humans. Furthermore, fruit tissues protect the pathogen from surface sanitation (such as chlorine washes), making it difficult to implement effective fruit wash procedures. Promoting safety of fresh domestic produce will help avoid future attribution errors. Ensuring microbiological safety of tomatoes will benefit millions of consumers, tens of thousands farmers, packers and retailers.

The project did not build on a previously funded Specialty Crop Block Grant Program project.

Project Approach

Briefly screened were 21 tomato cultivars (at two maturity stages, field and greenhouse-grown) for their “susceptibility” to *Salmonella*. Because *Salmonella* does not cause any obvious symptoms in tomato fruits, “susceptibility” was defined as multiplication of the pathogen in fruits to a level that is above average across cultivars tested. Tomato fruits were inoculated with the type strain of *Salmonella enterica* sv. Typhimurium 14028 and with the six isolates of *Salmonella* (sv. Braenderup, Javiana, Newport) that were isolated either from tomatoes linked to outbreaks of human salmonellosis, or from humans with salmonellosis linked to the consumption of tomatoes, or from tomato fields on the Eastern Shore of Virginia. Several thousand tomato infections were performed to obtain statistically-significant data.

As described below, seven potentially interesting varieties were identified, which were more or less “susceptible” to *Salmonella*. To begin understanding the basis of this phenotype, expression of four *Salmonella* genes was tested in each of these varieties at two maturity stages using *in vivo* expression technology. Both the “resistant” and “susceptible” candidate varieties were pursued in order to gain a better understanding of this phenotype.

Goals and Outcomes Achieved

1. Screen of tomato cultivars for “susceptibility” to the type strain of *Salmonella enterica* sv Typhimurium 14028.

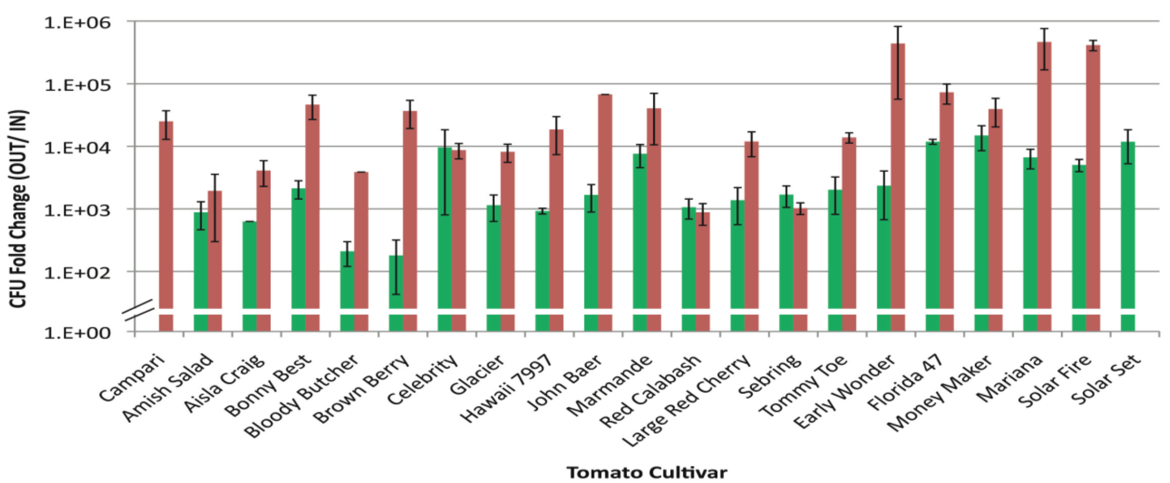


Figure 1. Proliferation of *Salmonella* 14028 in red ripe and mature green fruits of tomatoes. Green bars represent data for green tomatoes; red bars represent data for red tomatoes. Error bars are averages of at least three technical replications and three biological repeats (each cultivar was tested at least nine times). Tomatoes were harvested from the field in Quincy, Florida and from the biocontainment roof-top greenhouse on the University of Florida's Gainesville campus. Fruits of Campari tomatoes were purchased at a local supermarket. *Salmonella* was inoculated onto shallow surface puncture wounds made in harvested fruit. Tomatoes were incubated at 20oC (40 to 60 percent Relative Humidity) for a week. Fruits were then stomached in an equal volume of Phosphate-buffered saline, and aliquots were plated onto a selective medium (XLD). *Salmonella* colonies (which appear black on XLD medium) were counted. To account for the differences in tomato sizes, data are presented as increase in *Salmonella* numbers within the fruit.

These results are important because they represent the first systematic screen of tomato commercial and heirloom varieties for their susceptibility to *Salmonella*. As shown in Figure 1, green tomatoes were on average much less conducive to multiplication of this human pathogen (in green tomatoes, numbers of *Salmonella* increased by 100 to 1,000 fold; in red ripe tomatoes, *Salmonella* increased by 1,000 to 1,000,000 fold). Green fruits of heirloom varieties Bloody Butcher and Brown Berry were the least conducive to proliferation of the type strain of *Salmonella*. The 100-fold cultivar-dependent differences in proliferation of *Salmonella* within green tomato fruits were observed (Figure 1). Of the commercial cultivars, green fruits of cv. Sebring and Early Wonder were least conducive to growth of the type strain of *Salmonella*. The type strain of *Salmonella enterica* proliferated the least in the red fruits of heirloom varieties Amish Salad and Bloody Butcher, equally low proliferation was observed in red ripe fruits of cv. Sebring. Red ripe fruits of tomatoes Early Wonder, Mariana and Solar Fire were the most conducive to multiplication of the type strain of *Salmonella enterica* sv. Typhimurium 14028. The 1,000-fold differences in the proliferation of the type strain of *Salmonella* in red ripe fruits were observed.

2. Multiplication of the outbreak strains of *Salmonella enterica* in tomatoes.

To test whether strains of *Salmonella*, which were linked to or recovered from the actual outbreaks of salmonellosis, associated with the consumption of tomatoes, the ability of a cocktail stains of *Salmonella* to multiply within green or ripe fruits of tomatoes was measured as below.

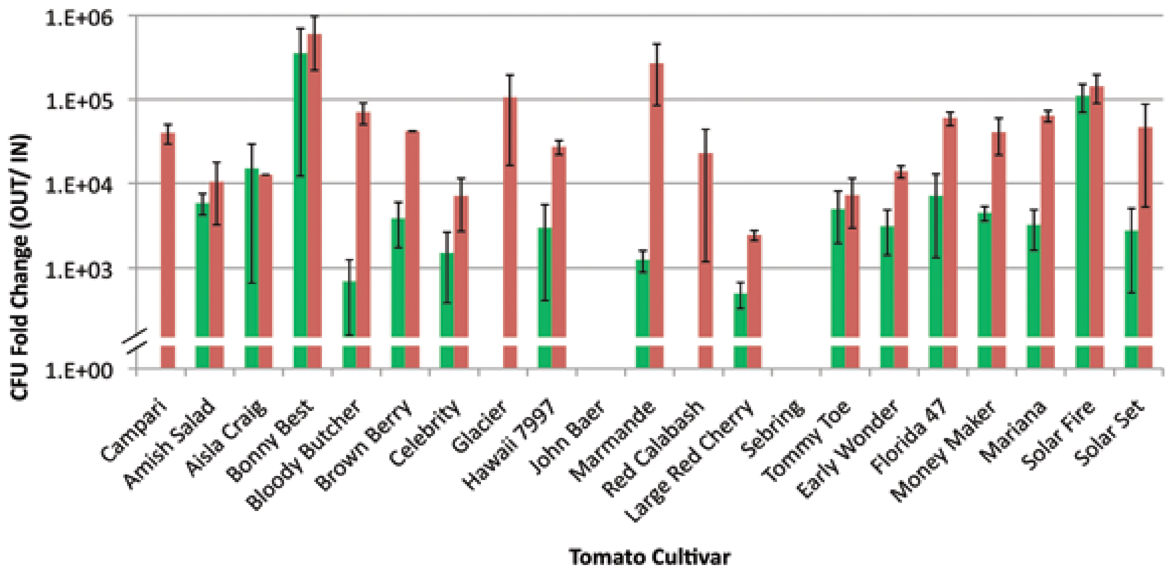


Figure 2. Proliferation of the outbreak strains of *Salmonella* in greenhouse-grown tomatoes.
Data was collected and assembled exactly as in Figure1. Tomatoes were only harvested from the biocontainment facility. Fruits of Campari tomatoes were purchased at a local supermarket. The analysis of data for varieties John Baer and Sebring is still in progress.

On average, less dramatic (compared to the type strain) differences in the ability of the outbreak strains to proliferate in green tomatoes, compared to red tomatoes were observed. Even though outbreak strains of *Salmonella*, on average, grew somewhat better in tomatoes, the overall final numbers of the pathogen in tomatoes was not higher for the outbreak strains. As with the type strain 14028, less proliferation was observed in green fruit of the heirloom tomato Bloody Butcher. Green fruit of Large Red Cherry tomato were also not very conducive to proliferation of the outbreak strains. With the exception of Solar Fire, all green fruit of commercial tomato varieties had a similar ability to sustain proliferation of the type stain of *Salmonella*. The outbreak strains of *Salmonella* proliferated the least in the red fruit of Large Brown Cherry. Proliferation within red ripe fruits of commercial varieties Celebrity, Early Wonder and Solar Set was similar. Red ripe fruits of tomatoes Solar Fire, Bonny Best, Glacier and Marmande were the most conducive to proliferation of the pathogen.

3. *Salmonella* gene expression tomatoes of "resistant" and "susceptible" varieties.
It was previously observed that *Salmonella* gene expression differed in tomatoes of different varieties, and also depended on the maturity of the fruit (and the accumulation of specific compounds that depend on fruit ripeness) (Noel et al., 2010).

Therefore, tests were performed to see whether the observed "susceptibility" or "resistance" of tomatoes to *Salmonella* would also correlate with differences in gene expression in tomato specific *Salmonella* genes. Using *In Vivo* Expression Technology, the regulation of two representative *Salmonella* tomato-specific genes (*cysB, fadH*) was tested.

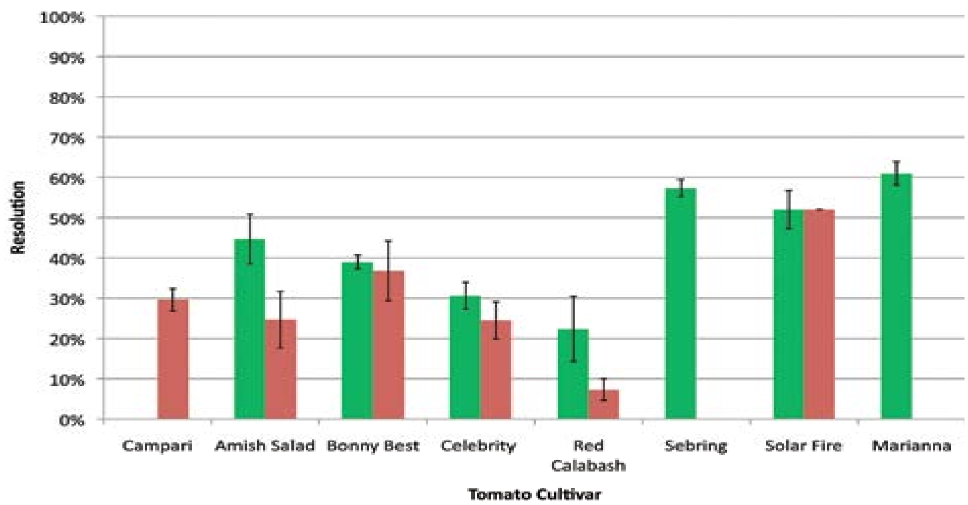
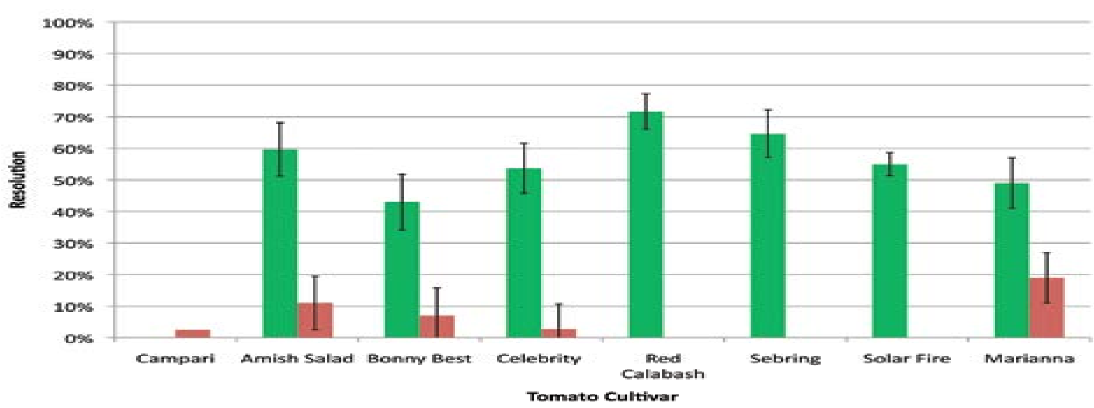


Figure 3. Expression of the *Salmonella* reporter *cysB* inside green and red tomatoes.
The expression of the *Salmonella cysB* gene depended on the tomato variety, which was previously reported (Noel et al., 2010), even though deletion of *cysB* did not affect the ability of *Salmonella* to proliferate in tomato fruit (Noel et al., 2010). As shown in (Figure 3), again differences were observed in the regulation of the *Salmonella cysB* gene in tomatoes of different varieties, however differences in *cysB* gene regulation did not correlate with the ability of *Salmonella* to proliferate in tomato fruits (e.g. in fruits of Sebring and Red Calabash *Salmonella* proliferated the same way (Figure1), however expression of *cysB* was dramatically different.

Figure 4. Expression of the *Salmonella* fadH gene reporter in tomato fruits.
It was previously reported (Noel et al., 2010) that expression of fadH depended most strongly on the ripeness of the fruit, and was driven by the availability of linoleic acid, (which is high in green fruit). Consistently with this previous finding, the expression of fadH depended strongly on the maturity of the fruit. Cultivar-depended differences were statistically insignificant (with the exception of Bonny Best versus Red Calabash). Even though Bonny Best and Red Calabash supported different levels of *Salmonella* proliferation within fruits, no similar trends were observed for other cultivars.



This project attempted to "match" a resistant/susceptible tomato cultivar with changes in gene expression of specific *Salmonella* genes. If such a correlation exists, it would make future breeding programs much easier. So far, it does not appear that such a correlation exists. However, two more *Salmonella* genes will be tested for their differential regulation in "susceptible" and/or "resistant" tomatoes.

As seen in (Figures 1 and 2), data is still missing for two tomato cultivars. Due to an outbreak of a tomato disease in a greenhouse, there was a delay in collecting and analyzing the remaining data. The missing data will be collected and analyzed within the next few weeks. *In vivo* expression technology was also attempted to be used to document *Salmonella* gene expression on surfaces of tomatoes. However, this technology requires that cells of *Salmonella* actively divide, and this is generally not the case, unless samples are incubated in a high humidity chamber.

A study carried out by another team attempted to enumerate attachment of *Salmonella* to seedlings of tomatoes of different varieties. Even though interactions of *Salmonella* and *E. coli* with vegetative structures of leafy greens and sprouts is of interest to scientists and producers alike, it is not entirely clear that attachment of the human pathogens to seedlings of tomatoes are consequential under the field conditions. What is presented here is the first systematic study, which surveyed existing commercial and heirloom tomato varieties for their "susceptibility" to *Salmonella*. In this study, a prick-inoculation method was used to mimic the most likely route of contamination of tomatoes under the production conditions. Up until now, no such data existed.

<u>Beneficiaries</u>
When conceiving this project, the aim was to provide (producers) with the data on which of the already existing tomato varieties may be more or less susceptible to *Salmonella*. This was first such a screen, and was a fairly risky project. If differences in "resistance" to *Salmonella* in tomatoes were found, this would provide (breeders) with a list of tomato varieties that could be used in future breeding programs to develop a more *Salmonella* resistant variety.

While these results are not by themselves sufficient to dictate the choice of a cultivar that a producer will plant in a given production season, knowing that fruits of some tomato varieties are more conducive to *Salmonella* proliferation gives the producers the knowledge to make educated risk management decisions. For example, if a more "susceptible" variety is planted, additional care should be taken to cull damaged tomatoes in the field. Alternatively, fruits of the "susceptible" varieties can be harvested at the mature green stage. Producers can also choose to sample smaller batches of "susceptible" tomatoes and larger batches of "resistant" tomatoes during their microbiological surveys. These are not recommendations, rather are examples of potential applications of these discoveries.

While the project screen has been limited, it revealed 10 to 1,000-fold differences in susceptibility of tomato varieties to *Salmonella*. These differences could now be exploited in tomato breeding programs. Collaborations have been initiated with a tomato molecular biologist Dr. J. Giovannoni and tomato breeder, Dr. J. Scott, to more systematically approach this question and learn more about the genetic basis of this phenotype.

Lessons Learned

Even though testing of *Salmonella* gene expression was attempted on tomato surfaces, it is noted that because *Salmonella* does not readily multiply on tomato surfaces under the field conditions, the utility of *in vivo* expression technology is limited.

Also noted was that tomatoes of one heirloom variety harvested in the field were almost completely resistant to *Salmonella*, no such resistance was observed in greenhouse tomatoes of the same variety. The data was interesting; however, further investigation of this phenomenon was beyond the scope of the current proposal. The differences may be due to the presences of endophytic microorganisms. Samples of these field-grown tomatoes were cryopreserved in order to later investigate whether endophytic microbes can somehow inhibit growth of *Salmonella* in tomatoes.

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 50	Project Title: Using Leafy Green Marketing Agreement audit data to determine non-compliance areas and preparation of training and recommendations for improvements in future growing seasons	
Grant Recipient: Regents of the University of California, Davis, Center for Produce Safety	**Grant Agreement No:** SCB09053	**Date Submitted:** December 2012
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** 530-757-5777	**Email:** bfernandez@cps.ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The California Department of Food and Agriculture (CDFA) conducts audits related to the best practices outlined in the Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens (the Metrics). The data collected during these audits can provide information on inefficiencies and gaps in the Metrics, as well as where producers are having difficulty adhering to the best practices.

Intertox in collaboration with the CDFA, Leafy Green Marketing Agreement (LGMA), and the Center for Produce Safety (CPS) proposed mining this database to enhance the effectiveness of the Metrics and the CDFA audit process. Growers have expressed concerns with some of the Metrics and audit practices; given the recent origin of this program, it is likely there are many possibilities for improvement that can decrease compliance costs yet maintain a high level of food safety.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

This audit data project had four primary goals:

1. Collaborate with LGMA, CDFA, and CPS to obtain confidential data for analysis.
During the first year of the project Intertox: a) finalized an agreement with LGMA and CDFA for access to the data; and b) worked with LGMA to build a usable dataset after some initial issues with the LGMA database. In late 2010, Intertox Decision Sciences (IDS), a subcontractor, received the first set of data files, which ultimately contained more than 7,000 records from the LGMA for September 2008-March 2011. IDS removed confidential grower and handler details and assigned growers new random identification numbers.

Throughout 2011, based on different Intertox data requests, IDS evaluated and coded the comment records in order to score the data.

2. Complete a statistical analysis of the data for trends and compliance issues.
Intertox conducted statistical analysis of 1,382 audits for 303 growers. The use of regression analysis was explored and rejected due to too few predicator variables. Statistical analyses that were completed included calculating population distributions that describe the numbers of audits per grower and per month/growing season and the number of violations per month; conducting correlation analysis to assess relationships between numbers and types of violations in a given category compared to others; and characterizing the number and type of violations by audit category and changes in number/ type over time.

3. Prepare training tools and training sessions for growers.
Based on the findings from this project, Intertox recommended LGMA offer training programs for supply chain participants (e.g. handlers, growers and harvesters) focusing on identified issues. Recommended training topics included knife/glove sanitization and knife dip tests. In June 2012, a training program was developed for these areas. The LGMA's stated training goals for the program were to increase confidence in sanitization and water sampling procedures and ultimately to improve testing and sampling audit results. Eight training sessions were held focused on pH, chlorine and water testing in Salinas, Santa Maria and Oxnard, California. For the training program, Intertox developed the hands on training demonstrations (pH and chlorine testing) and breakout sessions (quality circles) that focused on sharing best practices and cross company problem solving.

4. Recommend changes to the Metrics and/or audit methodology based on results.
Recommended changes to the audit methodology included: 1) Consider certification for LGMA supply chain participants that are not audited; 2) Establish a feedback process for using observations from audits to address industry issues; 3) Consider developing a mechanism for scoring the audit checklist to focus on the known contributors to food safety issues; 4) Provide grower and harvesting company data to the LGMA staff for training purposes; and 5) Develop an Internet-based system to manage required documentation and testing results for all handlers/growers.

Support from CDFA auditors and auditing supervisor, the LGMA compliance officer, the LGMA technical director, and the LGMA chief executive officer was critical to the completion of the project.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The research methodology consisted of statistical analysis followed by benchmarking, gap, and root cause analysis. The dataset was first evaluated for trends and then scored, after which benchmarking levels were developed. Deviations from benchmarking levels were examined (gap analysis) as well as the underlying root causes. The results of the analyses were used to develop recommendations for addressing deviations from benchmarks.

For benchmarking purposes, each violation, deviation, infraction, and observation was assigned a score. The scoring was coded as: potentially flagrant violation = 5 points; major deviation = 4 points; minor deviations = 3 points; minor infraction = 2 points; observation = 1 point; and no violation = 0 points. The scores were then summed by audit. While an "observation" does not reflect noncompliance in most cases (e.g., it may reflect a listing of water test dates or similar information), in some cases it could reflect an issue that needs to be addressed. Since differences in these types of observations were not noted in the database, for the purposes of this evaluation, all observations were assigned a minimal score of "1." In the future, this scoring assignment could be revisited, or criteria for assigning an "observation" vs. "no violation" could be refined.

Non-compliance rates were used to identify subject areas that could explain the gaps between scored and best-in-class audits. Using the audit checklist, those questions with a non-compliance rate of 5% or greater, regardless of the type of violation, were examined. Seven questions had a non-compliance rate > 5%; of these, five were related to water and two were related to worker practices and field sanitation. Pareto analysis was conducted on non-compliance questions to discern and rank contributors in order of significance. Data used in the Pareto analysis were derived using individual audit data details and findings comments. Audits where no level was assigned were also included in the analysis.

Based on the benchmarking and gap analysis, several training related recommendations were made including:

1. To reduce audit compliance costs for producers and handlers, the gap between benchmarked performance and optimal performance needs to be narrowed.
2. In order to narrow the gap, training should be a combination of supply chain-specific training and functional training, i.e., handler-specific supply chain training to improve operational efficiencies and functional training for specific areas such as worker practices that continue to affect audit results.
3. The handler-specific supply chain training and the functional training could be outsourced to minimize handler costs. The LGMA, while not currently staffed to manage the expanded training, should be viewed as a strategic option for housing the additional training.
4. Opportunities for functional training opportunities include worker-related training, testing (e.g., harvest equipment sanitation), documentation, and third party management. Training content was outlined for each of the areas.
5. LGMA focused Internet-based tools could support the audit program, streamline paperwork requirements, and reduce audit compliance costs.

Additional recommendations were suggested for changes to the LGMA program including:

1. Certifying suppliers (e.g., harvesters, compost companies) to validate quality levels.
2. Establishing a process to use observations from audits to address industry issues.
3. Considering development of a mechanism for scoring the audit checklist to focus on the known contributors to food safety issues
4. Providing grower and harvest company data to LGMA staff for training purposes.

Eight training sessions were conducted in Salinas, Santa Maria, and Oxnard, California on June 11-15, 2012. Three sessions were conducted in Spanish and five in English. Training sessions were three hours and consisted of classroom, hands on, and breakout session components. A total of 137 individuals from 56 companies attended. Attendees include LGMA members and their growers, growers-shippers, and harvesters, and feedback was positive with wide support for additional training sessions.

Diane Wetherington, Intertox Inc., presented interim research results at the 2011 CPS symposium in Florida, and final research results at the 2012 CPS symposium in California. The 2011 symposium had 249 attendees, and survey respondents rated the relevance of this project to the fresh produce industry as 2.4 (1=very important; 5=very unimportant). The 2012 symposium had 325 attendees and survey respondents rated the relevance of this project to the fresh produce industry as 2.0 (1=very important; 5=very unimportant).

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The value of this research is its ability to measure where the industry is in terms of ideal quality levels and then provide a means for individual growers and handlers to understand how they are positioned within the industry. By measuring and tracking performance against quality metrics, improvements can take place. The results of this study can be used to improve processes and reduce inefficiencies that will lead to reduced costs for the growers/handlers and, along with additional training, lead to a greater ability to understand and address food safety issues. Measuring the cost savings that should accompany process efficiency improvements is achievable. If the training recommendations are implemented, it should be possible to document the post-training process improvements made and quantify an associated time (cost) savings.

Finally, this research has applications for other industry groups beyond leafy greens. Similar studies could be conducted for other fresh produce commodity groups with audit programs (such as tomatoes). Additionally, as new audit programs are being considered (e.g., herbs and cantaloupes), planning for this type of analysis could be included as part of the audit process, with results made available to industry participants.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

It was observed that, given the sensitivity of the data and challenges involved in processing it for statistical analysis, the time required for negotiating first time access to the data and then obtaining the data was much greater than originally anticipated and scheduled. This experience suggests that the amount of time assumed to be required should be doubled.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Presentations:
Wetherington, Diane. Session III, The Challenges and Opportunities of Mining Industry and Surveillance Data to Assess Risks in the Produce Industry. June 28, 2011. 2nd Annual CPS Produce Research Symposium, Orlando, FL.
Wetherington, Diane. Session III, Good Agricultural Practices – Inputs, Cultivation and Harvest. June 27, 2012. 3rd Annual CPS Produce Research Symposium, University of California, Davis.

Other:
Wetherington, D.; Bruce, G. Intertox, Inc. "Using Leafy Green Marketing Agreement Audit Data to Determine on-cmpliance Areas and Preparation of Training and Recommendations for Improvements in Future Growing Seasons: LGMA Training Appendix." June 30, 2012.

The final research report written for the CPS Technical Committee is posted on the CPS website https://cps.ucdavis.edu/grant_opportunities_awards.php
The final research report from this research will be included in the CPS Global Research Database https://cps.ucdavis.edu/global_research_database.php

Project 51 – Regents of the University of California, Davis - Center for Produce Safety (CPS)

Final Performance Report

Project Title
Differential Susceptibility of Spinach Grown under Slow and Fast Growth Conditions to Enteric Bacterial Colonization

Project Summary
Spinach is grown during several months of the year in the Salinas Valley of California. Because of the proximity to the California west coast and protected environmental conditions from the surrounding hills, the Salinas Valley is ideal for spinach production most months of the year. Early season spinach is harvested from March through early June, followed by mid and late season spinach harvested during the warmer months of late June through September and October. During the cooler months spinach grows slowly, taking 40 to 50 days to reach maturity. This is in contrast to spinach grown in summer when it takes 35 to 40 days to reach maturity.

During the summer some spinach harvested is subject to a phenomenon called "spinach breakage," where the leaves are folded over during processing and packing. These folded leaves are more susceptible to breaking and water soaking. There is circumstantial evidence to link outbreaks of human enteric pathogens with the summer months, suggesting that perhaps spinach breakage and foodborne illness may be related. Intuitively, this seems likely, but, there is no scientific evidence that slow-growing (SG) and fast-growing (FG) spinach is structurally different, and that summer grown FG spinach is more susceptible to bacterial contamination. The CPS addressed this question by documenting structural and physiological differences in spinach grown under cool season SG and warm season FG conditions.

Specifically, Objective One was to measure physical and structural differences between FG and SG spinach by light, scanning and transmission electron microscopy. Objective Two was to test for differential attachment of *Salmonella enterica* to FG and SG spinach. Objective Three was to test for differential susceptibility of FG versus SG spinach that had been infested with piercing sucking insects.

Project Approach
Objective One:

Growth Chamber Studies
Plants were sown in standard potting mix (Metromix 600) in 128 plug trays in the FG chamber and at approximately three weeks plugs were transplanted into 4.5 inch pots. The cohort was then separated, half remaining in the FG chamber and half moving to the SG chamber. The two first true leaves were measured every third day using a Licor leaf area meter. When leaves in the FG leaves stopped expanding, samples were collected and processed for microscopy. The CPS continued measuring the SG plant leaves until they too stopped expanding, approximately two weeks later. Both FG and SG leaves were collected and processed for microscopy. Samples of

the same physiological age (FG date 1 and SG date 2) and chronological age (FG date 2 and SG date 2) were compared.

Light and Transmission Electron Microscopy (TEM)
Small 2 mm (millimeters) sections of the growth chamber-grown plants were cut from leaves approximately two cm (centimeters) from the distal end adjacent to the midrib. Plant tissues were fixed in two percent glutaraldehyde for seven to 10 days at 4°C (Celsius), and then subjected to a standard dehydration sequence before a two hour exposure to one percent osmium tetroxide. The tissues were then embedded in Spurr's resin. Samples were thick sectioned and stained with methylene blue and examined with a compound microscope. Thick sections were cut and mounted on carbon coated grids and examined using a Leica digital transmission electron microscope. At least five to six leaves per treatment were processed, but three samples per treatment were examined, comparing FG and SG leaves at the same physiological age and at the same chronological age. This was repeated in its entirety three times. The field grown samples were compared only once.

Results
Measurements of the thick sections revealed that SG plants were 50 percent thicker than FG leaves at the same physiological age, and 30 percent thicker than FG leaves at the same chronological age. Examination of the ultrastructure by TEM revealed no major anatomical differences, but the cell walls of both the epidermal cells and the palisade cells were much thicker in SG cells compared to FG cells. This strongly suggests that the SG leaves are structurally sturdier than FG leaves.

Scanning Electron Microscopy
The FG and SG plants at the same chronological age were fixed and dehydrated, and then critically point dried. Samples were then mounted on metal stubs and sputter coated with palladium and examined by scanning electron microscopy.

Results
It was difficult to see any microtears or artificially-induced wounds in both types of plants. There were, however, several ridges present on the surface of the FG plants that were not as evident on the SG plants. These may represent structures for easy attachment of surface bacteria.

Fatty Acid Analysis
Extracted waxes were analyzed by gas chromatography (GC) to determine differences in wax amount and composition. Waxes were extracted from the top and bottom of a 10 mm diameter area near the middle of each leaf using chloroform (30 seconds, two times). After chloroform was evaporated under a stream of nitrogen trimethylsilyl, derivatives of hydroxyl containing compounds were prepared by adding 50ul (microliters) each of BTSFA [bis (trimethylsilyl) trifluoroacetamide] and pyridine, and incubating at 70°C for 30 minutes. A one microliter sample was then injected onto a 30 m (meters) long DB-1 (100 percent dimethylpolysiloxane) column on a GC equipped with a flame ionization detector (FID). Semi quantization of wax components was done by comparing to tetracosane and heptacosanol internal standards. Identification of wax component peaks was done using authentic standards and GC-mass spectrometry.

Results

Cuticular waxes consisted mainly of primary alcohols and alkanes. The FG and SG leaves had significant differences in the amount of alkanes and primary alcohols but not in total wax. SG leaf waxes consisted mainly of primary alcohols while FG waxes were predominantly alkanes. This appears to be independent of leaf size, but it may be related to chronological age. This is because one set of young FG leaves (42 days) had slightly more alcohols (not significant due to small sample size). Furthermore, based on this analysis, cuticular wax thickness does not appear to vary by leaf size or on different sides of the leaves. Wax amount did increase with chronological age although the correlation was poor.

Leaf Strength Tests

The second or third pair of leaves from four plants from each growth condition was clipped into two 10 mm wide by 20 mm long test samples. These were placed in an Instrong machine for a tensile test at a strain rate of 10mm per minute. One leaf from each plant was tested immediately; the second one was stored on a tray at 14°C for about two hours. The leaves were slightly wilted after two hours. Leaf fracture strength was tested using similar tissue preps, but instead of pulling the tissues, these preparations were folded over until they broke.

Results

Leaves that were grown under both conditions and tested after a two hour wilting period were stronger than leaves tested immediately. This makes sense because wilted leaves are "stretchier" and less crisp than fresh leaves. The SG leaves were stronger than FG leaves, requiring up to 20 percent more strain force to break the leaves in the wilted state.

Field Grown Spinach Comparisons

Field grown spinach, varietal "Silverwhale," was harvested by NewStar crews in April 2010 for SG plants and late June 2011 for FG plants, and bulk shipped to Oklahoma State University. Representative leaves were prepared for microscopy using methods outlined in objective two.

Results

These samples have not yet been sectioned and measured.

Objective Two:

Attachment of Salmonella to FG and SG Spinach

Spinach leaves were assayed for *Salmonella* attachment using two methods. The first method used whole leaves immersed in resuspended bacterial culture at approximately 10^6 cfus/ml (colony forming units per milliliter). After rinsing and drying, leaves were macerated in 1:10 volume of 0.1 percent peptone and 100 ul was plated on lysogeny broth (LB) ampicillin plates. The second method used a two cm circular punch taken from both types of leaves. Punches were placed on LB agar plates to keep them moist and 50 ul of culture was pipetted onto the adaxial side. After one hour, the inoculum was removed, the leaf punches carefully rinsed, and then macerated in one ml peptone water using a bead-beater. Samples were plated as above.

Results
Observations of FG and SG plants exposed to green fluorescent plasmid (GFP) tagged *Salmonella* gave inconsistent and highly variable results when comparing attachment between samples and between replications. In some replications, more GFP-tagged bacteria were observed by fluorescent on SG leaves than on FG leaves, whereas other replications resulted in the opposite finding. The leaf punch method gave more consistent results, but variations between numbers of bacteria recovered remained high. On average, more cells attached to the SG leaf tissues (unbroken) than to FG tissues. This was an unexpected result and does not support the hypothesis that FG plant tissue is more susceptible to bacterial contamination.

Several attempts to mimic the damage inflicted upon FG spinach during the packing process were carried out with variable success. Finally, slow wilting, accompanied by increased applied weight to mimic the compression and folding that occurs in a field harvesting bin, resulted in minor folding and water soaking of FG and SG spinach. Using these leaves, an attachment study revealed that more bacteria attached to the SG leaves than to FG leaves. Again, this is opposite of what was expected, and does not support the hypothesis that FG leaves are more susceptible to bacterial contamination.

Project Partners
NewStar Fresh Vegetables provided valuable information and advice about the problem of spinach breakage. The field crew and research team at NewStar planted and harvested material for the CPS and gave any inputs to the project when requested.

Dr. Jack Dillwith, Robin Madden and Jim Hardin provided fatty acid analysis and leaf strength measurements.

Objective Three:

Objective Three was not completed due to the inability to obtain enough insects for adequate feeding pressure.

<u>Goals and Outcomes Achieved</u>
1. Collaboration with NewStar Fresh Vegetables was established in 2010 to obtain field samples.
2. Initial growth chamber studies were done to establish study parameters for Objective One.
3. Dr. Sophia Kamenidou was hired to carry out the research.
4. Growth chamber studies began for determining the differences in structural and physiological parameters between FG and SG spinach in 2010, and three replications of the experiment were completed in 2011.
5. Collected samples were processed for scanning, light and transmission electron microscopy. Completed measurements in 2011, determining that SG plant leaves were thicker and more robust than FG leaves.
6. Established collaboration with Dr. Dillwith at Oklahoma State University to evaluate fatty acid analysis and leaf strength of FG and SG spinach. Documented that fatty acid profiles differed between the two types of leaves and that the SG leaves were stronger after a period of wilting.

7. Initiated experiments designed to meet Objective Two in 2011. Data obtained did not support the hypothesis that FG leaves were more susceptible to bacterial attachment than SG leaves.

Beneficiaries

The primary beneficiary of this research will be the spinach growers and processors in the Salinas Valley. This data suggests that slight differences in handling may improve the quality of the final packaged product. The data shows that spinach grown under cool season conditions is 30 to 50 percent thicker, stronger and more resilient to packing conditions. Secondly, the scientific community will benefit by access to more information regarding pathogen plant interactions.

Lessons Learned

Results obtained for the following objectives:

Objective One: Were straightforward and not unexpected, except that the magnitude of difference was very high. The differences between the two growth types were marked.

Objective Two: Were surprising. The hypothesis was that FG spinach would be more susceptible to pathogen attachment. Collected data suggested the opposite. However, one important lesson was that sample sizes of plant pathogen attachment studies should probably be very high. The standard error representing the level of variation between plants and experimental replications was very high, so much so that any differences (if any) between attachments to plant types was masked.

Objective Three: (Impact of whitefly feeding upon susceptibility to bacterial attachment) was not achieved because of the difficulty in obtaining high enough whitefly numbers to carry out the project. Although it was anticipated that there would be an adequate supply of insects, this objective was not met. It would have been better to have established whitefly colonies with the project team than to use another researcher's colony insects.

Finally, two aspects of the project, fatty acid analysis and leaf strength, were not included in the original project goals. However, after discussing project ideas with colleagues, the project team realized there were other parameters that could be measured that may provide insight to the mechanisms of spinach breakage.

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California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.: 52	**Project Title:** Wildlife Survey for *E. coli* O1157:H7 and Salmonella in the Central Coastal Counties of California	
Grant Recipient: Regents of the University of California, Davis, Center for Produce Safety	**Grant Agreement No:** SCB09055	**Date Submitted:** December 2012
Recipient Contact: Bonnie Fernandez-Fenaroli	**Telephone:** 530-757-5777	**Email:** bfernandez@cps.ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Samples were collected from nine geographical regions (i.e., watershed) within three California central coastal counties by Department of Fish and Game staff to develop results regarding which species of wildlife are a significant or insignificant risk to produce safety. Fecal samples were collected to determine if wild animals are carrying human pathogenic strains *Escherichia coli* O157:H7 and *Salmonella*. This information will help the produce industry better manage and protect wildlife and provide food health safety information to farmers and to the food industry. In addition, the information will assist agencies to develop policy and wildlife management plans to reduce the food safety wildlife uncertainty. The future of sustainable wildlife populations is dependent on having cumulative and accurate scientific data to properly manage wildlife and to protect human health. The purpose is to bring practical science and farm practice to the farming and ranching communities.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

A survey was conducted of wildlife across California's three central coastal counties that support leafy-green production from thirty-six sites on both private and public properties. Fecal samples were collected using anal swabs from small birds, Canada geese, and small mammals, and colons or fresh feces from wild pigs, elk, and deer. Small birds were captured using mist nets or Potter traps and small mammals were captured using live-box traps. Canada geese were captured during their flightless molt season using funnel traps. Big game colons were collected from freshly hunter-killed deer, elk, and wild pigs or as a result of depredation permits.

Fecal samples were collected from birds and rodents using anal swabs and placed into transport media tubes and colons were placed in zip-locked plastic bags. All samples were shipped one-day service to the laboratories with blue-ice. Fecal material was placed into Trypticase Soy Broth enrichment at 25°C for two hours with shaking at 100 rpm (revolutions per minute), then at 42°C for 8 hours at 100 rpm, and held overnight at 6°C, followed by IMS (immunomagnetic separation). Broth cultures were plated onto two separate selective media (Tellurite Cefixime – Sorbitol MacConkey Agar (TC-SMAC) and Rainbow Agar) for isolation and confirmation. All samples were analyzed by United State Department of Agriculture, Agricultural Research Service (USDA-ARS) or University of California, Davis, Western Institute for Food Safety and Security (WIFSS) laboratories.

Results

Research staff captured 17 species of rodents and 63 species of small birds from a variety of habitats. The habitats included oak woodland, grasslands, riparian zones, and agricultural production fields. All geese, rodents and deer were negative for *E. coli* O157:H7 (Tables 1, 2, and 3). Only one (0.11%) small bird, a dark-eyed (Oregon) junco, three (2.0%) Tule elk (n = 149) and 10 (4.2%) wild pigs (n = 240) were positive for *E. coli* O157:H7. The junco was captured in native habitat approximately 20 kilometers from the 2006 spinach outbreak and the strain isolated was similar to the 2006 outbreak.

All the Canada geese were negative for *Salmonella*. Twenty rodents (11 California ground squirrels, 5 deer mice, 3 house mice and one black rat) were positive for *Salmonella*. Fourteen birds (2.7%), representing eleven species, were positive for *Salmonella*. Four deer (2.3%) (n = 175), three elk (3.9%) (n = 76) and six wild pigs (5.9%) (n = 102) were positive for *Salmonella*. All positive deer and elk were from herds that occupy natural habitat areas and were not near agricultural production areas. These results represent all samples collected since 2007.

The prevalence of *E. coli* O157:H7 and *Salmonella* appears to be low in native wildlife and is highest in non-native wild pig. Comparing this study to other California food safety-wildlife studies, the overall prevalence for *E. coli* O157:H7 and *Salmonella* tends to be less than 2% and around 5%, respectively, in native wildlife.

An *E. coli* O157:H7 outbreak occurred in strawberries in northern Oregon during the summer of 2011. Deer have been implicated as a source for this outbreak. Farmers in the Yuma Valley, Arizona, are also concerned about deer as a potential risk to food safety. Andrew Gordus, Department of Fish and Game, subaward principal investigator, recommends big game continue to be surveyed across the state for human pathogenic bacteria. Other studies indicate blackbirds that occupy confined animal facilities, such as stock yards, have a slightly higher *E coli* O157:H7 prevalence than this study. High density flocks utilize these facilities and move out to agricultural areas to feed, thus being a potential vector to crops. As such the researchers recommend blackbirds be surveyed for human pathogens in and nearby confined animal facilities. Geese also form large concentrations on agricultural fields and roost on sewage treatment ponds, thus geese should continue to be surveyed. Tests were run for only two major pathogenic types of bacteria, thus the researchers recommend other pathogenic strains associated with outbreaks or recalls of fresh produce (e.g. non-O157 Shiga toxin producing *E. coli*, *Listeria monocytogenes*) be included in future wildlife studies. Thus, Dr. Gordus recommends funding for big game, bird species that form large density flocks around agricultural facilities and goose studies be continued.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

With better knowledge about the spatial and temporal incidence of *E. coli* O157:H7 and *Salmonella* in local wildlife, this data will provide more accurate information for growers, landowners, processors and auditors in order for them to make decisions that will balance food safety concerns with wildlife management. The results will assist resource agencies and growers in developing strategies, management plans and policies for preventing crop contamination in the fields to protect public health and to protect wildlife and their habitats.

It was found that the occurrence of *E. coli* O157:H7 is negative in almost all native wildlife, including deer, and rare in birds and elk, indicating that the risk of food contamination with *E. coli* O157:H7 is low from these species. The single positive small bird (junco) had the same strain that was isolated during the 2006 spinach outbreak suggesting this strain continues to exist in the environment. However, it remains unknown where or how this individual bird came in contact with this strain. The highest prevalence of *E. coli* O157:H7 and *Salmonella* was in the non-native wild pig, which may indicate that the risk from these species is higher. *Salmonella* was detected in a larger diversity of avian and mammalian species and may indicate that under certain high density situations (i.e. flocks of birds, colony of California ground squirrels) the food safety risk is more elevated if these species are in close proximity to produce fields. Please note, these results show that some wild animals carry *Salmonella*, but the level of significance remains unknown. The house mouse, black rat, and wild pig are non-native species to North America, thus, their removal will not impact native species. Dr. Andrew Gordus, California Department of Fish and Game, presented final research results at the 2012 CPS symposium in California. The 2012 symposium had 325 attendees and survey respondents (72 total) rated the relevance of this project to the fresh produce industry as 1.7 (1=very important; 5=very unimportant). Dr. Gordus prepared a poster of his interim research for the 2011 CPS symposium in Florida. The 2011 symposium had 249 attendees, and 83% of the survey respondents (63 total) rated the poster session as very valuable or somewhat valuable.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

As stated above, growers, landowners, processors and auditors in California can make better decisions addressing food safety concerns with wildlife management and environmental protection. This study will further assist resource agencies and growers in developing strategies, management plans and policies for preventing crop contamination in the fields to protect public health and to protect wildlife and their habitats. Farmers are being pressured, at great economic expense, to build deer- and wild pig-proof fences around their fields, and remove habitat and wildlife from their farms. Growers and processors can focus their resources to key management practices, instead of taking a "shotgun" approach to manage food safety issues in the field.

In this project it was found that the occurrence of E. coli O157:H7 is negative in almost all native wildlife, including deer, and rare in birds and elk, in California's central coastal counties watersheds, indicating that the risk of food contamination with E. coli O157:H7 is low from these species. Without science-based data, California growers were being pressured to build game-proof fences, remove habitat and trees, and haze/shoot/poison wildlife to prevent intrusion into fields; costly investments if not necessary for food safety. The beneficiaries of this project are California fresh produce growers required to implement food safety practices; a group that produced $22.6M in cash income for California fruit, nut, and vegetables crops in 2011 (as stated in California Agricultural Statistics, Crop Year 2011, USDA National Agricultural Statistics Service, California Field Office, www.nass.usda.gov/ca, October 31, 2012).

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

E. coli O157:H7 and *Salmonella* are low in most native wildlife species. In addition, the same strain as the 2006 spinach outbreak continues to exist in the environment, but it is not known where or how one bird came in contact with this strain. The highest prevalence occurs in the non-native wild pig, suggesting this species poses higher risk. *Salmonella* was detected in a diversity of birds and mammals. However, it is most likely related to certain high density situations such large flocks of birds or colonies of California ground squirrels and relates to the proximity of these animals to produce fields.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Publications:
Gorski L, Parker CT, Liang A, Cooley MB, Jay-Russell MT, Gordus AG, Atwill ER, and Mandrell RE. 2011. Prevalence, distribution and diversity of Salmonella enterica in a major produce region of California. Appl Environ Microbiol 77:2734-2748.http://www.ncbi.nlm.nih.gov/pubmed/21378057

Presentations:
Gordus, Andrew. 3rd Annual CPS Produce Research Symposium. Session I, Good Agricultural Practices – Buffer Zones and Animal Vectors. University of California, Davis. June 27, 2012.
Gordus, Andrew, Robert Mandrell, and E. Robert Atwill. *Wildlife Survey for E. coli O157:H7 and* Salmonella *in the Central Coastal Counties of California*. Poster Session. 2nd Annual CPS Produce Research Symposium, June 28, 2011, Orlando, Florida.

Mandrell RE. Presented Division Lecture for Food Microbiology Division (P) of the American Society for Microbiology at the 111th General Meeting, New Orleans, LA; "Microbial food safety of produce: In the lab and in the field." May 22, 2011.

Other:
The final research report written for the CPS Technical Committee is posted on the CPS website https://cps.ucdavis.edu/grant_opportunities_awards.php
The final research report and publications resulting from this research will be included in the CPS Global Research Database https://cps.ucdavis.edu/global_research_database.php

Project 53 - University of California Cooperative Extension, Monterey County (UCCE)

Final Performance Report

Project Title
Survival of *E. coli* on Soil Amendments and Irrigation Water in Leafy Green Field Environments

Project Summary
Spinach and lettuce are both high-value leafy vegetable crops that are extensively grown in California. The coastal spinach and lettuce producing area is the most important and productive region for these commodities. Because spinach and lettuce have been subject to *E. coli* contamination, it is critical to develop practical information on how *E. coli* may behave in these particular cropping systems. Field generated research information developed under commercial coastal California conditions can contribute significantly to the understanding of *E. coli* ecology and assist the industry in further understanding the dynamics of this foodborne pathogen. If field studies conducted in the Salinas Valley it was found that *E. coli* survived for relatively short periods in soil and that such bacteria did not contaminate spinach or lettuce grown in the inoculated soil.

Project Approach
Experiment 1. Pre-emergence soil inoculation
Spinach was planted per commercial practice (42 lines on 80 inch wide beds, standard seed density at three million live seed per acre and sprinkler irrigation) at the experimental site in the Salinas Valley. The treatments were applied to the bed tops prior to spinach emergence and were the following: generic *E. coli* (three rifampicin-resistant strains) as liquid inoculum, attenuated *E. coli* O157:H7 (two rifampicin-resistant strains) as liquid inoculum, generic *E. coli* (same three strains) on sand medium placed inside mesh bags, attenuated *E. coli* O157:H7 (same two strains) also in mesh bags. The fifth treatment was an untreated control.

Soil sampling began approximately one hour after the spray application, hence defined as zero days post inoculation (dpi), and was continued at 1, 3, 7, 14, 22 and 28 dpi. Soil samples were gathered with sterile disposable scoops. Soil samples from the mesh bag plots were taken in triplicate at designated distances (0 cm (=adjacent to the bag), 25 cm, and 50 cm) from the bags. Soil samples were processed and analyzed for presence of the *E. coli* strains.

Sprinkler irrigation run-off samples were taken from each plot at 23 and 30 dpi. Samples were collected in sterile bottles after three to four hours of irrigation when water began to run down all furrows. Samples were transported in an iced cooler and processed within 24 hours of collection. Water samples were processed and analyzed for presence of the *E. coli* strains.

Plant samples were taken at 14, 22 and 28 dpi. Plant material was gathered from five evenly spaced areas within each half bed to achieve a composite150 g sample (except at 14 dpi when plants were too small to collect more than 75 g). Plant samples from the mesh bag plots were taken in triplicate at designated distances as mentioned above. Plant samples were processed and analyzed for presence of the *E. coli* strains.

Results

Both generic and attenuated O157 strains of *E. coli* survived similarly in the field after spray inoculation and were not recoverable from soil in direct plating assays at the lower limit of detection within 14 days after inoculation. For the mesh bag sand inoculum, bacterial survival for both generic and attenuated O157 strains was almost identical throughout the experiment. At zero cm from the mesh bag, direct plating recovery from soil remained above the lower limit of detection after 28 days. Direct plating recovery from soil at 25 cm away from the bags fell below the limit of detection around three days. At the 50 cm distance, recovery was at or below the limit of detection for all sampling days. None of the strains were directly recovered from water run-off or plant samples.

Experiment 2. *E. coli* survival on crop residue

A second spinach planting was germinated and grown according to standard commercial practice. When the crop was mature, plots were set up in preparation for inoculation with generic and attenuated *E. coli* strains.

Plots were comprised of two adjacent 80 inch beds that were each 50 feet in length and were replicated four times. Treatments used the same bacteria as described in Experiment 1 and were the following: generic *E. coli* (three rifampicin-resistant strains) as liquid inoculum, attenuated *E. coli* O157:H7 (two rifampicin-resistant strains) as liquid inoculum. Immediately following the foliar inoculation sprays, the crop in each plot was incorporated into the soil with a tractor and disk. No other field production steps were taken until the field was irrigated on September 16 at 96 dpi and disked a second time on September 24 at 104 dpi. Soil samples were taken at 0, 1, 3, 7, 14, 22, 28, 35, 63, 96 and 104 dpi. Samples were processed and analyzed for presence of the *E. coli* strains.

Results

Both inoculated strains were recovered from the soil plus crop residue samples. Bacterial populations generally increased within the first week after inoculation and then gradually declined. However, despite an additional application of water at 95 dpi and disking at 103 dpi, bacterial numbers did not reach the limit of detection even after 105 days post-inoculation. Recovery of attenuated O157:H7 was lower, overall, than recovery of generic *E. coli.*

Experiment 3. Survival on compost amendments

The experiment was conducted in a field in Monterey County representative of the coastal vegetable production environment. Large strip plots, measuring 400 feet long by 30 feet wide each, were set up in a randomized complete block design with three replications. Two types of commercially available compost (composted 100 percent yard waste and composted 60 percent cow manure per 40 percent yard waste blend) were applied separately to designated plots at a rate of five tons per acre using a commercial compost-spreader truck. Treated areas were separated by 20 foot wide un-amended buffer strips. Within each large plot, two 30 x 30 sq ft sections were watered by a commercial water-truck (at a rate of 0.1 gallons per square foot). For plots receiving inoculum, these 30 x 30 sq ft sections were sprayed with bacteria immediately after the watering. The inoculum consisted of three generic strains of rifampicin-resistant *E. coli* applied with backpack sprayers. Unamended buffer strips functioned as control plots that did not receive compost but were inoculated with bacteria.

The applied composts were chiseled into the field immediately following inoculation, and 24 hours later the field was prepared for planting by listing the field (incorporating the composts into the soil to approximately a 10 inch depth) and applying a pre-irrigation. Romaine lettuce was direct seeded into the prepared 80 inch wide beds. The crop was subsequently grown according to commercial practices.

Soils were first sampled after the pre-irrigation at 6 dpi. Soils were collected to a depth of 12 inches using a one inch diameter soil probe, with each plot sample consisting of 10 probes. Soils were later sampled at 11, 19 and 43 dpi. Samples were processed and analyzed for presence of the *E. coli* strains. Plants were sampled at 48 dpi only, near harvest maturity, by cutting the lettuce plants at crown level just above the soil surface. Each plot sample consisted of five plants. In the laboratory plant samples were processed and analyzed for presence of the *E. coli* strains.

Result

The first soil sample was collected six days post-inoculation (dpi). Few bacterial colonies were recovered from the soil for any of the treatments at 6, 11 and 19 dpi. Recovered colonies were analyzed by PCR (Suslow lab) and confirmed that they were the inoculated generic strains. By 43 dpi, no colonies were recovered at the limit of detection. There were no significant differences between yard waste compost, yard waste plus manure blend, or inoculated soil without compost. At no time were bacterial colonies recovered from the control soils. Romaine grown in the plots was sampled at 48 dpi. Enrichment of the plant material showed that the inoculated generic *E. coli* strains were absent from all plant samples.

Experiment 4. Survival in liquid and solid organic supplements

In another experiment, survival of generic *E. coli* and *Salmonella* when introduced into a field as a contaminant in two commonly used nutrient supplements in organic lettuce production: fish emulsion (liquid) and chicken pellets (solid) was examined. Supplements were inoculated prior to application to the field with a mixture of three strains of generic *E. coli* plus one strain of attenuated *Salmonella* (all resistant to rifampicin). For the field experiment, conducted on a sandy-loam soil in the Salinas Valley, 40 inch wide beds were prepared according to commercial practice and then seeded with two rows of romaine per bed. Surface drip irrigation lines were then placed on top of the beds (one line per bed). Experimental plots measured two 40 inch beds wide by 160 feet long and were replicated four times. After planting, the field was sprinkle irrigated to germinate the crop. After germination the field was irrigated via surface drip lines. The crop was grown, thinned and produced according to commercial practices.

Field inoculation was completed when the crop had grown to the thinning stage.

Treatments were the following:

- Liquid fish emulsion inoculated with *E. coli* plus *Salmonella* and injected into the appropriate drip lines over a period of 60 minutes.
- Chicken pellets spray inoculated with *E. coli* plus *Salmonella*, allowed drying for 15 minutes, then spreading on each designated bed for a final rate of 1,000 lbs pellets per acre.
- Uninoculated chicken pellets for control plots.

Soils were sampled on 1, 7, 21 and 36 dpi and were processed and analyzed for presence of the *E. coli* and *Salmonella* strains. Plants were sampled on 7, 21 and 36 dpi. Whole lettuce plants were cut at the crown just above the soil surface. Each sample consisted of five plants per plot. In the laboratory, the outer leaves and upper and lower quarters of the lettuce head were removed. The remaining section was chopped into large pieces, mixed thoroughly, and processed and analyzed for presence of the *E. coli* and *Salmonella* strains.

Results

Bacteria were recovered from all soil samples for each of the sampling days (0, 1, 7, 13, 21 and 35 days post inoculation) in both contaminated solid and liquid supplement treatments. Bacteria were not recovered from control plots at the limit of detection, log 1.43 cfu/g. Romaine grown in the plots were sampled at 7, 13, 21 and 35 dpi. Inoculated bacteria (both generic *E. coli* and *Salmonella*) were recovered by direct plating from plant samples at 7, 13 and 21 dpi but not at 35 dpi. However, generic *E. coli* and *Salmonella* were recovered by enrichment of plant samples on all sampling dates for both solid and liquid supplement treatments.

In a final test to determine the presence/absence of introduced bacterial strains on lettuce grown with the supplements, three replicates of 60 leaves each (collected when plants were at harvestable size) were randomly taken from throughout the contaminated solid supplement plots. Samples were collected as composites of 25, 75 or 125 g per plot and were enriched in TSB-rif. All enrichment tests were negative. Composites of the lettuce enrichments spiked with log 3 cfu Salmonella/sample, as positive detection controls, were all positive.

<u>Goals and Outcomes Achieved</u>

How generic and attenuated, non-toxigenic O157:H7 strains of *E. coli* survive when introduced to soil, water and spinach plants in a commercial production setting was investigated. The overall results are consistent with previous experiments conducted under commercial Salinas Valley agricultural environments. Both generic *E. coli* and attenuated *E. coli* O157:H7, when applied to soil, survived for relatively short periods of time. In addition, both inoculum types failed to move significantly into irrigation water runoff or move in the soil. Bacterial inoculum was not recovered from spinach plants that were grown in inoculated plots.

However, when mature spinach plants were inoculated with either *E. coli* strain and disked back into the soil, both types of bacteria were recovered from soil and crop residues for an extended period of time (over 100 days). This was an unexpected outcome and additional studies would be appropriate to examine factors that could enhance decline of such inoculum.

How generic and non-toxigenic O157:H7 strains of *E. coli* survive when introduced into field settings via production inputs was also examined. Compost, liquid and solid supplements were inoculated as standard amendment materials, then introduced the contaminated materials into the soil and tested soil for survival of the inoculated strains. Plants from the romaine lettuce crop grown in these plots were evaluated for any indications of contamination. Contaminated compost did not result in persistent survival in soil and did not result in contaminated romaine. For liquid and solid supplements, which were inoculated with generic *E. coli* and non-toxigenic *Salmonella*, the lettuce had low levels of recoverable bacteria until day 35, at which time recovery was negative.

Beneficiaries

Outbreaks of foodborne pathogens on leafy vegetables occur at sporadic intervals and are not new developments. However, extensive and widely publicized foodborne pathogen outbreaks resulting in national-scale food recalls, such as the spinach case in 2006 and some recent lettuce recalls, have highlighted the need and increased the urgency for practical information on the dynamics of such organisms in agricultural systems. While the biology, ecology and epidemiology of E. coli O157:H7 have been extensively researched and studied in animal and human contexts, such information is not well developed for E. coli as it occurs in leafy green production environments. The activity and dynamics of these pathogens on leafy vegetable plants have been mostly studied under laboratory and growth chamber environments. Until further information is available, such lab studies may have limited predictive value for food safety policies and practices as applied to commercial field vegetable production.

In addition to concerns about E. coli O157:H7 and other human pathogens, the leafy green vegetable industry and the produce industry as a whole must contend with the presence of non-pathogenic, generic E. coli as well. Generic E. coli can be readily detected in many farm environments, yet the ecology, biology, and fate of these organisms are not well documented in this setting. Current food safety concerns, buyer contracts and conditions, and food safety metrics all list generic E. coli as an organism of concern because this bacterium is assumed to be a validated indicator of fecal contamination.

Due to the extensive leafy green vegetable acreage in California, it is imperative to obtain more information on the biology, ecology and epidemiology of both generic and pathogenic E. coli under coastal California agricultural field conditions. Applied field-oriented research increases the practical understanding of how E. coli operates in the field and assists industry and regulators in making informed decisions on growing practices, metrics, and regulatory food safety policies for the field. This study therefore can benefit all participants involved in food safety, including grower and producer, marketer, regulator, policy makers, industry metric designers and others.

Lessons Learned

The major lesson learned regarding how *E. coli* operates in the field is that survival under commercial, coastal California conditions is surprisingly brief. Therefore, it seems likely that if *E. coli* contamination takes place in the field, the bacteria will end up on the finished product if such contamination occurred late in the growing cycle and close to harvest. Contamination events that occurred pre-plant or when plants are very young may not be significant sources of final product contamination.

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Additional Information

1. Publications related to this project

Koike, S. T. 2010. Ground zero: Food safety research and extension in California's Salinas Valley. Abstract for APS Special Session Presentation. Assuring the safety of fresh produce: Issues and strategies. Phytopathology 100:S155.

Koike, S. T. 2010. Examination of the survival and internalization of E. coli on spinach under field production environments. Abstract. Produce Research Symposium. June 23. Center for Produce Safety.

Koike, S. T., Cahn, M., Suslow, T., and Smith, R. 2010. Field survival of E. coli in a spinach production system. California Leafy Greens Research Board. Progress report. October 5.

Koike, S. T., Cahn, M., Suslow, T., and Smith, R. 2010. Survival of *E. coli* under a commercial spinach production environment. Abstract. Food Safety and Water Quality Co-Management Forum. Watsonville. December 8.

2. Presentations related to this project

Koike, S. T. 2010. Examination of the survival and internalization of E. coli on spinach under field production environments. Produce Research Symposium. Center for Produce Safety. UC Davis. June 23.

Koike, S. T. 2010. Outreach to growers: Extension and food safety in California. Symposium: Human pathogens associated with edible plants. International Association for Food Protection annual meeting. Anaheim. August 2.

Koike, S. T. 2010. Ground zero: Food safety research and extension in California's Salinas Valley. Symposium: Assuring the safety of fresh produce -Issues and strategies. American Phytopathological Society Annual Meeting. Charlotte, North Carolina. August 10.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 54	Project Title: Assessing postharvest risks for *Salmonella* in pistachios	
Grant Recipient: Regents of the University of California, Davis	**Grant Agreement No.:** SCB09049	**Date Submitted:** December 2012
Recipient Contact: Linda J. Harris	**Telephone:** 530-754-9485	**Email:** ljharris@ucdavis.edu

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

In the past decade, outbreaks associated with consumption of raw almonds, hazelnuts, pine nuts and peanut butter have been documented in the U.S. and in 2009 there was a large recall of pistachios when *Salmonella* was isolated from commercial products. As a broad group, tree nuts share many characteristics. At the onset of this research, very little was known about the ecology of foodborne pathogens in nut production and processing environments with the exception of almonds. Since then, significant research has been conducted on the pecan and walnut harvesting and postharvest handling; these data have supported the value in evaluating unique characteristics of the postharvest handling of different type of nuts for the development of targeted commodity-specific intervention programs. One approach is to use quantitative microbial risk assessment (QMRA) as a framework for identifying critical data gaps and evaluating the overall effectiveness of current and proposed risk-reduction strategies. The overall goal of this research was to develop data to identify points during post-harvest handling of pistachios where *Salmonella* may be reduced, controlled or amplified and to use these and industry data to construct a pistachio QMRA that would assist in the development of scientifically-based food safety risk reduction strategies for the pistachio industry.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Objective 1. Identify points during post-harvest handling of pistachios where *Salmonella* may be reduced, controlled or amplified.

Microbial loads in pistachios during the hulling process. For the 2010 and 2011 harvests a temporary laboratory was established on site at one of the collaborating pistachio processors. Samples were collected from three (2010) or one (2011) pistachio processing facilities to evaluate microbial loads throughout the hulling process and to collect raw materials for in-laboratory studies. In 2010 general microbial loads were assessed throughout postharvest handling of pistachios. Pistachio samples were collected weekly for 3 weeks during the time that facilities were operating at near capacity. The samples were collected beginning at receipt and through hulling and to initial and final drying pre- and post-silo. Samples were available from facility A and C on weeks 1, 2, and 3 and from facility B on week 1. Similar microbial trends were observed among the three pistachio handlers surveyed as well among the three weeks of the study. In general, aerobic plate count (APC), coliform, and presumptive *E. coli* levels were found to be the highest on the hulls discarded from the huller (6.8 ± 1.1, 5.9 ± 0.9, and 3.0 ± 1.8 log CFU (colony forming units)/g, respectively). Similar APC and coliform counts were found on sinker and floater pistachios as well as in water collected from the float tank, indicating that this step may be a point of cross-contamination. Significant reductions in APC, coliforms, and presumptive *E. coli* were observed during drying (2.5, 2.9, and >1.0 log CFU/g, respectively, for float tank sinkers). These data were used to direct additional studies.

Temperatures in harvest trailers. Pistachios are harvested onto catchframes and then transferred to trailers for transport to the hulling facility. Under ideal conditions, the trailers are unloaded within a 3 to 4 hour (h) timeframe. However, there are circumstances where unloading is delayed (e.g., during periods of high volume or equipment breakdown. Temperature and humidity within loaded pistachio trailers was monitored. Within the first 2 h the humidity in the pistachio trailers was over 90% and the temperature was above 30°C. By the end of the study (13 h) the humidity approached 100% and the temperature was near 37°C.

Growth of *Salmonella* in in-hull pistachios. In-hull pistachios collected from the huller at the receiving pit were inoculated at a level of approximately 4 log CFU/g with a cocktail of *Salmonella* in the laboratory at Davis, CA. After inoculation, samples were dried briefly and then stored at 23 or 35°C and 50 or 90% RH. With the exception of 23°C and 50% RH, growth was observed within 6 but not 3 h. At 35°C significant increases (2 log) were observed after 6 h with maximum populations of approximately 8 log CFU/g observed after 24 h.

Reduction of microbial loads during drying. After the float tank pistachios are dried to moisture levels below 15% (range 9 to 14%). Significant reductions of aerobic plate count and coliform levels (2.5 to 2.9 log) are observed during commercial drying. It is impossible to mimic commercial dryers (forced air, multiple stages/temperatures) under pilot or laboratory conditions; however, several approaches were taken to determine potential reductions of *Salmonella* during drying.

Pre-dryer pistachios were also inoculated with either *Salmonella* or *Enterococcus faecium*, a strain standardly used as a surrogate for in the nut industry. The *Salmonella*-inoculated nuts were dried in a laboratory oven at 160°F (71°C) to a target kernel moisture of 15% (actual moisture 12 and 15%). At these moisture levels the water activity was below 0.88, lower than the water activity that will support the growth of *Salmonella* (0.94). The level of *Salmonella* decreased by 3 to 4-log CFU/g during drying. These nuts were then held at ambient temperature and 50% RH for up to 28 days; after drying levels of the organism did not increase during storage.

E. faecium-inoculated pistachios were dried on-site in a drying oven with forced air (160°F) that was able to better mimic commercial drying than a laboratory oven. This organism is widely used as a surrogate for *Salmonella* in thermal validation studies for tree nuts. A 2.3 log reduction of *E. faecium* was observed within the first hour of drying (whole nut moisture fell from 30 to 18%). No further reductions of *E. faecium* were observed over the next 2 h of drying. Similar to the data collected for commercially dried pistachios aerobic, plate counts of uninoculated pistachios fell by 2.6 log within 2 h of drying.

Reduction of *Salmonella* on dried inshell pistachios during storage. After initial drying, pistachios are transferred to silos where they are further dried with ambient forced air to moisture levels of less than 7%. Pistachios may be stored in the silos for a few days after drying to more than a year. In the laboratory, a cocktail of *Salmonella* was inoculated onto dry inshell pistachios. Inoculated pistachios were dried to the original moisture levels and then stored at ambient, refrigerated or under frozen storage. Time did not significantly influence ($P > 0.05$) populations of *Salmonella* during frozen or refrigerated storage. In contrast, the linear rate of decline for *Salmonella* was 0.15 log CFU/g per month at ambient storage (24°C and 38% RH).

Pistachio moisture content and a_w during storage. The moisture and a_w values at all three storage temperatures (initial 4.4% and 0.40, respectively) remained very similar until about month 7, at which point the values began to diverge. Average moisture contents at the storage temperatures 24, 4, and −19°C were 4.2, 5.9, and 5.1%, respectively, and the average a_w values were 0.34, 0.55, and 0.46, respectively.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The outcomes of this research are described in the results section above and the lessons learned below. All objectives were met and the data generated by the laboratory research provided information used for the QMRA (qualitative microbial risk assessment).

Dr. Linda J. Harris, University of California, Davis, presented interim research results at the 2011 CPS symposium in Florida, and final research results at the 2012 CPS symposium in California. The 2011 symposium had 249 attendees, and survey respondents rated the relevance of this project to the fresh produce industry as 2.4 (1=very important; 5=very unimportant). The 2012 symposium had 325 attendees and survey respondents rated the relevance of this project to the fresh produce industry as 2.1 (1=very important; 5=very unimportant).

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The primary beneficiaries of this research are the collective pistachio industry. The development of the QMRA would not have been possible without the collaborative efforts of Drs. Don Schaffner (Rutger's University), Michelle Danyluk (University of Florida), and Carl Winter (UC Davis). Also critical to the success of the project was the high level of cooperation among the pistachio industry. A temporary laboratory was able to be established on-site at one pistachio handler (Nichols Farms) for two harvest seasons and were given access to a wide arrange of samples from this and two additional facilities (Paramount Farms and Horizon Nut Company). They also provided support with sample collection and access to a number of employees for discussions on research approaches, to answer questions, and for assistance with equipment set up. Dr. Bob Klein, Administrative Committee for Pistachios (ACP), collected, coordinated and blinded data provided by the industry and arranged multiple meetings with the ACP technical committee (with representatives from the entire California pistachio industry) for presentation and discussion of results. These meetings were important in elicitation of expert opinion at points in the risk assessment where data was unavailable. Also critical to the research were the large number of students (graduate and undergraduate), postdoctoral associates, and technicians who collected and processed samples, analyzed data and assisted in writing reports and publications. While not formally quantified the results of this research are being used by the pistachio industry to support their current food safety programs.

The research generated in the grant benefits the pistachio industry, primarily during postharvest handling of the product. There are approximately 10 processors or "handlers" of pistachios in California. These handlers support over 200,000 acres of pistachio production. The annual production is growing and varies significantly from year to year; totals of 350, 520, and 440 million pounds were reported in 2009, 2010, and 2011, respectively. Estimated crop value for these years was 550, 1,200, and 880 million dollars, respectively.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The following summarizes the key lessons learned:

1. The results of the QMRA suggest that risk of salmonellosis from consumption of pistachios is very low based on current industry practice and currently-available data. The risk assessment model can be updated as new data (e.g., prevalence and concentration) become available. However, the current model can be used to support food safety programs for the pistachio industry.
2. *Salmonella* will multiply at ambient temperatures and above in in-hull pistachios, pistachio hulls and pre-dryer pistachios. Increases in populations of *Salmonella* are minimal in the first 3 h but can be significant after 6 h. Holding pre-dryer pistachios (pre or post hulling) for long periods of time should be avoided when possible.
3. The float tank is an opportunity for cross contamination of pistachios. Further studies should evaluate means to reduce this potential (e.g., by treating the wash water with antimicrobials that are maintained at an appropriate active level; by applying a rinse after the pistachios leave the float tank).
4. Microbial populations are reduced in the dryer by approximately 1 to 3 log CFU/g. Most of the reduction occurs in the initial stages of drying. Greater reductions in the dryer may be possible with optimization of the drying times/temperatures. The potential for recontamination after the dryer should be considered.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Publications:

The following publications were funded, in part, by this grant:

Kimber, Martha. 2011. Changes in total aerobic, coliform, and presumptive *Escherichia coli* counts on pistachios during postharvest handling and survival of *Salmonella* spp., *Escherichia coli* O157:H7, and *Listeria monocytogenes* on almond kernels and inshell pistachios. M.S. Thesis, UC Davis (available from the UC Davis library).

Kimber, M.A., H. Kaur, L. Wang, M.D. Danyluk, and L.J. Harris. Survival of *Salmonella*, *Escherichia coli* O157:H7, and *Listeria monocytogenes* on inoculated almonds and pistachios stored at −19, 4, and 24°C. J. Food Prot. In Press.

The following published abstracts and their poster presentations were funded, in part, by this grant:

Kimber, M.A., and L.J. Harris. 2011. Changes in total aerobic and coliform counts on pistachios during postharvest processing. Institute of Food Technologists, New Orleans, LA, June 11-14 (Abstr. 199-06).

Kaur, H, M. Kimber, M.D. Danyluk, and L.J. Harris. 2011. Long-term survival of *Salmonella* spp., *Escherichia coli* O157:H7, and *Listeria monocytogenes* on inoculated almonds and in-shell pistachios at three storage temperatures. IAFP Annual Meeting, Milwaukee, WI. (P3-114).

Morales, V.M., H. Kaur, I.Y. Zhao, and L.J. Harris. 2011. Behavior of inoculated *Salmonella* spp. in postharvest pistachio handling. IAFP Annual Meeting, Milwaukee, WI. (P3-115)

Presentations:

Harris, L. J. 2nd Annual CPS Produce Research Symposium. Session III, The Challenges and Opportunities of Mining Industry and Surveillance Data to Assess Risks in the Produce Industry. June 28, 2011, Orlando, Florida.

Harris, L.J.: 3rd Annual CPS Produce Research Symposium. Session III, Good Agricultural Practices – Inputs, Cultivation and Harvest. June 27, 2012, University of California, Davis.

Other:

The final research report written for the CPS Technical Committee is posted on the CPS website https://cps.ucdavis.edu/grant_opportunities_awards.php

The final research report and publications resulting from this research will be included in the CPS Global Research Database https://cps.ucdavis.edu/global_research_database.php

Final Performance Report

Project Title
Establishment of Critical Operating Standards for Chlorine Dioxide in Disinfection of Dump Tank and Flume Water for Fresh Tomatoes

Project Summary
The beginning of this project was a direct response to and results of a discussions among industry associations, representatives of the full fresh tomato supply chain, public health regulators, government and private auditors and academia during the development of the Tomato Food Safety Audit Protocol (http://www.unitedfresh.org/). The general lack of performance data for specific postharvest water sanitizers currently in use or being adopted and developed under conditions reflective of commercial systems was identified as an obstacle to setting meaningful standards. Performance metrics were needed to build consensus around these audit criteria in a manner that would advance tomato food safety goals in both business integrity and consumer protection. This need was identified as a priority applied research need to fill in critical data gaps by the California Tomato Farmers' cooperative and the California Department of Food and Agriculture representatives charged with the auditing standardization and functions of the voluntary program. Similar needs were expressed by the Florida Tomato Committee. The overall objective of this bicoastal project was to develop scientifically-based critical operating standards for chlorine dioxide use in dump tank and flume tank water for the fresh tomato industry. A two-prong approach was developed through an iterative process of model system assessments and on-site surveys of post fruit-contact water quality and incoming and post wash process fruit.

Objective 1:
Conduct on-site assessments of chlorine dioxide dose management and quantitative microbiological water quality in commercial dump tank and flume systems within commercial tomato packing operations in California and Florida.

Objective 2:
Determine the comparative correlative capacity of oxidation reduction potential (ORP; mV) versus dose (mg/L; ppm) to monitor, control and document water disinfection status within commercial tomato packing operations in California and Florida.

Project Approach
The anticipated outcome was to develop data-based Best Management Practices (BMPs) guidance for chlorine dioxide treatment of process water used in the fresh tomato industry that would be applicable to primary packers, re-packers and fresh processors. The work plan was further designed to result in outcomes and BMPs that would be reasonably transferable to other commodities with similar water quality management challenges and safety performance expectations. A model system was developed for creating "synthetic" dump and flume challenge water for pathogen inactivation studies. This synthetic water composition was based on a quantitative and qualitative analysis of commercial tomato handling systems. In the model

system, it was determined that doses of ClO2 between 1, 3 and 5 mg/L (ppm) could result in at least a six-log reduction of *Salmonella enterica* sv. Newport. Contact time for the inoculated pathogen in water was strongly influenced by the temperature and chemical parameters in the water. Increase in water turbidity increases the contact time for required inactivation of *S. enterica* at any water temperature. Increase in temperature and dose of chlorine dioxide reduced the contact time to achieve a six-log reduction. Additionally, substantial differences in contact time were observed for different *S. enterica* serovars and not all types were killed within the two minute goal.

The UC concluded chlorine dioxide can be managed as a water treatment sanitizer for tomato flume and spray-wash systems but current operational limitations greatly restrict its efficacy in typical dump tank management. Current standards in the Tomato Food Safety Audit Protocol should be modified to reflect this reality. Modifications to enhance the management of dump tank systems where application of ClO2 is desirable for an individual operation remains a reasonable approach.

AquaPulse Systems, Incorporated, Management, the ClO2 system supplier, and the tomato packing facilities in California and Florida were instrumental and essential partners in completing this project. Thousands of dollars of in-kind support from staff as well as donations of water quality assessment equipment made this project possible and within budget.

<u>Goals and Outcomes Achieved</u>
Overall, each data-baseline setting goal and definition of performance standards to develop practical audit criteria for the use of chlorine dioxide in tomato handling systems was addressed and completed collaboratively by both the UC and University of Florida researchers. On-site studies were conducted in three tomato facilities and over 12 dates to provide a sound basis for expected performance in water disinfection for a range of incoming fruit.

A positive correlation was determined between Oxidation-Reduction Potential (ORP) (mV) and ClO2 (ppm) and ORP and Turbidity Formazin Attenuation Units as well as Turbidity and ClO2 in both, dump and flume tanks. Despite better outcomes in flume water systems, the strength of the relationship between ClO2 and ORP appears to be insufficient to rely on ORP sensors alone to predictably control microbiological water quality in real-world systems involving this first-stage tomato supply chain point. All statistical evaluations of the on-site data demonstrated that the data distribution was valid but the linear correlations were not valid. The functional message from this analysis means that, at this time with current operating systems, the preliminary performance and audit standards recommended by the Tomato Food Safety Workgroup would not be reliably indicative of adequate food safety management of postharvest water quality in a predictive manner from day to day or facility to facility.

The key accomplishment was to demonstrate some major obstacles to dump tank management based solely on the addition of chlorine dioxide under normal commercial conditions. The data based delineation of industry challenges and a descriptive characterization of critical operating standards for chlorine dioxide in disinfection of dump tank and flume water for fresh tomatoes were quantitatively defined. As an alternative to the use of chlorine and hypochlorite based treatments, ClO2 remains a viable option for some unit operations but significant obstacles for dump tank management were revealed. The adoption of industry-wide audit criteria should be carefully structured around these plausible limitations so as not to unnecessarily destroy tomatoes or potentially place the consuming public at risk.

Beneficiaries
The immediate beneficiaries of the outcomes of this project include the domestic and international fresh tomato industry. The data developed on the efficacy and operational limits of the chlorine dioxide treatment of dump and flume water is applicable to primary packers, re-packers and fresh processors. The outcomes are readily transferable to other fresh produce commodities with similar water quality management challenges and safety performance expectations.

The apparent limitations of microbiological control, within the regulatory restrictions on ClO2 dose, is of keen economic interest and impact to those providing the technical services to provide these injection systems and to the operators charged with meeting audit criteria for water quality and food safety. Those dedicated to utilizing this disinfectant will be better able to modify their operations to improve performance and remain compliant with the new tomato industry standards.

Lessons Learned
There were several outcomes documented within the cross-sectional and longitudinal industry performance surveys that were unexpected by industry partners and stakeholders. In general, industry anticipated a much higher level of performance in microbial reduction in water and on fruit based on research reports published in peer-reviewed journals. However, these reports, while highly valuable in setting parameters, are all based on bench-top model systems alone. The limitations in efficacy were essentially anticipated by the principal investigators: primarily, lack of correlation among ORP, ppm, and microbial log reductions, based on preliminary data from both model and earlier on-site assessments. The single greatest unexpected negative outcome was the strong interaction between Salmonella serotype and water quality in terms of sensitivity to chlorine dioxide. Replicate tests confirmed the observations were reproducible within the model system.

One challenge that was experienced, particularly in one facility, was the tendency of shed workers to continually adjust the chlorine dioxide parameters throughout the daily operations in response to on-site sampling test results. There is a tendency to frequently compare researcher obtained values with system values and adjust the parameters. It was felt that there was an understandable desire to ensure low bacterial counts in data that would be shared in a public report. This human-nature occurrence can be a barrier to collecting data in the field and tends to defeat the industry desire to have “real-world” data.

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Funding Expended to Date

Grant Award Amount	$49,296.00
Invoiced to Date	$ 4,501.77
Remaining Grant Balance	$44,794.23

Project 56 – California Department of Food and Agriculture (CDFA)

Final Performance Report

Project Title

Determining the Status and Early Detection of the European Grapevine Moth (*Lobesia Botrana*) in Southern California to Strengthen the Competitiveness of Grapes and Other Specialty Crops

Project Summary

The European Grapevine Moth (EGVM) was first reported in North America from Napa County vineyards in October 2009. The United States Department of Agriculture (USDA), Plant Protection and Quarantine (PPQ) has listed the EGVM as reportable/actionable and is also listed on the USDA Regulated Plant Pest List. The EGVM can have three generations per year in California. The California Primary State Entomologist also considers the EGVM to have the potential to cause great economic harm to California's diverse grape industries as well as other specialty crops.

According to the USDA, the EGVM has two main hosts, grapes and olives, as well as many other minor hosts. The EGVM is an important pest of grape, in which losses of 80 percent have been reported. Young larvae can penetrate grape berries and hollow them out leaving the skin and seeds. This causes direct damage to the berry and predisposes the grape clusters to fungus infection (mold).

To determine if the EGVM exists in the grape growing areas of southern California, the CDFA deployed and monitored pheromone traps in these regions. Additionally, deployment of the traps increased the likelihood that the EGVM would be detected at incipient levels, and may be eradicated or controlled at lower costs and environmental impact. Negative survey data is also beneficial because it supports the validity of existing state and federal regulations while promoting California's export program.

In December 2009, the USDA convened an International EGVM Technical Working Group (TWG) to review the situation. This advisory group consisted of experts in EGVM biology. The TWG advised that the current distribution and density of the EGVM in California must be better defined through a trapping survey.

The deployment and monitoring of the pheromone traps would mitigate the following negative impacts:

Economic Impact

The EGVM is an important pest of grape, in which losses of 80 percent have been reported. The presence of larvae and rotten fruit lowers the quality and value of the crop. Further losses include time and labor spent on cleaning bunches of the silk webbing and feces deposited by larvae. This accounts for 30 to 40 percent of the harvesting effort.

In addition to the direct damage caused by the larvae, other loss occurs when the damaged berry is exposed to infection by fungi (mold). In grapes, rot development causes "off flavors" reducing the quality of wine. In 2006, the retail value of California wine was estimated to be $16.5 billion. In table grapes, both larval boring and rotting lead to lower quality grapes and a significant reduction in their market value. In 2007, grape complex of table grapes, wine raisins and grape juice accounted for $1.6 billion in export value or 14.8 percent of total California agricultural exports.

Trade Implications
The EGVM is a quarantine pest for many countries. If its pest status was not determined in California, its introduction could result in a loss of foreign markets or additional restrictions and regulations for California grown grapes, stone and pome fruits. Grapes from countries known to be infested with the EGVM require methyl bromide fumigation before they are permitted entry into many countries.

Environmental Impacts
The EGVM will also feed on wild grapes and other non-cultivated native plants. This could lead to destruction of native habitats. Additionally, to combat the EGVM, growers and private citizens apply pesticides. The economic impact is not just in the cost of the pesticide, but in environmental costs due to misuse of pesticides and disruption of biological control programs.

The information obtained from monitoring the pheromone traps is crucial for the CDFA, USDA and county departments of agriculture to determine an appropriate treatment and response plan to protect California grapes and other specialty crops from this invasive pest. A rapid and appropriate response mitigates the damage caused by the EGVM. Early detection of the EGVM is critical to the ability to eradicate incipient infestations. Negative survey data of this project identified which counties are free from the EGVM, minimizing the impact of any quarantine and facilitating trade.

Project Approach

Project Activities	Who	Timeline	Status
Hire temporary help	Logistics Section of the CDFA Plant Detection/Emergency Projects (PD/EP) Branch	April 12, 2010	Completed
Provide training to trapping staff	Detection Entomologists of the PD/EP Branch	April 12, 2010	Completed
Begin deployment and monitoring of the pheromone traps in southern California. Place traps at a density of 16 traps per square mile	Southern California Agricultural Commissioners	April 15, 2010	Completed

Compile data from the trap inspections to determine if counties are positive or negative for EGVM	Data Section of the PD/EP Branch	Ongoing	Completed – All negative
Remove traps from southern California	Southern CA Agricultural Commissioners	November 30, 2010	Completed

County	Total Traps	Number of EGVM Trapped
	Commercial	
Imperial	10	0
San Bernardino	23	0
San Diego	143	0
Santa Barbara	920	0
Ventura	35	0
Total	1,131	0

All traps were inspected every two weeks through October 31, 2010. No EGVMs were detected. This negative survey demonstrated that southern California is free from EGVMs. This allowed for trade to continue with other states and countries.

Following the conclusion of this survey, the EGVM Technical Working Group (TWG) reviewed all of the data. Although the results of this survey allowed for trade to continue, the TWG recommended that traps be placed at a density of 25 traps per square mile in 2011.

Goals and Outcomes Achieved

Measurable Outcome: Goal: Deploy and monitor pheromone traps throughout the commercial grape production areas in Riverside, San Diego, Imperial, San Bernardino, Ventura and Santa Barbara counties of California. This goal was achieved on schedule.

Performance Measure: One hundred percent of traps distributed and inspected in the target areas; trap inspections reveal whether the EGVM exists in this area of the state; 100 percent of trap data, including negative survey data entered into CDFA Pest and Damage Report system and/or the USDA's National Agricultural Pest Information System. This performance measure was achieved.

Beneficiaries

The grape, stone and pome fruit industries will be greatly served by the field surveys which determined the existence and/or the extent of EGVM populations in southern California. For example, exports of California table grapes to China from California were estimated at more than $56 million in 2007. If the Chinese Ministry of Agriculture/AQSIQ imposed statewide treatment protocols for all California table grape exports, significant costs to growers would occur, impacting the $56 million in exports to the Chinese market. Field surveys determined that southern California was free from the EGVM. Without field survey data, growers outside of the Napa valley quarantine zone could be impacted by a variety of foreign market restrictions, quarantines and treatment protocols.

Overall, represented industry benefited from:

- Determination of EGVM in key growing areas of southern California.
- Reduction of treatment protocols, restrictions and quarantines for growers in non-infested areas.
- Continued free flow of export products (more than $800 million) without phytosanitary barriers.

Lessons Learned

Due to the detection of the EGVM in other areas of California, the significance of trade embargoes was realized by program staff and the grape industry. Through this survey, the CDFA was able to demonstrate that southern California was free from the EGVM and was spared from the phytosanitary requirements imposed by trading partners.

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Additional Information

Websites include:
http://www.cdfa.ca.gov/phpps/egvm/index.html
http://www.aphis.usda.gov/hungrypests/euroGrapeMoth.shtml
http://www.ipm.ucdavis.edu/EXOTIC/eurograpevinemoth.html

Project 57 - Buy California Marketing Agreement (BCMA)

Final Performance Report

Project Title
California Grown Promotions in Asia

Project Summary
Project Abstract
The BCMA requested Specialty Crop Block Grant Program funds for a marketing and public relations campaign in China, Japan and South Korea to promote sales of California specialty crops in these markets. Specifically, activities focused on media events and retail promotions to increase exposure of California specialty crops in these growing markets.

Purpose
The purpose of the project was to build awareness and positive consumer perceptions of California agricultural products that will support increased California exports to these markets in the long-term.

Background
In 2009, total California agricultural exports reached $15.6 billion of which almost 20 percent ($3 billion) were exported to Japan, China and South Korea. Japan was recognized as the second largest export market behind Canada for California agricultural products with an approximate value of $2.2 billion. China and South Korea were the fifth and sixth largest export markets with $842.6 million and $713.6 million, respectively. One of BCMA's priorities was to seek additional market development opportunities for California agriculture around the world. Based on the trade figures mentioned above, China, Japan and South Korea were identified as important markets, yet consumers had low awareness of California agricultural products. While many California agricultural producers and companies have conducted their own market development programs, these efforts were specific to their associated products. Therefore, there was a need to improve consumer perceptions of California agricultural products to the benefit of all and with a scope greater than any one organization would undertake on its own. In the fall of 2010, high level government officials from California, including former Governor Arnold Schwarzenegger and former California Secretary of Agriculture, A.G. Kawamura, were scheduled to visit China, Japan and South Korea to promote California agricultural products in these markets. This project would include supermarket visits, promotional events, media events and receptions to coincide with the delegation's trip to Asia. BCMA's strategy was to leverage the momentum or the high level government officials' visit.

Project Approach
The BCMA accomplished all goals established in the workplan for this project.

The following is a brief summary:
Working with Bryant Christie Incorporated (BCI) to manage the trade mission activities and events in Asia, as well as the in-country representatives, BCMA executed “California Grown" marketing and public relations campaign in China, Japan and South Korea to promote sales of

California specialty crops in these markets. Activities included media events and retail promotions to increase exposure of California specialty crops.

The following is a summary of the activities conducted by market:

China

The BCMA conducted a "Taste California" in-store promotion and sampling event from September 4 through 13, 2010 at CityUfe, Century Mart Huashang Store in Hangzhou, China. Local media were invited to the store to cover Governor Schwarzenegger's visit on September 11, 2010. Total California product sales during the promotions reached approximately $3 million (US), a 32 percent increase compared to non-promotional period. In addition to the in-store promotions, BCMA also invited ten journalists to a tasting event and roundtable discussion with California representatives at the Hyatt Regency in Hangzhou. The BCMA hired a chef specializing in California cuisine to create a five-course meal using California grown products. BCMA achieved a value of $21,000 (US) in media coverage.

Japan

The BCMA conducted a "California Fair" from September 14 through 17, 2010 at five AEON stores (Shinagawa Seaside, Yono, Sagamihara, Minamisuna and Yachiyo Midorigaoka). Governor Schwarzenegger visited the Shinagawa Seaside store on September 14, 2010. Total California product sales during the promotions reached approximately $38,000 (US). In addition, BCMA gained a total of 53 media exposures, valued at approximately $2 million (US) as a result of Governor Schwarzenegger's visit to AEON. In addition, in February 2011, BCMA was granted a project extension to conduct additional promotions in Japan utilizing the remaining funds from this project. The BCMA continued to retain Uniflex Marketing Incorporated to help manage the additional California Grown promotions in Japan to boost sales of California specialty crops in this market. Promotions took place in Inageya Supermarkets and Summit Stores between April 25 and May1, and between June 18 through 19, 2011. As a result, total sales increased 135 percent to $50,000 (US) during promotions, compared to non-promotional periods. South Korea BCMA encountered a challenge in securing promotions in South Korea. Governor Schwarzenegger's visit to Seoul was scheduled around the same time as Korea's Thanksgiving holidays, which is one of the country's major celebrations. Traditionally, consumers purchase local products to give as gifts, therefore, most retailers in Korea promote only local products during this time period. Fortunately, BCMA was able to secure a one-day “California Fair” promotion at Lotte Department Store, one of the largest premium department stores in Korea, due to BCMA's current relationship with the store and the Governor's visit. While the promotions were only held for one day, total California product sales increased 106 percent compared to the previous non-promotional day. In addition to the in-store promotions, BCMA participated in the "California-South Korea Trade, Travel and Tourism Extravaganza" event led by the California Travel and Tourism Commission. BCMA's booth consisted of a display of California agricultural products and a cooking demonstration by Ms. Eun-Kyung Kim, the first Veggie and Fruit Meister and renowned chef in Korea. Chef Kim developed three recipes incorporating products grown in California that visitors were able to sample at the booth. As a highlight, Governor Schwarzenegger also visited the booth and sampled some of the dishes. BCMA received a total of 47 national media exposures as a result of the two events across on and offline media outlets, valued at approximately $181,233 (US).

BCMA retained BCI to provide overall management of the trade mission activities and events in Asia associated with this project. As a project partner, BCI managed the in-country representative and coordinated all program communication between BCMA, the in-country representative, California Department of Food and Agriculture, and participating groups as appropriate. BCMA also retained local agencies (Uniflex Marketing Incorporated in Japan, KorCom Porter Novelli in South Korea and SMH International in China to help organize and facilitate promotions and media events in-country. These agencies were selected because of their experience and familiarity with other United States agricultural commodity programs.

Goals and Outcomes Achieved

To achieve performance goals and measureable outcomes for this project, BCMA monitored and evaluated all California Grown in-store promotions in China, Japan and South Korea. Media coverage was also monitored and analyzed to collect performance data. All performance indicators measured short term results, including sales increased during promotional periods and media exposure. The goal of this project was to increase exports of California specialty crops to China, Japan and South Korea by increasing consumer awareness levels about the availability and high quality of California grown products. The success of this project was measured by the percent increase in sales during three promotional periods in each target market. BCMA's goal was to increase retail sales by at least 50 percent for California specialty products during promotional periods compared with non-promotional periods. In addition, BCMA sought to reach a minimum of 40 million consumers and achieve a total advertising value equivalency of $500,000 (US). BCMA's actual accomplishments surpassed several goals. First, sales increased an average of 128 percent during promotional periods compared to non-promotional periods in Japan. In South Korea, total California product sales increased 106 percent during the California Grown promotion. In China, although BCMA did not achieve its goal of increasing retail sales by at least 50 percent, sales did increase 32 percent to reach approximately $3 million (US) during the promotion in Hangzhou. Also, BCMA's in-country representatives estimated that the media exposure obtained by the promotional events reached 40 million consumers through online, print and television outlets. Total advertising value was equivalent to $2.2 million (US).

Beneficiaries

This project directly benefited the 12 specialty crop member industries of BCMA representing California asparagus, avocadoes, cherries, figs, kiwifruit, nectarines, olives, peaches, pears, plums, raisins and table grapes. Other California products such as wine also benefited. The project also positively impacted all agricultural products from California that are sold in China, Japan and South Korea as this project conveyed the message that California provides a wide variety of quality products to China, Japan and South Korea. As a result of this project, it was expected that awareness levels and preference for products from California would increase in these three markets. This in turn would allow industries to continue to increase exports and ultimately increase California's market share in these markets. BCMA estimated that retail sales for California specialty products would increase by at least 50 percent during the promotional periods planned for this project compared with non-promotional periods. The beneficiaries of this project directly benefited from the sales increases and media exposures generated by these in-store promotional events. During the promotions in China, total California product sales reached approximately $3 million (US), a 32 percent increase compared to non-promotional period. BCMA achieved a value of $21,000 (US) in media coverage. In Japan, during the September 2010 event, total California product sales reached approximately $38,000 (US) (comparative sales data from non-promotional periods was not available to BCMA). The BCMA gained a total of 53 media exposures, valued at approximately $2 million (US). In April and June 2011, total California product sales increased an average of $50,000 (US) during promotional periods, which represented a 135 percent increase compared to non-promotional periods. In South Korea, total California product sales increased 106 percent compared to non-promotional days at the one day "California Fair" promotion at Lotte Department Store. Also, BCMA received a total of 47 national media exposures valued at approximately $181,233 (US).

Lessons Learned

The major challenge during this project was ensuring that all products included in the promotion would be available at all retail outlets that the delegation visited. However, with the use of the Specialty Crop Block Grant funds, BCMA was able to leverage the delegation's visit and "California Grown" promotions to encourage them to carry more California products during the time of promotion. The only goal that was not achieved was the percent increase in sales during the promotion in China. While California specialty product sales during the promotion did not increase by at least 50 percent, the retailer reported a 32 percent increase to reach approximately $3 million (US). To further increase sales during promotions in China, BCMA would recommend increasing the length of time of the promotion to provide more exposure to consumers.

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 58	**Project Title:** Enhancing Diagnostic Capabilities at the Plant Pest Diagnostic Center – Refrigeration and Accuracy	
Grant Recipient: California Department of Food and Agriculture, Plant Health and Pest Prevention Services, Integrated Pest Control	**Grant Agreement No:** SCB09058	**Date Submitted:** December 2012
Recipient Contact: Duane Schnabel	**Telephone:** (916) 403-6655	**Email:** duane.schnabel@cdfa.ca.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

The rate of introductions and outbreak of harmful plant pests have dramatically increased in California, subsequently leading to imposition of federal and state quarantines that directly impact domestic and international movement of specialty crops (SC). Outbreak events are highly unpredictable, thus the Plant Pest Diagnostics Center (PPDC) must be prepared to provide a rapid diagnostic response to new pest issues and deal with sudden large increases in sample workloads for new and on-going United States Department of Agriculture (USDA) mandated projects to protect California's SC industry, the environment, trading partners and other entities.

The majority of samples submitted to PPDC are from detection programs associated with pests of critical regulatory and phytosanitary significance that primarily affect SC, many of which California is the nation's primary or sole producer. These pests include, but are not limited to, Huanglongbing (HLB), Citrus Canker, Sudden Oak Death (SOD), Thousand Cankers, Laurel Wilt and Sweet Orange Scab.

The focus of the project is the purchase of equipment and supplies to enhance capability, speed and capacity for the diagnosis of plant pathogens, in particular those caused by *Liberibacter* species (i.e., HLB/citrus greening). To increase the PPDC's capacity to process higher sample loads, according to USDA protocols, additional equipment is needed to manage and efficiently diagnose the increasing number of samples.

The increased sample submissions require the purchase of laboratory refrigerators to preserve perishable SC leaf and fruit samples waiting to be processed both in the laboratory and the California Department of Food and Agriculture (CDFA) field offices. Without refrigerators, the leaf and fruit samples would decay and rot, thereby making pathogen testing impossible. New analytical balances are needed to confirm that each citrus sample received meets the specified weight requirements for the USDA Deoxyribonucleic acid (DNA) extraction protocol, as well as the numerous other testing protocols the laboratory performs for other plant pathogens. Citrus sample tested for HLB/Citrus Greening disease according to the USDA required protocol must be sampled in a biological-safety hood to contain any possible live insects such as the ACP. With the purchase of laboratory biological-safety cabinets, the lab has increased the amount of samples that can be processed without adding new staff. Additionally, biological-safety cabinets are required when handling samples of pathogenic organisms that are submitted under permits authorizing receipt of samples from out of state or out of country. To enhance and improve the diagnostic capabilities for plant pathogens, the requested dew chamber will be used in plant inoculation studies to identify plant pathogens at greater specificity than species level. Identification is critical to pathogen origin and biological understanding. Accessory equipment (pipettors, polymerase chain reaction (PCR) rotor, gel kits, bead dispenser, microplate shaker, stirring hotplates and custom adaptor for robotics) are needed to complete the equipment upgrades within the CDFA plant pathology molecular laboratory to develop and implement methodologies and protocols for high capacity throughput of plant pest disease samples.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

- Received and installed refrigerators, analytical balances, dew chamber and bio-security hoods in the PPDC Laboratory.
- Received, and installed refrigerators in CDFA field offices. The refrigerators will be used to keep plant and fruit tissue samples in optimum condition in the CDFA field offices in Riverside, Commerce, Lemon Grove, Van Nuys, San Jose, Fresno and Sacramento before shipment to the PPDC laboratory for testing.
- Received and placed into operations the accessory equipment pipets, PCR rotor, gel kits, bead dispenser, microplate shaker, stirring hotplates and custom adaptor for robotics.
- All of the equipment underwent calibration for accuracy and protocol methodology certification.
- Developed and implemented unique methodologies and protocols for high capacity DNA extraction and PCR diagnostics for HLB disease with new equipment.
- Developed tracking database for sample diagnostics evaluation to confirm progress towards goals and bench marks required by SCBGP.
- Initiated data collection and quality control assurance of data.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

- **Expected Measurable Outcomes:** Increase SC growers' ability to appropriately respond to plant disease detection in a more favorable timeframe in order to prevent crop damage.

- **Goal:** Reduce the amount of time needed to detect plant diseases within quarantine areas. **Benchmark:** Currently transect surveys covering 10 square miles within a quarantine can take up to 26 weeks to test at the current lab capacity of 400 samples per week. **Target:** The scientific equipment will increase the number of samples tested from 400 to 1,600 per week and reduce the detection time from 26 weeks to six weeks.
- The addition of two biological-safety hoods increases sampling capacity for HLB plant samples by 100 percent per day. These additional hoods will address one of the critical bottlenecks in sample testing and allow diagnostic technicians to select and sample more plant leaf samples in a day.
- After the initial sampling step, plant tissue samples are handled in groups of 96 for DNA extraction and PCR testing and require fewer diagnostic technicians. DNA extraction and PCR testing methodology protocol was developed with some existing lab equipment and the new lab equipment acquired under this grant. The lab capacity for DNA and PCR testing has increased by 300 percent.
- The new refrigerators for the field offices will reduce work time by insuring samples are kept in good condition until they arrive in the lab. This will save shipping costs because it will not be necessary for samples to be shipped every day they are collected. Samples that are stored and refrigerated will arrive in good condition, so resample requests will be reduced. New refrigerators will prevent the deterioration of samples now stored in antiquated refrigerators that repeatedly stop cooling and have to be repaired. It has also increased our refrigerator storage capacity for samples by 150 percent.

The CDFA lab has developed spreadsheets to track goals and benchmarks for sample processing and diagnostics as required for the grant. Below is the table summarizing the samples processed and diagnosed during the grant period through the month of September 2012. Prior to August 2012 the diagnostics capacity of the lab was 400 plants per ACP samples per week (400x52/12=1,733). Current diagnostic capacity has increased to 1,600 plants per ACP samples per week (1,600x52/12=6,933).

2012 - Total samples tested for HLB through September 2012

Month	Lab Capacity Samples Per Month	Plant Samples	ACP samples	Total
April	1,733	452	664	1,116
May	1,733	215	1,347	1,562
June	1,733	1,327	537	1,864 (overtime required)
July	1,733	1,021	99	1,120
August	6,933	980	25	1,005
September	6,933	490	3,081	3,571
October	6,933			

November	**6,933**		
December	**6,933**		
Total	**4,485**	**5,753**	**10,238**

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

- The California citrus industry is the main beneficiary of these laboratory improvements. These improvements will allow many more citrus plant samples and ACP samples to be tested in California. This will presumably result in earlier detection of HLB-infected Asian citrus psylla and HLB-infected plants. This will result in effective quarantine and remediation action that can be taken to prevent the spread of this disease into commercial citrus orchards.
- The nursery industry and other growers of SC also benefit by increased capacity for programs that require large scale sample testing such as SOD.
- California agriculture benefits overall because of the new ability to test many samples of diseases of quarantine significance. With these additions, the laboratory has become more prepared for the next significant plant disease that arrives in California. In times of decreasing state funds for agriculture, this grant allowed staff to increase the amount of work accomplished without the addition of any new employees.
- The impact of a single plant pathogen can be devastating to California SC. For example, a recent economic study of the Florida Citrus Industry projected direct and indirect economic losses related to orange juice production since 2006 at $3.64 billion and 6,611 jobs, which were all due to the devastating HLB citrus disease (Hodges, A. W. and T. H. Spreen, Economic Impacts of Citrus Greening (HLB) in Florida, 2006/07 through 2010/11, University of Florida EDIS document FE903). This disease has been recently detected in two locations in Texas. The HLB disease has also been detected in one location in California (Hacienda Heights), and the insect vector of this disease ACP is present in various areas of the state. As one of the top three citrus producing states in the nation, HLB could have a dramatic impact on the estimated $1.1billion per year California citrus industry (Federal Register Vol. 71 No.83; published May 1, 2006; pg 25487). As part of the surveillance for the HLB disease in California, the PPDC laboratory tested more than 15,000 samples for HLB in 2011. The PPDC laboratory expects to test more than 20,000 samples in 2012.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

- Even though PPDC have increased their laboratory testing capacity by the addition of new equipment and methodology/protocol development, this capacity has not yet been fully tested. When the USDA systematic survey for HLB in Southern California begins in the next few weeks, PPDC will have the opportunity to demonstrate the full value of this new equipment.
- DNA and PCR methods development is very complicated. A step by step approach using state of the art equipment coupled with scientific staff with expertise is needed to accomplish the task. There were many technical obstacles and equipment limitations to overcome.

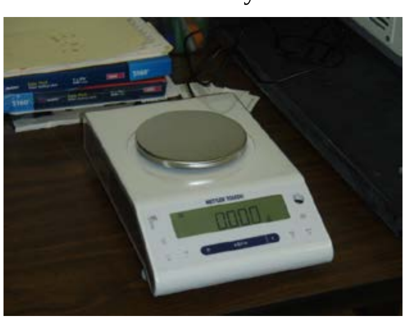
Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Photographs of equipment:

New Bio-Security Hood

New Norlake Industrial Refregirator



New Mettler Precision Balance

New Tissuelyzer with bead dispenser

California Department of Food & Agriculture
Specialty Crop Block Grant Program
FINAL PERFORMANCE REPORT

USDA Project No.: 59	Project Title: Small Farm Food Safety Education Campaign – Phase 1	
Grant Recipient: California Department of Food and Agriculture, Inspection Services Division, Inspection and Compliance Branch	**Grant Agreement No:** SCB09059	**Date Submitted:** December 2012
Recipient Contact: Steve Patton, Project Director	**Telephone:** (916) 900-5190	**Email:** steve.patton@cdfa.ca.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Outbreaks of food borne illness and the increasing popularity of small farmers selling specialty crops at farmers markets has made small farm food safety an important emerging concern. New food safety regulations, in the process of being enacted at the federal level, are targeted toward large scale farming operations. However, there were no comprehensive farm food safety educational materials targeted toward small specialty crop growers.

This project was designed to increase the food safety knowledge of California's small specialty crop farmers by creating educational materials tailored to meet their unique needs. The small specialty crop farmer often does not have the resources available to them that a larger farming organization does. The infrastructure is limited and knowledge of food safety is often limited or not known. Larger farming operations are often required by their buyers to have a food system in place, while smaller operations are not. The materials were aimed to inform small specialty crop farmers of the benefits and importance of enacting a food safety program, as well as teach them how to develop and implement their own programs.

Many small specialty crop farmers do not have a farm food safety plan in place because they are unaware of the benefits and do not know how to create a program. The purpose of this project was to develop, produce and evaluate farm food safety educational materials to be used in future workshops.

This project was important and timely because the growing popularity of small farms has increased and therefore the potential for food borne illness outbreaks due to the lack of awareness of farm food safety practices is on the rise.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Activity 1: Research farm food safety practices and draft content
The Branch Chief for the Inspection and Food Safety Unit within the Inspection and Compliance Branch was tasked with creating a list of topics from which the educational materials would be made. This list was created by using information based on a national good agricultural practices program developed by the Department of Food Science and Department of Horticulture at Cornell University. Once a simple yet comprehensive list of topics was created, the content writing was then handed off to an Environmental Scientist with the Feed, Fertilizer and Livestock Drugs Regulatory Services (FFLDRS) Branch. His previous work in both research and technical writing made him a good fit for this job. He researched many different food safety references, papers and studies and utilized those that seemed to fit the project's purpose best.

During this time, it was also discussed that in order to reach the broadest audience, the booklet should be available in many of the several languages used throughout California's diverse farming community. Through discussions with colleagues at the University of California, Davis, Cooperative Extension, it was decided that the booklet would be available in Spanish, Hmong, Vietnamese, Tagalog, Lao and Chinese in addition to English.

Activity 2: Develop and produce educational materials
Several working drafts were made and revised according to the needs of the program. The content had to be informative yet easy to understand and concise. After the wording was completed, design of the final product began. The actual end product shifted from being a two to four page double sided laminated document to a durable, full color, booklet complete with several applicable food safety task checklists dedicated to each part of the farming process. Before going to print, the final product was sent out to several of CDFA's food safety experts for a final review. Minor changes were made but overall the booklet was viewed as meeting the needs for which it was intended. Once the final draft was created, it was sent out for translation into the other non-English languages. The booklets were then produced in house over the course of several weeks.

Based on discussions with local University of California Cooperative Extensions it was determined that the following amount of booklets would be provided in the following languages: approximately 1,500 English, 800 Spanish, 600 Hmong, 250 Vietnamese, 150 Tagalog, 400 Lao, and 350 Chinese. The Cooperative Extensions were the best resource to determine the amount of booklets needed as they work with small specialty crop farmers on a day to day basis.

Activity 3: Submit to panel of experts for content review
A panel of experts was gathered to review the content of the booklets prior to them being finalized. It was reviewed by both the University of California Cooperative Extensions in Fresno and Santa Clara to ensure accuracy, thoroughness, and simplicity as the final product would need to be translated into

many different languages and be understood by different cultures. The CDFA Food Safety Program Manager and Standardization Supervisor both reviewed the booklet for accuracy and practicality. The product was completed after a few minor updates and this final review.

Activity 4: Conduct mock workshop using educational materials produced to assess percent increase in learning of participants
A food safety exam was created using the food safety booklet as a guide. A workshop was held with several CDFA employees who did not have any previous experience in the realm of food safety. The group of ten was called together, and an explanation of the program was given along with what their role would be. An initial exam was then given to the participants. The same exam would be given at the conclusion of the workshop to indicate how effective the educational materials were at conveying the food safety knowledge.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

The target outcome for this project was a minimum 25 percent increase in the knowledge and understanding of farm food safety practices obtained from the educational materials (booklets) created by this program for those workshop participants who scored 70 percent or less on the initial questionnaire.

To ensure this objective was met, a food safety exam was created using the food safety booklet as a guide. A workshop was held with a focus group made up of several CDFA employees who did not have any previous experience in the realm of food safety. The group of ten was called together, and an explanation of the program was given along with what their role would be. An initial exam was then given to the participants. The same exam would be given at the conclusion of the workshop to indicate how effective the educational materials were at conveying the food safety knowledge.

Of the ten participants, eight scored less than a 70 percent, and two scored 80 percent or better on the initial exam. After the workshop, of the eight participants who had initially scored less than 70 percent, six had shown improvements of 25 percent or more, the other two had either no improvement or improvement of less than 25 percent. It was also discovered that two of the ten questions on the exam had to be reworded to avoid confusion for future participants.

Overall, the booklets were seen as a success for this phase of the program. However, this same exam will be given during the second phase of this program to ensure that small farm specialty crop program participants are having the same favorable outcome of increasing their food safety knowledge.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

This project serves as Phase I of a two phase project with this phase being the materials development phase and next phase is when the product (booklets) will be distributed along with interactive workshops to small specialty crop farmers.

The intended beneficiaries are California's small, socially disadvantaged, specialty crop farmers who do not currently have a food safety plan in place. The project, when both phases have been completed, is projected to assist over 4,000 farmers via the informational booklets that were created during this phase of the program.

It was estimated that the booklets would assist over 4,000 specialty crop farmers and the workshops would reach approximately 500 participants by discussions held with the local University California Cooperative Extensions in the eleven locations that the workshops would be located. It is not known what economic impact this Program may have if successful, but the small specialty crop farmer will have a better understanding of the importance and use of a food safety program. Extra booklets will be given to local County Agricultural Commissioners and UC Cooperative Extensions so that those who did not come to the classes will still have material to help them with their food safety needs.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The timeframe necessary to complete the Expected Measureable Outcomes for this project was under-estimated. While development of the training module and training materials, as well as measuring the effectiveness of the training and materials, was accomplished, it took longer than anticipated. Consequently, there was insufficient time to conduct workshops.

At the beginning of this project, it was thought that the timeframe would be sufficient to use an outside group for both the "expert panel review" and "mock workshop" portions of the project. However, the compressed timeframe contributed to scheduling conflicts with the expert panel review meeting, and it was determined that it would be more efficient for the review session to be held via teleconference, rather than a meeting as originally planned.

Similarly, the persons originally anticipated to participate the mock workshop had scheduling conflicts and several CDFA staff members who had no previous food safety experience, rather than the outside group, participated in the mock workshop. This proved to be much more efficient while providing the benchmarks required by the project.

However, this resulted in unspent funds in the travel budget, which were used to print additional training booklets. Going forward, monitoring will be strengthened for projects with compressed timeframes, such as meetings and conference calls between reporting cycles. In addition, more consideration for potential scheduling conflicts will be given for future projects with compressed timeframes.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Attached are the California Small Farm Food Safety Guidelines booklet that was produced and the Food Safety Guidelines exam that was given to the participants at the beginning and end of the workshop.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

USDA Project No.: 60	**Project Title:** Increasing the speed, capacity and accuracy of specialty crop analysis for pesticide residues	
Grant Recipient: California Department of Food and Agriculture, Pesticide Residue Program	**Grant Agreement No:** SCB09060	**Date Submitted:** December 2012
Recipient Contact: Nirmal Saini	**Telephone:** 916-262-1434	**Email:** nirmal.saini@cdfa.ca.gov

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.
- If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced previously completed work.

Specialty crops are a multi-billion dollar industry vital to California's economy. The California Department of Food and Agriculture's Pesticide Residue Laboratory (PR) screens fresh produce for pesticides, and in cooperation with enforcement agencies assures the safety of California's specialty crops. To provide timely, accurate and relevant results to enforcement agencies, the PR laboratory needed a single Gas Chromatograph-Tandem Mass Spectrometer (GCMS/MS) instrument with a workstation, a sample mixer, a centrifuge, a balance, and two food processors to screen over 100 pesticides on specialty crops daily.

This grant has been used to enhance the capacity and efficiency of testing specialty crops. The PR Lab has a 24 hour turnaround obligation for specialty crop samples. The enforcement agencies require timely submission of analytical results so they can quarantine crops that are deemed violative (either a pesticide is found on a commodity with no EPA established tolerance or the amount of the pesticide found is over the EPA established tolerance). Historically, if a violation was detected during the normal screen, the sample(s) was re-extracted and reanalyzed to confirm the finding on the same instrument. This disrupted the workflow and rendered the instrument unavailable for the screening of the next set. The additional instrument facilitates the violation confirmation process while allowing for continuous program operation.

A balance that provides weight to 0.01g is needed to accurately measure small sample sizes. Food processors are used to homogenize specialty crop samples for accurate representation. A large capacity (7 quart) processor is used for most commodities and a small capacity processor (3 quart) for smaller commodities such as garlic and herbs to ensure sample homogeneity. The use of the GCMS/MS and workstation, sample mixer, centrifuge, balance, and food processors will be monitored by the Pesticide Residue Program to ensure they are used solely for screening pesticides on specialty crops.

Project Approach

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

GCMS/MS – purchased and installed. Agilent (the manufacturer) worked closely with the PR lab to get the instrument set up and quickly addressed the software and hardware problems.

Balance – purchased and installed. Balance was verified by a Mettler Toledo technician who certified the balance for ISO-17025. The PR lab has been using the balance with great success since then.

Food Processors – purchased and installed. The PR lab is achieving a high degree of sample homogenization with the new food processors.

Sample Mixer – purchased and installed. Samples are now being homogenized equally during the dispersive solid phase extraction step of the extraction process which increases the uniformity and reliability of the results.

Centrifuge – purchased and installed. The PR lab now has its own centrifuge for sample separation and no longer has to share with another group which decreases the time needed to extract samples.

Workstation & Monitor – purchased. The PR lab is waiting for IT to finish installing data processing and security software.

Printer – purchased and installed. The printer has been installed in the PR office to increase the efficiency of printing reports.

Goals and Outcomes Achieved

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

An increase in the capacity to run samples and the resulting decrease in sample turnaround time will provide a more favorable time frame for enforcement agencies to take action when violations occur.

Goal: Reduce the time needed to provide sample analysis results.

Performance Measure: Measure the time needed to provide enforcement agencies with sample analysis results.

Benchmark: Currently with one instrument, the time needed to analyze a set can vary based on the number and type of violations and can be upwards of 32 hours. Additional sets waiting to be analyzed are delayed until the first one is completed. Another instrument and workstation will allow the lab to run samples, analyze data and perform violation confirmation concurrently for uninterrupted laboratory operation which translates to a savings of up to 8 hours for each set.

Target: Decrease the turnaround time for samples from 32 hours to 24 hours by December 31, 2012.

Status: The instrument was purchased and installed however, there were some problems with the computer and a replacement had to be installed. The instrument is now ready to be validated which is targeted to be completed by November 21, 2012. Once completed, the instrument can be put into production and it can be used to run our routine samples and confirm violations.

Goal: Increase the accuracy of sample analysis results.

Performance Measure: The measurement of sample weight for analysis.

Benchmark: The current balance can accurately weigh down to 0.1g. A more sensitive balance that accurately weighs down to 0.01g will improve sample weight precision and ultimately, data accuracy.

Target: Increase weighing accuracy from 15.0g +/- 0.1g to 15.0 +/- 0.010g for all samples by December 31, 2012.

Status: The new balance is in place and weighing accuracy is 15.0 +/- 0.010g for all samples.

The sample mixer, centrifuge, and food processors have been received and put into production. They are accomplishing the goals set forth for them; namely uniformly homogenizing and mixing the samples and separating samples through centrifugation.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The immediate beneficiaries of increased sample analysis capacity, speed and accuracy is the California specialty crop industry (a multi-billion dollar industry). California has strict guidelines for pesticide use. The ability to quickly and accurately test specialty crops will substantially decrease the potential for quarantines and public safety incidents that may result in loss of revenue for specialty crop farmers. With extensive importing and exporting of California specialty crops, the analysis and monitoring of pesticides is essential. The knowledge and assurance of quickly and accurately testing specialty crops also influences the potential of revenue growth on a national and global market scale.

The direct beneficiaries will be the 40,000 plus specialty crop growers in California, consumers and regulatory agencies. The ability to enhance the capacity and efficiency of testing will alleviate any public concerns.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were an effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

The instrument set up time and validation period take a significant amount of time. It has also taken some time to have the data processing and security software installed on the workstation equipment. For these reasons the PR lab's target date to complete the goals are December 31, 2012.

Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

No additional information.

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

2009
Specialty Crop Block Grant Program (SCBGP)
FINAL REPORT
APPENDIX

USDA, AMS Agreement No:
Specialty Crop Agreement No. 12-25-B-0910

State of California
Department of Food and Agriculture
1220 N Street
Sacramento, CA 95814

Contact(s):

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Federal Funds Management Office
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Phone: (916) 403-6536
Fax: (916) 653-0206

Date Submitted:
February 4, 2013

California Department of Food and Agriculture
2009 Specialty Crop Block Grant Program – Farm Bill
Final Report
CFDA # 10.170

APPENDIX
TABLE OF CONTENTS

SPECIALTY CROP BLOCK GRANT PROJECTS

Project Apis m.

Best Management Practices for Pollination Services

Christi Heintz
Project Apis m.

June, 2012

Project Apis m.

Why should we care about honeybees?

Pollinators are responsible for $29 billion in farm Income.

Nearly $20 billion directly or indirectly dependent on honey bees .

Calderone, PLoS ONE 5/22/12

© 2011 Heintz, almond

PAm interfaces with beekeepers and growers of pollinated crops.

Do you know about BMPs?

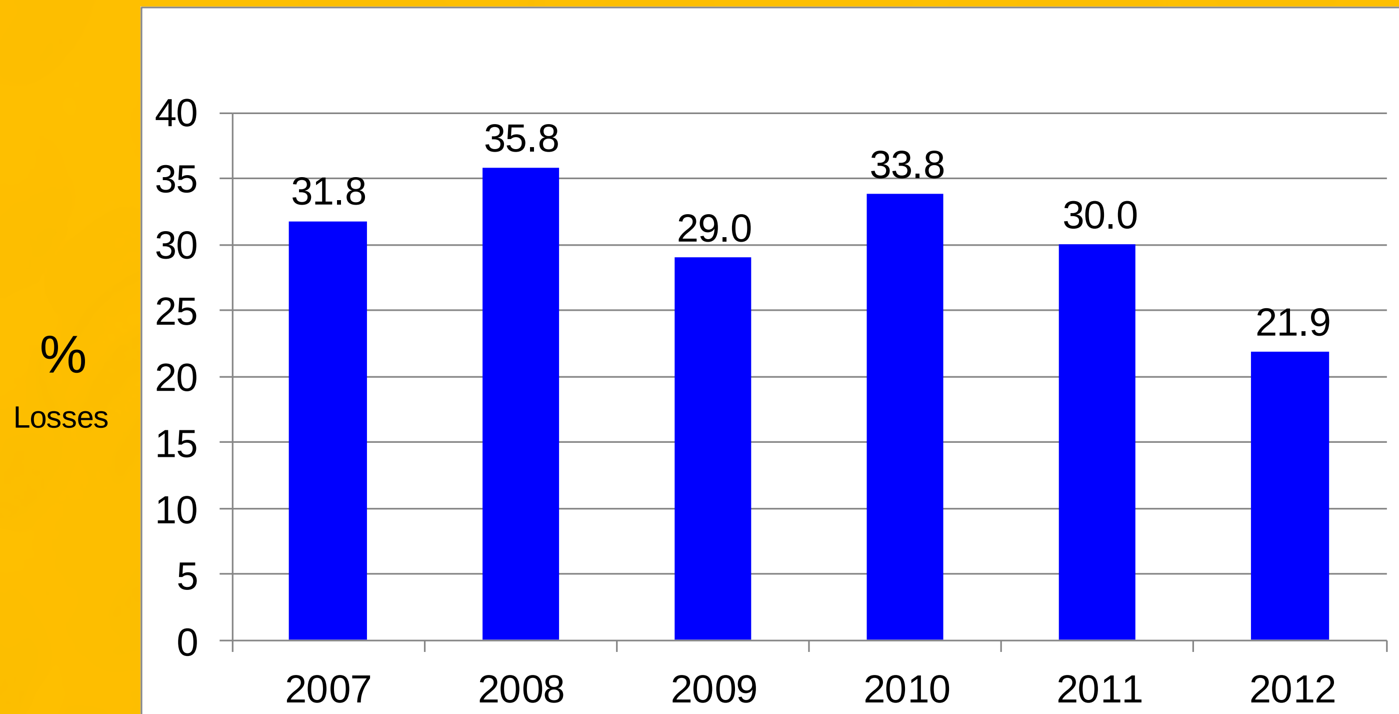
Project Apis m.

PAm 2009 Grant Project

Best Management Practices
- BMP's -
For Beekeepers Providing Pollination Services

Over-Wintering Colony Losses

AIA, BIP, USDA-ARS, 2012



Project Apis m.

Project Apis m.

BMP's

USDA-ARS, in conjunction with the AIA, reports 0ver-wintering managed honey bee losses at 30% - UNSUSTAINABLE.

Project Apis m.

Best Management Practices

PAm 2009 Grant Project

- BMP FOCUS -

- Nutrition
- Pest Control
- Disease Control
- Hive Management
- Colony Management
- Business Management

Project Apis m.

Best Management Practices

NUTRITION

Natural Forage

- **Healthy bees require a diversity of natural pollen.**
- **Locations vary in their carrying capacity – optimum density is the goal.**
- **Avoid overcrowding to minimize robbing, drifting, diseases and pests.**

Project Apis m.

Best Management Practices

NUTRITION

Supplemental Feed

- **Forage can be limited in late summer & fall in some areas.**
- **Feeding bees sugar syrup & pollen substitutes can improve colony survival.**

Project Apis m.

Best Management Practices

NUTRITION

Supplemental Feed

- Fall is a critical time to build bees for almond pollination.
- Provide supplemental feed, especially protein, to build strong, 8-frame colonies by ***February 1st***.

Project Apis m.

Best Management Practices

NUTRITION

- **Place pollen patties between brood boxes or on top of hive frames.**
- **Pollen substitutes should contain 3 essential properties:**
  - ***"Bee" Consumable, Absorbable and Nutritious***

Project Apis m.

Best Management Practices

NUTRITION

It is **critical** to provide supplemental feed when colonies arrive in California for almond pollination – dearth is a factor **prior to and after** bloom!

Project Apis m.

Best Management Practices

NUTRITION

Water

- Water is just as critical as food – keep your bees well-hydrated.
- Drought causes honey bee stress.
- Pesticides, fungicides and fertilizers may drift – locate clean H2O.

Project Apis m.

Best Management Practices

PEST CONTROL

***Varroa* control should be a primary activity in your beekeeping operation.**

Project Apis m.

Best Management Practices

VARROA CONTROL

- Monitor
- Early detection is key
- Check often
- Random sampling
- Follow regional guidelines for action thresholds

Project Apis m.

Best Management Practices

VARROA CONTROL

- Sticky boards for an accurate mite count
- Alcohol wash
- Sugar/Ether roll

Project Apis m.

Best Management Practices

VARROA CONTROL

Requeen with mite resistant stock.

Photo by
Kathy Keatley Garvey

Project Apis m.

Best Management Practices

VARROA CONTROL

- Biotech methods to suppress populations
- Drone brood removal
- Powdered sugar dusting
- Screened bottom boards
- Thymol-based products after honey flow
- Judicious treatment!
- Follow label instructions
- Rotate treatments
- Check with your local co-op extension office to find out which varroacides are most effective in your area
- Be aware! Strong colonies in mid-summer can be highly infested & crash in late-summer & fall!

Re-check for efficacy - Don't assume.

Project Apis m.

Best Management Practices

VARROA CONTROL

WARNING!

Minimize Toxin Exposure! Honey bees have a limited capacity to metabolize toxins – including beekeeper applied varroacides. Some toxins can accumulate in beeswax comb.

Project Apis m.

Best Management Practices

VARROA CONTROL

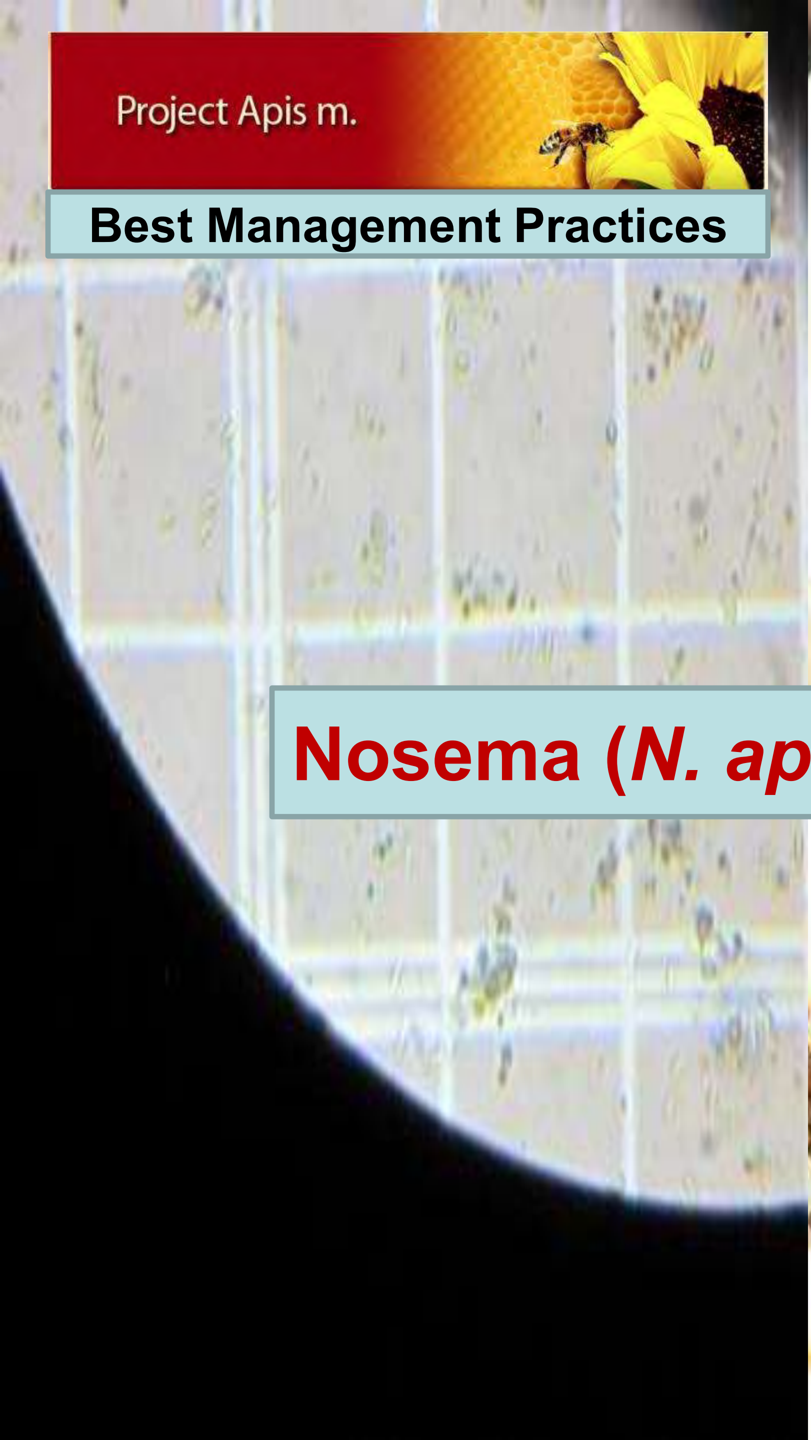
Project Apis m is on

YouTube

Broadcast Yourself

Best Management Practices: *Varroa* Control

Search for Project Apis on youtube.com



Project Apis m.

Best Management Practices

DISEASE CONTROL

Nosema (*N. apis* and *N. ceranae*)

Project Apis m.

Nosema Control

Best Management Practices

- Monitor
- Early detection is key
- Check often - ideally monthly
- Random sampling
- Collect live or fresh dead bees from hive entrance or top bars

Project Apis m.

Best Management Practices

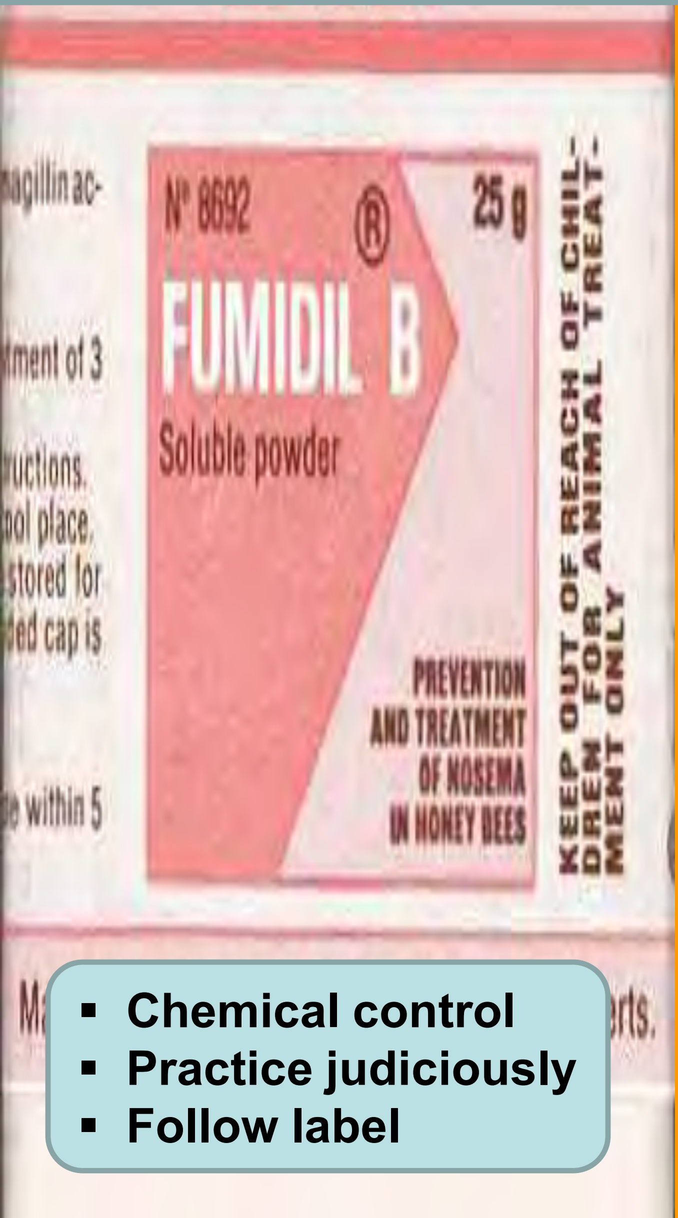
NOSEMA CONTROL

- **When levels exceed 1 million spores per bee, colonies can exhibit dwindling – but not always the case!**

- **On-site microscopic examination of honey bee gut for spore count**

NOSEMA CONTROL

Best Management Practices



- Chemical control
- Practice judiciously
- Follow label

- Hygiene
- Clean comb
- Clean or replace contaminated equip

- Nutrition
- Good ‘Fall flow’ of natural forage

Project Apis m.

Best Management Practices

HIVE MAINTENANCE

Project Apis m.

Best Management Practices

HIVE MAINTENANCE

- Extend the life of the hive
- Inspect for rotten, loose or broken frames
- Reconstruct, tighten or replace
- Paint with light colors
- Take advantage of the winter months to prepare for the new season

HIVE MAINTENANCE

HIVE MAINTENANCE

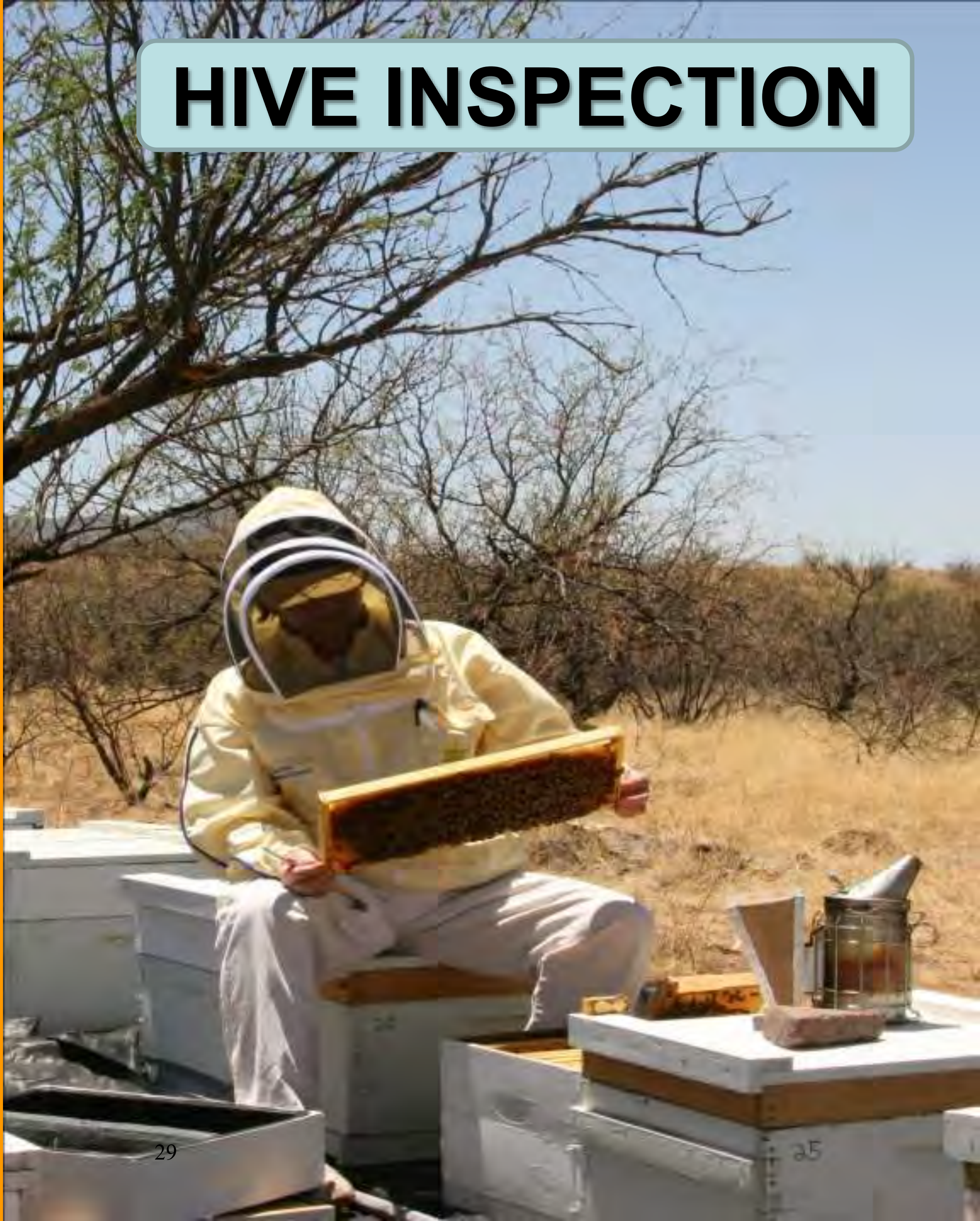
- Maintain yard equipment
- Inspect and repair trucks, loaders, trailers, forklifts
- Repair bunkhouses
- Eliminate apiary trash

Project Apis m.

Best Management Practices

HIVE INSPECTION

- Check bee attire
- Repair clothes, veil, gloves and bodysuit
- Practice good hygiene with hands, gloves & other equip to reduce transmission of pathogens between colonies
- Replace comb with new foundation
- Purchase equip with a history of clean health!



Project Apis m.

Best Management Practices

HIVE MAINTENANCE

- Hive theft has increased with the increased value of pollinating crops!
- ID hives
- Secure a signed contract when entering into a “wintering deal”
- Be discreet when showing where your yards are located

Project Apis m.

Best Management Practices

COLONY MANAGMENT

- Exert your energy wisely
- Invest time & money on your healthy colonies
- Cull weak colonies
- Maintain a reserve – don't commit all your healthy colonies to contract

Project Apis m.

Best Management Practices

COLONY MANAGEMENT

- **Check frames of brood to coincide with almond bloom.**
- **Work towards strong 8-frame colonies for pollination by February 1st**


Project Apis m.
Best Management Practices
BUSINESS MANAGEMENT
▪ Be visible to your growers
▪ Be dependable
▪ Develop contingency plans for the unexpected
▪ Determine pollination fees that are realistic relative to your operation costs

BUSINESS MANAGEMENT

- Use a contract
- Sample Pollination Contract
  www.ProjectApism.org

Project Apis m.

Best Management Practices

BUSINESS MANAGEMENT

Successful beekeeping is a rapidly changing art and science.

Project Apis m.

Best Management Practices

BUSINESS MANAGEMENT

- **Mentor new and young beekeepers**
- **Beekeeping needs ideas and leadership for a prosperous future**
- **Subscribe to bee journals – Bee Culture & ABJ**
- **Join your local bee association – attend conferences**

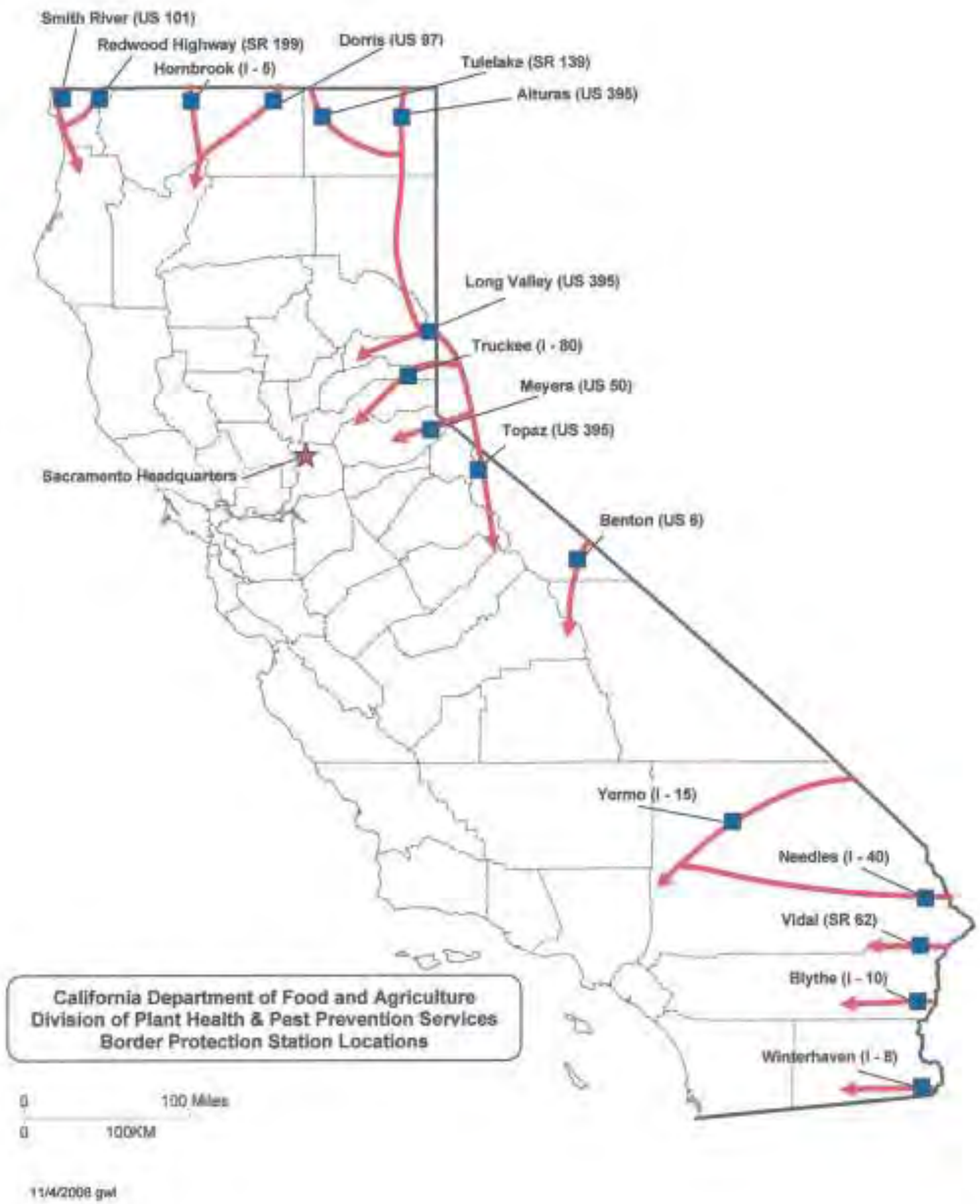
Truckloads (2010)
through CA Border Inspection Stations
2,700 !

Project Apis m.

Developed a Guide

Colonies Entering CA

2012 Heintz Lost Hills, CA


Smith River (US 101)
Redwood Highway (SR 199)
Hornbrook (I - 5)
Dorris (US 97)
Tulelake (SR 139)
Alturas (US 395)
Long Valley (US 395)
Truckee (I - 80)
Meyers (US 50)
Topaz (US 395)
Sacramento Headquarters
Benton (US 6)
Yermo (I - 15)
Needles (I - 40)
Vidal (SR 62)
Blythe (I - 10)
Winterhaven (I - 8)
California Department of Food and Agriculture
Division of Plant Health & Pest Prevention Services
Border Protection Station Locations
0
100 Miles
0
100KM
11/4/2008 gwl

Insert soaker hoses on your load.
Keep bees cool!

Project Apis m.

Best Management Practices

CAP & PAm

Reprints of BMP's for Beekeepers Pollinating California's Ag Crops are available at the PAm Booth

Managed Pollinator CAP
Coordinated Agricultural Project

Best Management Practices (BMPs) For Beekeepers Pollinating California's Agricultural Crops

Christi Heintz[1], Meg Ribotto[1]
Marion Ellis[2], Keith Delaplane[3]

Project Apis m. And CAP Have Teamed Up

1. **Best Management Practices for Nutrition**

Honey bees require food as an energy source.

Why is nutrition important to Honey Bees?

Vigorous well-nourished colonies are able to withstand bee diseases and parasites better than poorly nourished colonies. Scientists have emphasized that malnutrition may be playing a key role in the decline of colonies due to Colony Collapse Disorder (CCD). Honey bees can suffer from a compromised immune system related to poor nutrition.

Natural Forage
- Healthy bees require a diversity of natural pollen.
- Placing bees on locations with abundant and diverse floral resources will help them stay healthy.
- Locations vary in their carrying capacity, and experience will suggest optimum densities.
- Placing too many bees in one location will result in inadequate floral resources, robbing, drifting and the spread of bee diseases and parasites.

Supplemental Feeding
- Forage can be limited in late Summer and Fall. When floral resources are inadequate, feeding bees sugar syrup and pollen substitutes can improve colony survival and performance.
- Supplemental feeding is critical to build bees for early almond pollination by February 1st.
- Provide protein pollen patties.
- Pollen substitutes should have three (3) essential properties.
  - Consumable - honey bees should be readily able to eat and consume the supplemental feed,
  - Absorbable - honey bees should be able to digest and absorb the supplemental feed, and;
  - Nutritious - it should contain the necessary and vital ingredients for bee health.
- Place pollen patties between brood boxes or on top of hive frames.
- It is critical to provide supplemental feed when colonies arrive for almond pollination; dearth is a factor prior to and after bloom.

Water
- Provide plentiful and abundant water.
- Pesticides, fungicides and fertilizers may drift into water sources; locate colonies near colonies near accessible clean water.
- Drought causes honey bee stress. Work with your grower on identifying a potable water source for bees to avoid dehydration.

The Beekeeper's Goal

Provide bees a diversity of natural pollen.

When possible, locate natural forage for your bees.

Fall is a critical time to build bees for almond pollination.

Provide supplemental feed, especially protein, to build strong, 8-frame colonies by February 1st.

Water is just as important as food; keep your bees well-hydrated with clean water.

2. **Best Management Practices for Pest / Varroa Control**

Controlling pests, particularly Varroa, is a critically important management practice.

Why is Varroa harmful to Honey Bees?

Varroa mites reduce individual bee and colony vigor by feeding on their haemolymph. In addition, they vector viruses and facilitate infection by other bee pathogens.

Manage for Varroa control
- Varroa control should be a primary activity in your beekeeping operation.
- Requeen with mite resistant stock. Using stock selected for resistance may aid in slowing down the growth of Varroa populations.

Do your colonies have Varroa mites?
- Monitoring is important, early detection is key.
- Check often, every two to three months.
- Conduct a random sampling of hives.
- Follow regional guidelines for action thresholds.

How to check for Varroa
- Sticky Boards for an accurate mite count
- Alcohol Wash
- Sugar / Ether Roll

[1]Project Apis m.
[2]CAP BMP Chair, University of Nebraska
[3]CAP National Director, University of Georgia

Project Apis m.

PAm 2009 Grant Project

Plus a New Guide for Beekeepers Bringing Honeybee Colonies into California

Visit PAm's Tradeshow Booth

- BMP Fact Sheets
- Brochures for Beekeepers Pollinating CA Specialty Crops
- Sign up for our newsletter

PAm 2007 Grant Project

Can be accessed at www.ProjectApism.org

Lab Directory for Beekeepers

Published by Project Apis m.

2009


Project Apis m.
Q’s?

Oral Presentations

	State Mtgs	Regional	National	Grower	Collective audience
Biannual Rept 1	3	3	2	3	1,130
Biannual Rept 2		3			200
Biannual Rept 3	3	2	1	1	920
Last Task Apr-Jun 2012			1		
	6	8	4	4	2,250
Total				22	

Trade shows

Time Period	Location	Attendance	
BiAnnual 1	MT	75	
2009	CA	200	
thur 3/10	ID	100	
	ABC	2,000	
	Pam grower	30	
	Natl 1	500	
Apr-Spt 2010	WAS	100	
	CV	30	
BiAnnual 3	joint natl	1,300	
Oct 10 - Mar 11	ABC	2,024	
	MT	75	
BiAnnual 4	EAS	125	
Apr-Sep 2011	WAS	135	
	SO V	75	
	ARS MN	100	
BiAnnual 5	grower	2,000	22
Oct11- Mar2012	national bee	1,200	2
	state & reg	500	3
Apr-Jun 2012	no trade show booth		

27 conferences

10,569 visited trade show booths

Publications and Media hits

	Total		Number	Circ ea	Total Circulation		
BiAnnual 1	5						
2009		CDFA	1	30,000	30,000		
thur 3/10		WFP	1	10,000	10,000		
		Almond Facts	2	7,200	14,400		
		PAm enews	1	275	275		
BiAnnual 2	6	almond Facts	2	7,500	15,000		
Apr-Spt 2010		PAm enews	2	350	700		
		July Bee Cult	1	13,000	13,000		
		CatchBuzz	1	20,000	20,000		
BiAnnual 3	12	newspapers	12		157,000		
Oct 10 - Mar 11		magazines			66,000		
		newsletter			28,200		
BiAnnual 4	17	Almond F	3	7,500	22,500		
Apr-Sep 2011		CA Bee Times	2	500	1,000		
		WFP	1	25,000	25,000		
		PAm enews	3	310	930		
		PAm enews	1	400	75,000		
		Beek Qtrly	1	1,000	1,000		
		WFP	1	25,000	25,000		
		NAPPC	1	3,000	3,000		
		NPR		750,000		0	DeRisi
		Catch Buzz	2	25,000	50,000		
		CDFA News	1	1,000	1,000		
		ApiNews	1	50,000	50,000		
		Bloomberg News		1,000,000		1,000,000	DeRisi
		Various radio		5,000,000		5,000,000	DeRisi
BiAnnual 5	20	PAm enews	5	500	2,500		
Oct11- Mar2012		Almond Facts	3	7,500	22,500		
		WFP	1	25,000	25,000		
		CA Farmer	2	31,000	62,000		
		CA Almond Outlook	1	12,000	12,000		
		CSBA Bee Times	1	500	500		
		OR BeeLine	1	300	300		
		Catch the Buzz	1	20,000	20,000		
		Bee Culture branding	1	13,000	13,000		
		Modesto Bee	1	67,000	67,000		
		Washington Post/ nutı	1	750,000	750,000		
		NPR ND Bees	1	750,000	750,000		
		Acres (Nov)	1	17,000	17,000	6,000,000	6.8 M
Apr-Jun 2012	5	PAm enews	3	550	1,650		
		GV News	1	30,000	30,000		
		AF bee box	1	7,500	7,500		
Total	65		65		2,389,955		2.4 M
							9.2 M with DeRisi

Distribution of Printed Materials

Date of First Order	Item	Quantity Distributed
Fall 2010	One-page fact sheets - varroa	1000
Fall 2010	one-page fact sheets - nutrition	910
Fall 2010	One-page fact sheets - Nosema	900
Fall 2010	One-page fact sheets - Business Management	730
Jul-10	Beekeeper BMP Brochure	2800
Nov-10	Grower BMP Brochure	1250
Oct-11	Border/ Transportation BMPs Brochure	400

Conservation Agriculture Systems Institute
University of California
United States Department of Agriculture
Natural Resources Conservation Service
California Association of Resource
Conservation Districts
Sustainable Conservation

2010 Tillage Practices Survey Findings
January 15, 2012

1. Introduction to 2010 Survey Findings

California's Conservation Agriculture Systems Institute (CASI) has prepared its survey of tillage management acreage for 2010. This tillage survey was conducted as an ongoing comparison of annual row crop acreage that is farmed under different tillage systems throughout the Central Valley region of California. Over 35 local NRCS, University of California and private sector experts were surveyed and results were compared with 2010 County Agricultural Commissioner cropland acreage. Previous surveys have been conducted in 2004, 2006, and 2008.

Data in this survey were compiled for two general types of conservation tillage. Tillage practices such as no-till, strip-till, ridge-till and mulch-till, that leave at least 30% of the residue from previous crops in place on the soil surface are the typical forms of conservation tillage that are recognized throughout the world. In addition to these practices, "minimum tillage" practices that reduce the overall number of tillage passes by at least 40% relative to what was done in the year 2000, are also included in the Workgroup's tally of conservation tillage acreage.

In 2010, conservation tillage systems accounted for about 14% of the acreage for the crops that were surveyed including silage and grain corn, small grains for hay, silage and grain, tomatoes, cotton, dry beans, and melons throughout the nine-county Central Valley region. This was an increase from about 10% in 2008. Minimum tillage practices were used on about 33% of crop acreage in 2010, also up from about 21% in 2008.

The largest change in conservation tillage acreage over the 2004 – 2010 period is found in the amount of corn silage acreage that uses strip-tillage. In 2004, there were only about 490 acres of summer silage corn using strip-till, while in 2010 over 103,000 acres throughout the San Joaquin Valley dairy region had adopted the use of this form of conservation tillage. The overall use of minimum tillage practices has also greatly increased during this time from about 64,000 acres under reduced pass tillage in 2004 and just over 700,000 acres under minimum tillage in 2010.

Table 1. California conservation tillage acreage survey (2010) for tomatoes, cotton, edible dry beans, silage corn, grain corn, and small grains for grain, hay and silage, December 15, 2011

	> 30% Residue Cover after Planting				>40% reduction in total passes	< 30% Residue Cover after Planting	Total Acreage	CT %
Total	**No Till**	**RT/ST**	**Mulch Till**	**CT Total**	**Minimum Tillage**	**Conventional Tillage**		
Fresno County	-	1,280	3,331	4,611	148,800	389,688	394,299	1%
Kern County	-	-	711	711	-	220,504	221,215	0%
Kings County	3,037	54,498	32,154	89,689	44,156	228,157	317,846	28%
Madera County	100	14,909	-	15,009	-	46,511	61,520	24%
Merced County	3,000	18,100	19,866	40,966	-	227,928	268,894	15%
Sacramento	620	559	1,866	3,045	3,568	46,913	49,958	6%
San Joaquin	2,100	-	-	2,100	150,260	276,440	278,540	1%
Tulare County	-	68,478	12,270	80,748	305,184	340,382	421,130	19%
Yolo County	23,530	-	26,069	49,599	49,792	47,295	96,894	51%
Total	**32,387**	**157,824**	**96,267**	**286,478**	**701,760**	**1,823,818**	**2,110,296**	

2. General Trends Since 2004

Forms of 'classic' CT, no-till, strip-till, ridge-till and mulch till increased from 57,105 acres in 2004 to 286,478 acres in 2010. Minimum tillage acres also increased during this period from 64,613 acres in 2004 to 701,760 acres in 2010. The greatest contribution to the increase in the classic forms of CT acreage from 2004 to 2010 was strip-tillage (Table 2).

Table 2. Tillage system acreage for 2004, 2006, 2008, and 2010 (acres)

	No Till	**RT/ST**	**Mulch Till**	**Subtotal**	**Minimum Tillage**	**Conventional Tillage**	**Total Acreage**
2004	5,265	690	51,150	57,105	64,613	2,509,917	2,567,022
2006	17,181	9,020	42,964	69,165	318,006	2,060,151	2,129,316
2008	27,308	121,055	79,434	227,797	416,035	1,982,575	2,210,372

2010	32,387	157,824	96,267	286,478	701,760	1,823,818	2,110,296

3. All Forms of CT (2004 – 2010)

When all forms of CT are combined (no-till, strip-till, ridge-till, mulch till and minimum till), there is a trend toward increased CT from 2004 to 2010. Together, the classic forms of CT combined with minimum tillage approaches accounted for about 47% of total annual crop acreage in 2010.

Table 3. “Classic” forms of CT combined with minimum tillage, 2004 – 2010

	CT + Min. Till	**Conventional Tillage**	**Total Acreage**
2004	121,718	2,509,917	2,567,022
2006	387,171	2,060,151	2,129,316
2008	643,832	1,982,575	2,210,372
2010	988,238	1,823,818	2,110,296

4. CT Commodity Trends

In 2010, silage corn accounted for the greatest acreage when the classic CT categories are considered, followed by small grains. Silage corn, small grains, and tomatoes were highest in the minimum tillage category.

Table 4. CT acreage by commodity in 2010

	> 30% Residue Cover after Planting				>40% reduction in total passes	< 30% Residue Cover after Planting	**Total Acreage**	**CT %**
Total	**No Till**	**RT/ST**	**Mulch Till**	**CT Total**	**Minimum Tillage**	**Conventional Tillage**		
Tomatoes	-	1,280	10,045	11,325	150,287	246,503	257,828	4%
Cotton	-	10,000	10,975	20,975	48,718	275,259	296,234	7%
Dry edible beans	-	-	1,362	1,362	4,552	23,146	24,508	6%
Corn Silage*	-	103,278	17,984	121,262	158,296	381,400	502,662	24%
Corn for grain*	61	-	2,696	2,757	53,054	117,115	119,872	2%
Small Grains for grain*	18,731	15,868	23,446	58,045	94,795	317,105	375,150	15%
Small Grains, hay or ensiled*	13,595	27,398	28,170	69,163	181,291	419,842	489,005	14%
Melons	-	-	1,589	1,589	10,767	43,448	45,037	4%
Total							**2,110,296**	

5. *County Trends*

Kings, Tulare, Merced and Yolo counties were highest in classic CT categories in 2010.

	> 30% Residue Cover after Planting				>40% reduction in total passes	< 30% Residue Cover after Planting	Total Acreage	CT %
Total	**No Till**	**RT/ST**	**Mulch Till**	**CT Total**	**Minimum Tillage**	**Conventional Tillage**		
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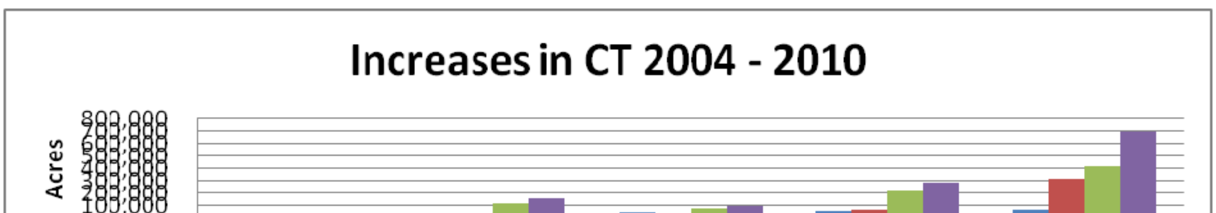
Total	**32,387**	**157,824**	**96,267**	**286,478**	**701,760**	**1,823,818**	**2,110,296**	

6. *Increases in CT 2004 – 2010*



	No Till	RT/ST	Mulch Till	Subtotal	Minimum Tillage
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2006	17,181	9,020	42,964	69,165	318,006
2008	27,308	121,055	79,434	227,797	416,035
2010	32,387	157,824	96,267	286,478	701,760

For additional information and photos of various forms of conservation tillage, please contact Jeff Mitchell at (559) 303-9689 or mitchell@uckac.edu .

Receive Recognition

for your Sustainable Food Policies

Many cities and towns throughout California and the United States are adopting policies that support sustainable food systems. The following recognition programs help cities and organizations support and learn from one another:

- Michelle Obama's ***Let's Move! Cities and Towns Campaign*** encourages officials to take action to reduce childhood obesity. Learn more at **www.letsmove.gov**.
- ***The Healthy Eating Active Living Cities Campaign*** by the California Center for Public Health Advocacy offers assistance, training, and publicity to California cities working on policies that improve their food and physical activity environments. Visit **www.healcitiescampaign.org**.

The San Mateo County Food System Alliance would like to thank the San Mateo County Health System, Ag Innovations Network, and all members and allies of the Alliance who contributed their time and expertise to develop this brief.

The San Mateo County Food System Alliance (FSA) is a collaborative of farmers, fishermen, farmers' market managers, environmental advocates, public health professionals, and residents seeking to support and promote a healthier and more vibrant local food economy. For more information, please visit **http://aginnovations.org/alliances/sanmateo**.

1 The San Mateo County Food System Alliance (FSA) defines local as value-added products, produce, and seafood that are grown or harvested in the county.

2 UC Sustainable Agriculture Research and Education Program. 2008. University of California. 27 May 2011. www.sarep.ucdavis.edu

3 A food system is defined as the chain of activities connecting food production, processing, distribution, consumption, and waste management, as well as all the associated regulatory institutions and activities.

4 Value-added products are defined as those products whose value is enhanced due to special manufacturing, marketing, or processing. www.merriam-webster.com

5 County of San Mateo, CA. Department of Agriculture, Weights and Measures. *San Mateo County 2010 Agricultural Crop Report.*

6 According to the Leopold Center for Sustainable Agriculture, the "local multiplier effect suggests that even small shifts in consumer spending offer positive results for local economies." http://www.leopold.iastate.edu/foodandfarm/ilffp.pdf

7 Kisner, Corinne. National League of Cities. *Developing a Sustainable Food System.* 2011.

8 National Policy and Legal Analysis Network to Prevent Childhood Obesity. *Establishing Land Use Protections for Community Gardens.* 2011.

9 City and County of San Francisco, CA. San Francisco Department of Public Health. Executive Directive on Healthy and Sustainable Food 09-03, Summary Report. 2010.

10 *Port Fest 2010.* 2010. Port of Redwood City. 27 May 2011. www.redwoodcityport.com

11 *The District.* 2006. Sonoma County Ag Preservation and Open Space District. 27 May 2011. www.sonomaopenspace.org

12 *As Fresh As It Gets* is sponsored by the San Mateo County/Silicon Valley Convention and Visitors Bureau in cooperation with the San Mateo County Farm Bureau and the San Mateo County Harbor District.

13 City of Albany, CA. Albany City Council. *Environmentally Preferable Food Policy.* 2008.

14 Half Moon Bay Fishermen's Association. 2011. sites.google.com/site/hmbfishing/home

15 City of Richmond, CA. Human Resources Management. *Environmentally Preferable Purchasing Policy.* 2001.

16 City of Kansas City, MO. Parks and Recreation Department. *Kansas City Parks and Recreation Vending Policies* 4.7.08. 2006.

Producing, Distributing & Consuming Healthy Local Food

Ingredients for a Sustainable Food System

A sustainable food system ensures equal access to healthy, local[1] food and is economically viable, environmentally sound, and socially just.[2] In this type of food system[3], farmers, fishermen and chefs profit from the sale of their produce, fish, and value-added products;[4] all residents can access and afford to buy local, healthy food, and our land is not just maintained, but preserved for future generations.

Why Does a Sustainable Food System Matter?

San Mateo County's agricultural production in 2010 and local seafood harvest in 2009 had a combined worth of $147 million. The actual impact of food production on the local economy is estimated to be much higher—as much as $513 million—due to a multiplier effect.[5,6] Our residents do not consume most of this food because it is purchased by food brokers and distributed outside of San Mateo County. Though this system works well for many farmers, it has decreased the variety of food grown in the county; reduced access to local, fresh and healthy foods, and distanced farmers from the local community.

A sustainable food system:

- Promotes the health of our residents by increasing access to healthy foods
- Benefits the environment by preserving agricultural land and working waterfronts
- Reduces our carbon footprint
- Enhances the economic vitality of our community by creating jobs
- Keeps money circulating within the community by boosting our local restaurant and tourism industries[7]

California Senate Bill 375 and Assembly Bill 32, which mandate planning and land use to reduce carbon emissions, contribute to a sustainable food system.

Actions *to Support a Sustainable Food System in Your Community*

The San Mateo County Food System Alliance can help you build a sustainable food system. You can find resources at http://aginnovations.org/alliances/sanmateo, or contact the San Mateo County Health System's Health Policy & Planning division at (650) 573-2398 or hpp@smcgov.org.

There are many ways your city or jurisdiction can join the movement:

Update Land Use & Other Local Policies

1 Support Urban Agriculture and Community Gardens

- Establish urban agriculture as an approved land use in residential, multi-family, open space and other zones.
- Encourage residents to donate surplus backyard produce to the food bank and other non-profit organizations.[8]
- Promote school gardens and garden-based education in our schools.

Neighborhoods often have parcels of land that are ideal for community gardens but are unused or unavailable due to zoning restrictions. Changing zoning rules can increase access to fresh produce and bring communities together.

San Francisco

San Francisco City & County revised its urban agriculture zoning policies to identify lots which could be used for community gardens.[9]

2 Protect Agricultural Land and Working Waterfronts

- Encourage strategies that protect working landscapes and waterfronts, such as easements, reduced tax burdens, and increased access to land and infrastructure.

Fishermen often struggle to access the space they need to operate their businesses due to tourism and residential and industrial uses that can overtake waterfronts. New farmers also struggle to establish their businesses. Investing in infrastructure for farmland and fisheries can contribute to the future food security of your community.

Redwood City

Redwood City recently began to celebrate an annual "Port Fest" to help residents learn more about the city's working waterfront.[10]

Sonoma

Sonoma County has preserved more than 70,000 acres of agricultural land and open space by creating an Agricultural Preservation and Open Space District that is funded by a quarter-cent sales tax.[11]

Purchase and Promote Locally Grown, Harvested & Produced Food

3 Bring the *As Fresh As It Gets* Campaign to Your Community

- Encourage local businesses, including restaurants, grocery stores, catering businesses, and corner stores to use locally grown or harvested produce and seafood. For information on restaurants that sell local produce, visit **www.freshasitgets.com**.

San Mateo County

The *As Fresh as it Gets* campaign was created in San Mateo County to increase the purchase of locally grown or harvested produce and seafood.[12]

4 Adopt Local Food Purchasing Policies

- Require a percentage of food purchased to be grown locally.
- Create incentives for contractors who prepare food made with local ingredients.

Local food purchasing policies create demand for local food. Guidelines can be added to current policies that address purchasing and describe nutritional guidelines for meals and snacks provided by an organization.

Albany County, New York

Albany County requires at least 10% of the county's food purchasing costs for Residential Healthcare and Correctional Facilities to be spent on locally produced food.[13]

5 Participate in Community-Supported Agriculture and Fishing Programs

- Connect local producers with residents by increasing participation in Community-Supported Agriculture (CSA) or Community-Supported Fishery (CSF) programs.

CSA and CSF members pay a monthly fee for a regular box of produce or fish. This provides a reliable source of income for farmers or fishermen, keeps money in the community and decreases carbon emissions from transporting food long distances.

Half Moon Bay

The Half Moon Bay Fishermen's Association Community-Supported Fishery is the first CSF in Northern California.[14]

6 Support Healthy Mobile Food Vending

- Offer incentives to run a healthy mobile food business such as discounts on permit fees, reserved spots at preferred locations, or low-interest loans to purchase equipment for healthy mobile food businesses.[15]

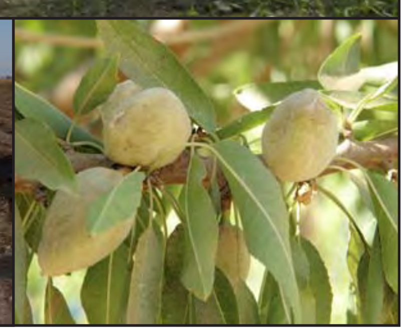
In many communities, mobile food vending is an important part of the local economy and a convenient way for residents to purchase food. Healthy mobile food vending policies support small businesses and increase the amount of healthy food available in neighborhoods.

Kansas City, Missouri

Food vendors with a 50% healthy inventory got a 50% discount on their vending permits, and vendors with a 75% healthy inventory received special roaming permits that enabled them to sell at special roaming locations.[16]

AG AND FOOD ALLIANCE
YOLO COUNTY

REGIONAL FOOD FORUM REPORT
YOLO COUNTY



REGIONAL FOOD FORUM REPORT YOLO COUNTY

Produced by

Morgan Doran, University of California Cooperative Extension
Wes Ervin, Yolo County Economic Development
John Young, Yolo County Ag Commissioner's Office
Miriam Volat, Ag Innovations Network
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All members of the Yolo County Ag and Food Alliance

February 2011

Table of Contents

Executive Summary

On July 22, 2010 the Yolo Ag and Food Alliance (formerly the Yolo Ag Futures Alliance) hosted a meeting with agriculture producers, food distributors, institutional food buyers and rural development advocates to address infrastructure needs in the Yolo and Solano county area to help develop a more regionally focused food system. Many farmers and ranchers in this area have a desire to sell their products more locally, but the lack of basic infrastructure is a major limitation. The purpose of the meeting was to identify the critical gaps in agricultural processing, storage and distribution infrastructure and begin a process to close some of the identified gaps through a discovery and prioritization process. We fully intend for this meeting to eventually result in a meaningful outcome rather than just a talking exercise.

More than 65 people participated, including 40 farmers/ranchers and 25 ag support representatives from Yolo and Solano Counties. Stakeholders including the Yolo Ag Commissioner, staff from UC Cooperative Extension and Economic Development, bankers, distributors, a farmers' market manager and the Health Department gathered to recommend specific actions towards enhancing the local economy and viability of regional agriculture.

Two recommendations were given to the Yolo Ag and Food Alliance (AFA) to work on initially, though other recommendations will be directly considered in the near future.

1. The Alliance will be working closely with Yolo County Economic Development Division to determine the specific needs of meat producers for slaughter, processing, storage and distribution. These needs will then be taken to Superior Farms, and potentially others, to collaborate on developing a plan for implementation. The Yolo AFA has already begun work on implementing this recommendation.
2. A position for a regulatory ombudsman for Yolo and Solano County will be pursued. This position will assist all producers in the region to navigate permits and comply with regulations, as well as advocate for farmers when appropriate. The Yolo AFA has met with other stakeholders, collected best practices from other counties in the state, and is actively working on implementing this position(s).

Other recommendations include:

3. Work with Environmental Health and Planning toward supporting the viability of small-scale poultry harvesting;
4. Create a manual for navigating the regulatory process for regional producers;
5. Create a marketing department that advocates for all producers; this would be a new job;
6. Create a buyer's guide for accessing local producers. The Ag Commissioner's office is already committed to assisting with this;
7. Conduct a feasibility study of aggregation centers for processing/distribution and market outlets in the region;
8. Identify retail outlets and create display packets highlighting local farmers and produce at locations not previously served in this way.

As the market demand for regionally produced food continues to grow, there is great opportunity to increase the economic viability of our local farms and ranches while improving the health and quality of life of all Yolo and Solano residents. The purpose of the Yolo Ag and Food Alliance (AFA) is to maintain and enhance agriculture and the environment in Yolo County in perpetuity. The Yolo AFA is committed to following through, with the support of many partner organizations, on many of the recommendations made at the Yolo County Regional Food Forum.

Many farmers and ranchers in this area have a desire to sell their products more locally, but the lack of basic infrastructure is a major limitation.

Forum Format/Process

Yolo AFA members opened the meeting by sharing their purpose for hosting the forum:

> *The Alliance is committed to working on projects identified during the forum as part of our mission to protect agriculture in perpetuity.*

The forum was designed to have full participation by attendees and to identify some key next steps by the end of the day. The agenda can be found in Appendix I.

Meeting Objectives

- Identify needs and interests in regional processing, distribution, and commercial outlets;
- Identify next steps in strengthening regional activities and collaboration.

Meeting Outcomes

- Create a report for participants and local agencies on needs and recommendations for creating robust regional food production and markets;
- Provide guidance for the Yolo AFA in supporting projects and activities in Yolo County

Participants created a map of challenges, needs and opportunities in the county to ensure the success of their operation. After the local activities, needs and asset assessment was completed, forum attendees heard three presentations designed to share economic, agricultural, and funding information from local presenters:

> David Shabazian, *Sacramento Area Council of Governments – RUCS Project*;
> Shermain Hardesty, *Ag Economics Specialist, University of California at Davis;*
> Morgan Doran, *UC Cooperative Extension*

Presentations can be found on the Ag Innovations Network website at http://aginnovations.org/alliances/yolo/action.

After a local lunch, participants identified 5 key areas for possible collaboration:

1. Aggregation centers, distribution, and transportation;
2. Processing and storage;
3. Accessing and growing regional markets;
4. Regulatory issues;
5. Education needs.

They then worked in break-out groups to recommend particular projects. Once project recommendations were made, all forum attendees prioritized the most crucial and important actions to be taken.

Perspectives on Regional Food Systems

The forum's 65 attendees represented a broad diversity of interests in local agriculture, food distribution, research and education, and economic development planning and policy. A list of participants can be found in Appendix II.

The activities described by participants in the opening session clearly illustrated a vibrant local food economy in which many farmers and ranchers are selling their products to local consumers through a variety of market outlets. These outlets consist of farm stands, farmers' markets, community supported agriculture (CSA) programs, restaurants and grocery stores. Access to some of these markets has been greatly enhanced by joining, or selling to, branded marketing programs (such as Niman Ranch), as well as substantial sweat equity invested in salesmanship. Another facet of the local food system commonly described by participants is the growing demand for local food, including meat and other animal products.

The upbeat scenario for the local food economy was buffered by many accounts describing a system that has reached its limits within the existing infrastructure, leaving additional demand largely unsatisfied by local producers. Although producers want to reach additional markets, they are not able to efficiently and affordably expand distribution without appropriate infrastructure that will economize the storage, sorting, processing and transportation of their products. Food distributors described their desire to source locally grown foods, but need conveniently located distribution centers for local foods, which do not exist. Institutional buyers expressed their desire to purchase local foods, but are limited because their food distributors cannot source local foods. The existing local food infrastructure, which primarily consists of individual and duplicative farm assets, allows local producers to sell through limited marketing outlets, but has inherent inefficiencies and constrained access to consumers. These limitations also work to restrict local food markets predominantly to the small and very small producers, despite an expressed interest by large producers to participate in local and specialty markets.

Many opportunities and needs were provided by participants when asked what they would like to see in a regional food system. Participants acknowledged that consumers are becoming increasingly aware of how and where their food is produced which is driving excitement and demand for local food. Large institutional food providers are also driving this demand by creating food service policies that require some local sourcing of food to improve their sustainability profile. Demand for local food is also found in low income communities where food security is a daily concern, but access is often non-existent or extremely limited due to the lack of markets and high prices often charged for locally grown food. In addressing these issues, participants primarily focused on infrastructure necessary to efficiently produce, store, process and distribute local food, but discussions also focused on the need for education for consumers and farmers, better regional planning that supports regional food systems, the integration of local communities into local food systems, new approaches to marketing local foods, funding and risk management assistance that encourages food system development and relief from a confusing multi-layered regulatory system that limits infrastructure development. The opportunities presented were often juxtaposed against challenges that limit farmers' ability to meet this growing demand. These challenges were the focus of the afternoon sessions. A complete list of opportunities, needs and challenges can be found in Appendices III and IV.

Participants primarily focused on the infrastructure necessary to efficiently produce, store, process and distribute local food, but also discussed education, regional planning, marketing, regulation, funding and risk management.

One popular idea for infrastructure development, was an aggregation center or hub that would provide several services to farms such as storage, sorting, consolidation and distribution. At sufficient scale, aggregation hubs could create efficiencies through smarter logistics that have been needed to expand local foods into larger marketing outlets. Another need repeated throughout the forum was a livestock slaughter and processing facility and the inclusion of meat products into local food supply streams. Other infrastructure ideas included the need for commercial kitchens to make value-added products from locally grown foods, an entrepreneurial incubation center for start-up enterprises that contribute to a local/regional food system, and the creation of municipal ag zones within or on the edges of cities that offer land for small-scale agricultural operations and educational opportunities that engage the public in agricultural production and strengthen local food systems.

Managing risk was on the minds of many due to the large amount of perceived risk in developing and operating a local food system.

In addition to infrastructure components, there are several more critical elements, necessary to enable a sustainable food system, requiring government participation at the local, state and federal levels. Regional planning requires coordinated efforts among city and county governing bodies. In this region, the Sacramento Area Council of Governments (SACOG; http://www.sacog.org/) is an association of local governments in a six-county region that develops long-term transportation plans and studies regional issues. David Shabazian, a Senior Planner for SACOG, presented information on large-scale planning strategies to maintain agriculture and urban growth and to enhance a local food system. Their analyses of production and consumption trends in the region suggest an enormous potential for increasing the consumption of local foods if specific barriers are removed. SACOG is using demographic, economic and land use data to generate recommendations to improve local food systems through appropriate land use decisions, regulatory changes, infrastructure development, educational opportunities and farm diversification. A draft of their Sacramento Region Local Market Assessment can be found on the internet by going to this web site (http://www.sacog.org/rucs/wiki/index.php/Main_Page) and clicking the link at the bottom of the page.

Managing risk was on the minds of many due to the large amount of perceived risk in developing and operating a local food system. Included in risk management is the securing of funds for infrastructure development and the creation of an operating structure that reduces the chance of failure. The general feeling was that there is very little money available for developing infrastructure for a local food system and that any investment bears substantial risk. Dr. Shermain Hardesty, an Ag Economist at UC Davis, presented on this topic and described our current system of commodity crop production as a risk-reduction system due to relatively

TYPICAL SUPPLY CHAIN

INPUT SUPPLIER
↓
PRODUCER
↓
PROCESSOR
↓
WHOLESALER
↓
RETAILER
↓
CONSUMER

good short-term predictability in markets and prices. This contrasts with a local production and market system that is less predictable and increases the risk to farmers, processors and distributors. Dr. Hardesty suggested one mechanism useful for spreading the risk across the food system, including consumers, is a values-based supply chain. In a values-based supply chain every enterprise throughout the supply chain operates as a trusting partner rather than engaging in a relationship in which one entity's loss is another entity's gain. When one entity experiences a cost increase, the cost is passed up through the supply chain, ultimately to the consumer, rather than one entity in the supply chain absorbing all the additional costs and risk. In this system, the consumer must be a committed partner willing to pay more for the risk throughout the system.

Other mechanisms to reduce risk can be offered by government organizations. Many participants cited a complicated and burdensome regulatory system comprising local, state and federal regulations that are difficult to know and understand, and ultimately suppress innovation in the development of a local food system. Reducing the complexity of regulatory compliance will help reduce the risk associated with local food system enterprises. The federal government also has specific financial programs such as grants and guaranteed loans available through the USDA Rural Development office (http://www.rurdev.usda.gov/CA/). Many of these financial programs can also be found on the USDA's Know Your Farmer, Know Your Food web page at http://www.usda.gov/wps/portal/usda/knowyourfarmer?navid=KNOWYOURFARMER. Unfortunately, there are many eligibility restrictions that exclude some potentially useful program funds from desired uses in developing local food systems.

Based on the information provided by participants during the forum's morning session, five topics were chosen for further discussion in smaller groups during an afternoon session:

1. Aggregation centers, distribution, and transportation;
2. Processing and storage;
3. Accessing and growing regional markets;
4. Regulatory issues;
5. Education needs.

The purpose of the afternoon discussion session was to add more substance to the topics and develop specific action items that the Yolo AFA could pursue on those topics.

Emerging Topics and Discussion

1. Aggregation Centers, Distribution and Transportation

There is a mismatch between available large-scale national packing/distribution networks and the packing/distribution needs of our small farmers. The former is fully developed and ubiquitous, but is not available directly to small farms. The lack of cost-effective distribution networks for small farms is a key constraint to improving the direct connection between the farmer and the consumer.

An aggregation center or hub was repeatedly mentioned as a significant opportunity to save logistics costs for small farmers. Most farmers individually wholesale their products and some have a roadside stand and/or sell at farmers markets. Many, however, are reluctant to expand into direct-to-consumer marketing because of the need to individually develop packing, sales, distribution and the complex record keeping required to track so many customers. Some have successfully made the leap, but for many it requires too much risk capital. Appropriately scaled aggregation centers could spread the risk among many farms, thus making the investment more plausible.

> The lack of cost-effective distribution networks for small farms is a key constraint to improving the direct connection between the farmer and the consumer.

The potential service components of an aggregation hub are many, and the components actually created at any hub should depend on the needs of user farmers. A hub could include a mix of one or more of the following components:

- Product storage, including cold storage*
- Warehousing of supplies*
- Sorting and packing (e.g. CSA boxes)
- Consolidation from multiple farms
- Distribution/trucking services
- Management and office support
- Technical assistance for growing, marketing, and business management
- Sales/brokering services
- Food processing*
- Commercial kitchen
- Demonstration kitchen
- Farmers' market and/or retail store
- Gleaning and food bank services
- Training/classroom space
- Public education
- Inspection/grading and/or lab services
- Farm-to-school/institution programs
- Other services

At sufficient scale, well-planned, properly managed aggregation hubs could create efficiencies for small direct market farms through smarter logistics. These efficiencies would make local foods more cost competitive and help expand access into larger marketing outlets, thus strengthening local food systems. These efficiencies would also enhance educational opportunities, and would increase citizen awareness of where food comes from and the farms surrounding our cities.

Several successful aggregation hubs exist throughout the country, which can be studied. In Yolo and Solano Counties, factors to consider include:

- Identifying end buyers;
- Scale and components of facilities;
- Farmer commitments to use the center;
- Business plan including startup financing and sustaining ongoing operations;
- Legal structure.

Farmer need is not necessarily homogenous, so it might make sense over time to develop a series of "centers" in different locations with different components that serve different commodities.

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* See the processing section of this report for more detail on the processing component of aggregation centers.

2. Processing and Storage

Mid and large-scale processing and storage facilities are well developed in the region, and are tailored to accommodate the output from larger farms. Most foods from large farms, including processing tomatoes, rice, and walnuts, are processed, stored and distributed by national chains, and also benefit by well established national/international distribution channels. As such, new investment is made by large processors who can typically afford the financing for construction and operation, and who use national/international distribution channels.

Our smaller farms often grow and sell much of their product directly to large processors, but as the grow-local, buy-local movement expands, they are also increasing direct sales to the customer at farmers' markets, on the farm, through small retailers, and in CSA boxes. To operate efficiently in expanding markets, our smaller farms also need access to processing and distribution networks, but these are not as well established. Processing at smaller scales is more expensive per unit processed, and also requires significant capital investment, which the smaller farmer or processor cannot typically afford. In addition, regulatory costs can also be disproportionately higher. Smaller-scale investment in processing and distribution tends to be through cooperatives, joint ventures and private-public partnerships so the investment risk can be spread out. Sometimes a mid-scale or large processor also makes their equipment available to others on a fee basis. The need for small processing and storage occurs in the following areas:

- *Meats*, including beef, lamb, goat and pig – slaughter, aging, cut & wrap, distribution and cold storage warehousing, brokering;
- *Grains*, including Sonora wheat and custom grains – cleaning, milling, cold storage, trucking, brokering;
- *Fresh market/row crops* – packing, cold storage, packing facilities for CSA boxes, distribution;
- *Wine grapes* – custom crush, fermentation, barrel storage, bottling, cool storage and brokering;
- *Olives* – custom milling, storage, bottling, cool storage, and brokering.

To operate efficiently in expanding markets, smaller farms need access to processing and distribution networks.

Development in all areas needs to occur. The forum's participants agreed on two actions:

1. Ask Superior Farms, the West's largest lamb slaughterer and packer, located in Dixon, if they are willing to make some of their excess capacity available to small meat producers. That meeting occurred on September 9, 2011. Superior is considering this opportunity;
2. Create an ad hoc team to discuss the regulatory issues of small scale poultry processing. Interested persons have been identified, and the Economic Development Commission is conducting interviews.

3. Accessing and Growing Regional Markets

Marketing is an important and necessary part of bringing local foods to local customers. The discussions about marketing that took place at the forum can be framed in terms of the traditional 4 P's of marketing: *product, place, price,* and *promotion*. Large food processors and distributors have developed cost-efficient ways to get foods to market based on high volume. Small farmers must find their own ways through the 4 P's in order to expand access to local products:

- *Product* involves growing the right amounts of the right commodities to meet customer demand. This means that farmers and their agents must reach out and identify their existing and future customers, talk to them, and learn about their desired product specifications. Market segment opportunities include:
  - > *Farmers' markets, roadside stands, and local produce stands.* Farmers traditionally sell most of their direct-to-consumer goods through these channels, including fresh fruits and vegetables, jams and jellies, sauces, honey, olives and olive oils, lavender, baked goods, and other minimally processed food and fiber products. Meats, poultry and prepared foods are less often sold this way because of their higher risk of food-borne contamination. Often sold in small quantities (small truckload and less), they are sold as-grown by the farmer. The consumer handles any subsequent processing. Farmers' markets are also a natural location for distribution and marketing hubs. Long waiting lists for farmer spaces and high patronage are indicators that more farmers markets are warranted.

    Farmers' markets are the most common way to directly interface with customers, but customer interface is increasingly going beyond farmers markets and into new and emerging markets;
  - > *Individual restaurants*. As varied as the UCD Cafe, a local hamburger stand, or Mulvaney's, these food service establishments routinely source the freshest, best quality ingredients for their customers. Such ingredients are often purchased seasonally in smaller quantities (boxes or cases rather than pallets or truckloads). Promoting local quality adds value at the restaurant and for the producer, and excitement for the customer;
  - > *Schools, hospitals, chain restaurants and other institutions* with interest in increasing the use of fresh high-quality ingredients for students and patients or all income levels. Suppliers in these market segments must often meet specifications similar to mass marketed foods because of the need to process in bulk using specialized machinery. They must also make sure the supply is large enough, regular and consistent in quality. The smallest farmers will have difficulty meeting such requirements as individuals, but may be able to as part of a collaborative. The USDA has a strong farm-to-school grant funding program which could help improve access;
  - > *Grocery stores* include small independent neighborhood markets in low income neighborhoods to chains such as Nugget and Raley's. Supermarkets and local markets often have their own buyers or belong to groups such as the IGA (Independent Grocers Association). Local farmers can tap into the small amount of local sourcing these stores do, or can try to compete in the larger wholesale environment. Since farmers often already sell much of their crop outright to wholesalers for processing and aggregation through existing channels, they must think twice about

The marketing discussion can be framed in terms of the traditional four P's of marketing: product, place, price, and promotion.

competing directly. Competing often means setting up one's own processing, distribution, and sales function, which may be inefficient and costly for the medium sized farmer and prohibitive for the small farmer;

- *The price* the farmer can realize depends on who buys their product. The farmer can earn a reasonably consistent income strictly as a grower selling wholesale, and does not therefore need training for direct selling, nor does he/she incur added costs of distribution or marketing. But the small farmer can keep all the value added when developing the capacity to sell direct to the final consumer. Given the high excitement and increasing demand at farmers' markets and other local food outlets, such as the Davis Coop and Ferry Building, consumer prices for high quality and organic commodities do support the extra cost of small scale growing, harvesting, distributing and marketing. But as more locally grown high quality foods become available, pressure to reduce prices will increase, and profits will be squeezed. The efficient small growers who have developed cost-effective approaches will survive, and inefficient growers will fade back to strictly wholesaling.
- *Place* includes the farm location(s), the market location(s), and all the labor inputs, processing and distribution in between. Access to healthy foods by low income families is an important place consideration and is of great interest to public health officials. Enthusiasm is also strong for establishing more farm storefronts and/or an agricultural entertainment center along I-80 with its 130,000 vehicles per day. As competition increases over time, those with easy market access will gain a competitive advantage, an important consideration with a growing clientele composed of small buyers spread throughout the region. Processing and distribution are more fully discussed in sections 1 and 2 of this report.
- *Promotion* includes how the product is promoted and sold. Forum participants offered a plethora of ideas. Cooperative promotion is an obvious low-cost marketing tactic. Discussions about the possible branding region-wide of Yolo and Solano County products should be expanded. Promotions such as price discounts for UC Davis students or food stamp recipients can also be considered. Farm visits are an excellent promotional tool. Customer service – the personal touch – is an important part of the buying experience, as is identifying the provenance of the food and fiber.

> *The Internet* is the most promising fast-growing promotion and direct sales tool. Many wineries and those who provide CSA boxes and other products have individual web sites, as do cooperatives such as Capay Valley Grown and several Suisun Valley farm groups. Setting up a website, offering on-line purchasing, and monitoring and maintaining the site are time consuming for an individual farmer, so cooperative approaches seem prudent. Publishing cooperative catalogs and creating joint web sites are cost-effective ways to market on the Internet, on Facebook and Twitter. Both counties should consider participating in such efforts;

The small farmer can keep all the value added when developing the capacity to sell direct to the final consumer.

> *A farm and winery map* is one suggested follow-up item. Re-creating the farm tour map previously published by the Yolo County Visitors Bureau, perhaps as a bi-county map, would be a relatively inexpensive and effective cooperative advertisement. Similar handy slip-in-the-purse (or pocket) maps fly out of booths and kiosks at hotels and the California State fair, and are desirable as handouts at farmers markets, schools and other venues;

> Another suggestion from the forum was creating a *marketing coordinator position* like the Placer Grown program, or a consultant-driven effort like the successful Ann Evans/Georgiana Brennan collaborative that created the Taste of Yolo campaign. Budget problems

have eliminated both county-funded programs, but perhaps there is a way to more securely create and/or fund the capacity, if not the positions;

> *Education* about what is being eaten is perhaps the best way to promote healthy foods and local farms. The concept of *know your farmer, know your food* is catching on. Consumer information is provided through newsletters and recipes in CSA boxes, the Taste of Capay website, and other popular avenues. *Ag Alert, California Farmer* and other farmer-oriented publications educate farmers rather than the consumer, but farmer education is equally important. Education is discussed in section 5 of this report.

4. Regulatory Issues

One of the largest most recognized problems identified in every sector of our food system is the regulatory mine field that must be navigated in order to connect farmers to consumers. These regulatory issues often impede business expansion, development, and economic opportunities, and even prevent business entities from entering the marketplace.

During the morning session, fourteen stakeholders identified regulations as a barrier to their enterprise. Participants specifically felt that government regulations were scaled for medium to large businesses, were inappropriate for small and micro-operations and created an unfriendly environment for small businesses. Some commented that unique business ideas were given the most restrictive regulatory category because regulatory staff were unfamiliar with the business. Inquiries and communication to regulators by agriculture businesses were felt to be further restricted due to a general fear that questions would trigger an inspection or audit. In general, the regulatory process was perceived as not being transparent and taking too long. Forum participants made the following proposals:

- Create a central clearinghouse of regulatory information and an individual to guide people through the process;
- Shorten the time frame from planning to construction of agricultural building projects;
- Compile the stories of business owners who have been told, "NO you can't do that!" time and time again;
- Establish a permit fee payment plan and defer some fees until the project is operational;
- Conduct no-cost pre planning meetings with all regulators in order to check projects.

Some efforts in recent years at the county level have been made to alleviate the regulatory burdens of agriculture projects. Yolo County has developed an Agricultural Permit Manual (see the Yolo County Department of Agriculture website), although it was not well recognized by the group. The manual can be found on the The 2030 County wide General Plan for Yolo County lists numerous actions that support the facilitation of agricultural processing. Specific action items listed in the general plan that are directly related to this topic include:

- *Action AG-A17* – Prepare and implement a farm marketing ordinance to streamline permit requirement for agricultural retail operations to the extent possible…
- *Action AG-A20* – Create an Agricultural Permit Coordinator position "Farmbudsman" to assist farmers and ranchers with the permitting process, to facilitate and expedite promising value-added agricultural projects.
- *Action AG-A22 and A23* – Collaborate with farming interest in the development and implementation of a program for Agricultural Districts.

In Solano County a regulatory ombudsman position was created and filled, but the person holding this position is transitioning into retirement. Budget difficulties will likely make it difficult to re-fill this position.

The top priority identified during the discussion on regulatory issues was the establishment of a bi-county position between Yolo and Solano Counties for a Farm Ombudsman. This position would facilitate and shepherd projects from concept to turn key operation and create a regulatory permit manual that explains the regulatory process for different types of ag-related enterprises.

The Yolo AFA will work with local agricultural organizations and counties to develop the ombudsman position. Future steps for this item should include working with Yolo County leadership to implement 2030 General Plan Action items AG-A17, A20, A22 and A23, as well as working with the Yolo and Solano County economic development managers to shift each county to a more business friendly climate.

5. Education Needs

Eight stakeholders met to discuss education needs. They began by identifying several types of education, including new farmer training and public education on food, agriculture and natural resources. The goal of new farmer incubation programs is to ensure future farming generations. Public education aims to raise awareness about local farms and their products, and to teach about nutrition, agriculture, and land stewardship.

Current educational activities include:

- Beginning farmer training program and incubator - *Center for Land-Based Learning;*
- Urban (small plot intensive) agricultural training and incubator; peri-urban and small farm focus - *Fresh Spin Farms;*
- Educational farm visits - *Davis Farm to School* and *Waldorf schools* from Sonora to Grass Valley;
- Facilitation of farm-to-school and farm-to-institution programs in Yolo County. Grants will be coming soon, including the food systems and agricultural systems sustainability grant - *UC SAREP;*
- Buy Fresh, Buy Local market and education program; would like more participation – *Community Alliance with Family Farmers;*
- Public education via agricultural reporting - *Davis Enterprise;*
- Public education of agricultural and natural resources issues in Yolo County; support for natural resource conservation activities on agricultural land - *Yolo County Resource Conservation District.*

Education aims to ensure future farming generations as well as raise awareness about nutrition, agriculture, and land stewardship.

Suggested venues for additional education include:

- Classes at all school levels, including a mandatory general education class at UC Davis;
- Broadening farm-based education to include farm dinners, classes, school field trips, and camps;
- A viral video concept;
- Working with the Catholic Diocese, which is already interested in social justice;
- Accessing the Latino community (barriers need to be identified);
- Other non-traditional outlets.

Next steps include:

1. Identify one or two outlets in Yolo County for educational displays about local agriculture and health issues;
2. Find a sponsoring committee to take on this activity.

Final Outcomes and Next Steps

Top priority projects recommended by participants:

1. Work closely with Yolo County Economic Development Division to determine the specific needs of meat producers for slaughter, processing, storage and distribution. These needs will then be taken to Superior Farms, and potentially others, to collaborate on developing a plan for implementation;
2. Establish a position for a regulatory ombudsman for Yolo and Solano Counties. This position will assist all producers in the region in navigating permits and compliance with regulations, as well as advocating for farmers when appropriate.

Other priority projects recommended by participants:

3. Work with Environmental Health and Planning toward supporting viability of small-scale poultry harvesting;
4. Create a manual for navigating the regulatory process for regional producers;
5. Create a marketing department that advocates for all producers; this would be a new job;
6. Create a buyers-guide for accessing local producers. The Ag Commissioner's office is already committed to assisting with this;
7. Conduct a feasibility study of aggregation centers for processing/distribution and market outlets in the region;
8. Identify retail outlets and create display packets highlighting local farmers and produce at locations not previously served in this way.

Conclusion

Preserving and strengthening Yolo and Solano Counties' vibrant local food and agriculture economy will support the economic and physical health of all of our citizens. The more food grown, processed and sold by local business to local consumers, the more benefit we receive from each dollar spent. Estimates of the beneficial impact on the economy of local products staying local are three to four times that of products leaving the region. Expanded regional markets lead to higher and more stable farm income and improved access by our citizens to fresh produce. Farmers with access to local markets tend to diversify, increasing their sustainability. Markets for locally produced food are rapidly expanding beyond direct marketing and farmer's markets and connecting growers to more markets can improve our urban and rural economies.

Preserving and strengthening Yolo and Solano Counties' vibrant local food and agriculture economy will support the economic and physical health of all of our citizens.

During the Yolo County Regional Food Forum, participants identified opportunities for building successful businesses, a robust local food economy, and health for our region's residents. The Yolo Ag and Food Alliance is committed to following these recommendations. Many of the suggestions given by forum participants echoed items in the Yolo County General Plan Goals. For example, AG-A18 states a need to, "Create an Agricultural Permit Coordinator position ('farmbudsman") to assist farmers and ranchers with the permitting process, including assistance with agricultural permitting and standards..." The Yolo AFA welcomes continued partnerships and input from organizations and individuals in the community.

Appendices

I. Yolo County Regional Food Forum Agenda
II. List of Forum Participants
III. Local Food System Opportunities
IV. Local Food System Challenges and Barriers

Appendix I

Yolo County Regional Food Forum

Yolo Ag Futures Alliance

AGENDA

July 22nd , 2010 - 8:30 A.M. to 3:30 A.M.

Yolo Housing Authority, 147 W. Main St., Woodland

Meeting Objectives

- Identify needs and interests in regional processing, distribution, commercial outlets
- Identify next steps in strengthening regional activities and collaboration

Outcomes

- Report for participants and local agencies on needs and recommendations for creating robust regional food production and markets
- Provide guidance for the YAFA in supporting projects and activities in Yolo County

8:30 Welcome, Forum Purpose and Agenda Review

Morgan Doran, UCCE and Yolo Ag Futures Alliance
Randii McNear, Farmer's Market Manager and Yolo Ag Futures Alliance
John Young, Yolo County Ag Commissioner and Yolo Ag Futures Alliance
Miriam Volat, facilitator, AgInnovations Network

9:00 Current Activities and Opportunities
***for* Regional Processing, Storage, Distribution and Outlets**

All participants
We will create a map showing Needs, Opportunities and Challenges toward assessing activities that will support successful collaboration and enterprises

11:10 Presentations and Resources

David Shabazian – SACOG – RUCS Project
Shermain Hardesty – Ag Economics Specialist, UCD
Funding opportunities - Morgan Doran - UCCE

12:15 Lunch – Fresh local food prepared by Yolo Ag Futures Alliance

1:00 Develop Strategies for Next Steps – large group

Identify areas of potential collaboration

1:30 Develop Strategies for Next Steps – break-out groups

Work on recommendations for particular projects

2:30 Closing Dialogue – Most valuable next steps and recommendations

3:30 Adjourn

Yolo Regional Food Forum, July 22, 2010
Contact List

Participants

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Appendix III. Opportunities participants see in local food systems.

INFRA-STRUCTURE	• Wine infrastructure – processing and storage, distribution, sales • Local meat locker for consumers • Consolidation and distribution center • Local food distribution such as a growers' collaborative – next generation foods • Smarter, more efficient logistics in aggregation • Distribution of local produce to foodservice operations in Sac Valley • Commercial kitchen to create value added products • Large potential to process wine grapes locally (99% of Yolo wine grapes are exported from county) • Build regional beef slaughter and processing facility • Value added processing for wine, cheese, fruits and nuts
DEMAND AND INTEREST IN LOCAL FOODS	• An increasingly aware and interested public • Lots of excitement by consumers for local food • UC Davis staff and students is a large potential market • There is great interest in local foods in Davis area • Growing demand for local foods and food products (wine, cheese) brings local wealth and jobs • Greater food security • More local products entering larger food distribution system
EDUCATION	• Integrating youth programs on farms • Ag parks create community farming systems and education on natural resource stewardship • Young farmer training • Agritourism can increase income and educate public
MARKETING	• UCD employee snack CSA • Use farmers markets as a hub for CSA sorting and distribution • Use "catalog" approach to selling local foods with the internet • Using social networking web sites for marketing local foods
PLANNING	• Brand Yolo/Solano as premier center for local food production • Include regional ag infrastructure in regional planning efforts working with metro planning organizations • Include many partners to make things happen
COMMUNITY INVOLVEMENT AND RISK	• Community involvement in supporting local farms • Building a critical mass of investment money • Include small farms/gardens in new development plans • Use prime farmland near cities to grow food for families within biking or walking distance
OTHER OPPORTUNITIES	• Variance for minor processing facilities that add value to farm products • Orchard acreage increasing • Olive production increasing • Produce Express – use existing enterprises to expand distribution

Appendix IV. Challenges and barriers to local food systems as presented by participants and divided into common categories.

REGULATION	• Understanding regulations (city, county, state, federal) • Too much regulation • Understanding regulations, especially concerning food safety and processed foods • Fear that approaching local regulators for advice/information will trigger inspection • Need approved winery wastewater treatments, other than sewer treatment
EDUCATION	• Inform public on value of farms and local food • Farmer education on agritourism • Teach aspiring farmers how to farm • Consumer education on eating whole animals • Consumer education on value of local foods, how to find and eat local food, seasonality of local food and how their food choices can affect the local economy • Farmer education on value of processing and selling locally
RISK MANAGEMENT	• Risk in starting new enterprises • Capital investment for improvements • Investment for commercial kitchen is too large for single farm • High level of capital investment for processing facilities • Lack of funding for creating infrastructure – high risk investment limits funding and activity
MEAT PROCESSING AND DISTRIBUTION	• Difficult to add protein to farmers markets • Distribution center should include meat products • USDA inspected meat harvest and processing facility.
FOOD SECURITY	• Access to local foods in low-income communities • Pricing product low enough to be accessible, but high enough to be sustainable • Keeping price low enough so local food is not a privilege
SMALL-SCALE PROCESSING	• Lack of commercial kitchen • Creating a model for small-scale and on-farm processing and storage that is economically feasible
OTHER CHALLENGES	• Farm succession and raising new farmers • Exclusion of large operations from local food systems • Limited space for new farmers in some farmers markets • Liability exposure from buying local foods • Poor roads increase expense for local distribution • Little or no connection farmers have beyond the initial buyer of their product

Yolo County is blessed with ideal conditions to provide healthy food in perpetuity if we are able to balance the needs of farms and ranches to be economically viable, ecologically sound, and socially just. The Yolo Ag and Food Alliance (AFA) is an association of individuals from agriculture, environmental groups, and the community who have come together to find a way to create this balance in Yolo County. We try to reduce political conflict by working through issues with our group's broad perspective in order to come up with solutions that can bring the community to a strong consensus. Ag Innovations Network is the convener/facilitator of the Yolo AFA, and its mission is to promote the long-term health of the food system and in particular, of agricultural production, by facilitating critical dialogues within the food system and between food system stakeholders and the wider public.

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FOOD SYSTEM ALLIANCE
SONOMA COUNTY

SONOMA COUNTY
Community Food Assessment

July 2011

  

SONOMA COUNTY

Community Food Assessment

This assessment was made possible by the dedication and strong collaboration of members of the Sonoma County Food System Alliance Assessment Committee, who are listed in alphabetical order below:

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Table of Contents

Executive Summary

Everyone in Sonoma County participates in our food system. Throughout the county and across the nation, individuals, and organizations are working collaboratively to improve our food system and develop solutions to complex food system problems, such as hunger, lack of food access, and agricultural viability and sustainability. An important part of this process is gathering information about the existing conditions of the food system. This information will be used to help inform policy and decision-making and to develop broader awareness and partnerships needed to facilitate systems change.

This assessment is broken down into chapters, based on the eight identified goals of the Sonoma County Food System Alliance. Each chapter is related to the others, and builds upon the proceeding chapter, developing a complete picture of the local food system. The goals are listed below, followed by the key findings from each chapter.

Sonoma County Food System Alliance Goals

Food Security

Residents are food secure and have access to sufficient affordable, healthy, fresh food.

Food and Agricultural Literacy

Residents of all ages are agriculture and food literate. Community members have awareness of local and global implications of their food choices, and the skills and knowledge to acquire or grow, prepare, cook, and preserve healthy food.

Demand for Locally Produced and Grown Food

Increase the demand for healthy, locally produced food.

Local Production

Expand local markets and food production in order to provide consumers with nutritious foods produced and processed as close to home as possible, and create a resilient food system for all citizens of Sonoma County.

Local Distribution and Processing

Sonoma County has a local distribution and processing system that effectively connects local producers, manufacturers, processors, vendors, and consumers.

Economic Viability

Farming and food system work are economically viable and respected occupations.

Opportunities for Food System and Farm Workers

There are meaningful livelihoods and opportunities for food system and farm workers.

Environmental Regeneration

Local agriculture, food production, distribution, consumption, and food waste management are part of a food system that regenerates nature.

Key Findings from Each Chapter

Food Security

- Hunger and food insecurity are significant and growing concerns in Sonoma County and have long-term health implications. Due to the high cost of living in Sonoma County, many families struggle to make ends meet, even when employed.

- Federal and local food assistance programs play a vital role in meeting the food needs for many Sonoma County residents and may be underutilized. Education and outreach about these programs and how to access benefits can help increase access to healthy food and potentially boost the local economy.

- Fresh, healthy foods are not consistently available in all communities. Some neighborhoods lack access to grocery stores and must rely on smaller markets or fast food restaurants that often have a poor selection of fresh, healthy food. Initiatives like the Healthy Food Outlet Project and the Smart Meal Program can play an important role in expanding healthy food access to areas that currently lack healthy options.

- Farmers' markets, community supported agriculture, and gardens have grown in popularity. Consumers in Sonoma County turn to farmers' markets, community supported agriculture, home gardens, and community gardens to increase access to fresh produce not available or affordable through traditional retail channels.

Food and Agricultural Literacy

- A number of organizations offer education about where food comes from, the health benefits of eating fresh food, and how to grow, prepare, and preserve food, but these efforts likely reach only a small percentage of the population and are not coordinated for maximum impact.

- Only a small percentage of students in Sonoma County schools participate in cooking and nutrition classes as part of their formal education. All of these classes are electives, and most do not focus on basic healthy cooking skills. Just over half of all schools in Sonoma County report having a garden on campus. A small percentage of students participate in extracurricular activities such as 4-H and FFA, which include food and agricultural literacy among their offerings.

- While a wide range of cooking classes exist in the county, many are focused on advanced or specialty cooking rather than basic healthy cooking skills, and very few are affordable for lower income residents. Among governmental and nonprofit organization, current efforts are strongest in promoting/teaching gardening skills and the benefits of local and seasonal food but much weaker in nutrition and cooking skills.

- Further research is needed to develop valid measures of food and agricultural literacy and to develop data systems that can track changes in local literacy over time.

Demand for Locally Produced Food

- Data are not available to know how much of the food consumed in Sonoma County is grown or produced locally, however it is likely to be a very small percentage. This is an important area for future data development.

- There is a large potential market to be tapped if local production was increased and distribution was configured to meet local demand. Locally directed spending by consumers more than doubles the number of dollars circulating among businesses in the community.

- The changing population demographics in Sonoma County will alter food preferences and food spending over the next 20 to 40 years.

- A number of efforts are underway to encourage local consumers to learn about and purchase local food products. Ongoing support and coordination among these organizations can support a growing demand for local food products.

Local Production

- Sonoma County has the capacity to produce large amounts of diverse types of food.

- In the last hundred years, the variety of food crops produced has decreased to mostly those products that can be distributed and marketed outside the county. The quantity of food produced has also decreased and has been replaced by wine grapes.

- Lack of availability and the high cost of cropland, limits to water available for farming, lack of gardening space for county residents, and declining fish populations are some of the barriers to increasing Sonoma County commercial and home food production. There is potential for expanding urban food production and for increasing the number of farms growing food for county residents.

- Since most food in Sonoma County is likely imported, residents are vulnerable to price increases, contamination problems, or transportation disruptions that originate outside the county and over which the county has no control.

- Sonoma County is prepared for emergency response to a sudden local disruption in the flow of food supplies, but may not be well enough prepared for large scale or slow-moving crises.

Local Distribution and Processing

- Sonoma County has limited infrastructure for processing and distribution of local products. Especially lacking is a multi-species meat processing facility.

- There are a growing number of cheese producers in Sonoma County and surrounding areas thanks to excellent pasture and climate.

- There is a need to develop and train more farmers to develop sufficient supply to meet the demands of large buyers.

Economic Viability

- A large percentage of farm businesses in Sonoma County are small operations, with 43% reporting annual income of less than $10,000.

- Local small growers have capacity limitations that make it difficult to meet demands for high volumes, consistent quality, and timely deliveries.

- Sonoma County has limited infrastructure for processing and distribution of local products, which challenges the economic viability of local farm and ranch operations.

- Investing in local distribution and processing facilities could bring significant economic benefit to Sonoma County, through new jobs, recirculation of sales dollars locally, and increased sales tax revenues to municipalities.

Opportunities for Food System and Farm Workers

- The low wages reported for farm and food system workers in Sonoma County suggest that many workers or families will have to take multiple jobs to make ends meet. These pressures reduce the amount of time that workers have to rest, spend with their families, and contribute to community life.

- Improved benefits and conditions for workers can increase economic viability. A growing body of research shows ways that farm or food system employers can increase the viability of their operations by offering a range of benefits that help to develop a skilled, stable and satisfied workforce.

- Better data is needed on wages, benefits, and working conditions associated with farm and food system workers in Sonoma County so as to identify opportunities to improve the health and well-being of these workers and their families.

- Farm worker overtime laws need to be revisited at the statewide level.

Environmental Regeneration

- Most of the water bodies in Sonoma County are on the state list as impaired due to pollution, including tidal estuaries and the Russian River. Agriculture has a role in helping to find a solution to this problem.

- Cumulative environmental impacts of agriculture in Sonoma County are not tracked.

- Loss of riparian habitat and other areas of native vegetation are important contributors to biodiversity loss in the County.

- Gases from livestock are the biggest contributor from agriculture to greenhouse gases in Sonoma County.

- Food imported into Sonoma County probably has a bigger environmental impact than the food produced in Sonoma County.

Closing

Working to build a vibrant and resilient food system requires a comprehensive approach that includes all components of the food system (production, distribution, education, consumption, and food waste management) and considers the various influences and external forces that impact the system. It will take the dedication and commitment of many in Sonoma County to build a local food system that supports the health of Sonoma County's people, environment, and economy.

This executive summary outlines only part of the story illustrated in the Sonoma County Community Food Assessment. For additional data and information please review the chapters that follow. With the combined data and information in this report, the Sonoma County Food System Alliance can develop the necessary actions to improve the health, economic vitality, and sustainability of the Sonoma County food system.

Why a Community Food Assessment?

In communities across the nation, individuals, and organizations are working collaboratively to improve our food system and develop solutions to complex food system problems, such as hunger, lack of food access, and agricultural viability and sustainability. An important part of this process is gathering information about the existing conditions in the food system. This information will be used to help inform policy and decision-making and to develop broader awareness and partnerships needed to facilitate systems change.

The idea for conducting an assessment of the Sonoma County food system originated in late 2009 during the early gatherings of the Sonoma County Food System Alliance (SCFSA). Recognizing the need for baseline data from the many interconnected areas of the local food system, a subcommittee was formed of SCFSA members to review and summarize existing data, trends, and food system issues.

The Sonoma County Community Food Assessment is intended to inform and support the work of the Sonoma County Food System Alliance, but it is also a resource that can be used by a wide array of individuals, organizations, and policy makers. Information included in this assessment comes from a variety of existing data sources, but in many cases is incomplete and only tells part of the story. Over time, the Sonoma County Food System Alliance and its many community partners will build on this information to expand the collective understanding of the Sonoma County food system and develop mechanisms to track progress and outcomes.

The SCFSA recognizes that this assessment is just the first step in engaging diverse community stakeholders in an ongoing, collaborative effort to build a vibrant and resilient food system that supports the health of Sonoma County's people, environment, and economy. This assessment is intended to generate discussion and action by providing a better understanding of Sonoma County's current food system and identifying areas where further research is needed.

Sonoma County Food System Alliance

The Sonoma County Food System Alliance (SCFSA) is a forum for diverse stakeholders, such as food producers and distributors, food security organizations, public health advocates, and other community leaders, to work on increasing access to healthy food in Sonoma County and to envision, advocate for, and create a vibrant local food system in Sonoma County.

Background. In August 2007, the Sonoma County Board of Supervisors authorized the Department of Health Services to convene a health action council (now called "Health Action") to work on improving the health of all Sonoma County residents. In November 2008, Health Action created an Action Plan to identify priority health issues and to develop local approaches to improve the health of the community. As one of seven initiatives recommended by Health Action, the Health Department partnered with the Redwood Empire Food Bank, the Sonoma County Agricultural Commissioner's Office, and Ag Innovations Network to convene the Sonoma County Food System Alliance. Since October 2009, the SCFSA, facilitated by Ag Innovations Network, has met monthly to define its role, identify goals, and provide recommendations. The SCFSA, along with the Sonoma County Board of Supervisors, UC Cooperative Extension, and the Sonoma County Department of Health Services, held a public Food Forum in February 2011 to engage the broader community in dialogue about the local food system.

Vision. The Sonoma County Food System Alliance envisions a county in which everyone has access to affordable, nutritious food. Local farms and operations play a primary role in producing that food. Each part of the food system, from seed to table and back to soil, is environmentally regenerative, economically viable, and supports a healthy life for all members of our community. The SCFSA has identified eight initial goals to help guide actions toward achieving the vision of a local food system that supports the health of our people, environment, and economy.

The Sonoma County Food System Alliance is part of a California network of county Alliances and State Roundtables that allow for consensus actions and policy recommendations from food and agriculture stakeholders. For more information, please visit the Sonoma County Food System Alliance website at: http://foodsystemalliance.org/sonoma/

I. Food Security

Photo: Redwood Empire Food Bank

Goal: Residents are food secure and have access to sufficient affordable, healthy, fresh food.

What Is Food Security?

The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life." Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences.[1] While this document does not address the cultural aspects of food security, it is interesting to note that the Food and Agriculture Organization of the United Nations offers a definition that takes into account cultural practices, religious beliefs, values, traditions, tastes and preferences, traditional food sources, as well as nutrition, and currently available resources – potential areas for further exploration in future county food assessments.[2]

Why Is This Goal Important?

Good nutrition is the foundation of good health. Hunger and malnutrition contribute to many long-term problems, including impaired physical and mental development, childhood obesity and metabolic problems, other serious illnesses such as heart disease, and they can undermine an individual's physical well being and ability to perform the tasks of daily life. Studies demonstrate that poor diet and physical inactivity may soon overtake tobacco as the leading underlying causes of death, further exemplifying the need to prioritize food security issues.[3] Nutrient-deficient diets and the resulting health issues are potential outcomes when people do not have either *physical* access to food through such access points as retail outlets, restaurants, or charitable distribution channels, or *economic* access to the food offered at these access points.

How Is Sonoma County Doing?

Signs that Number of Food Insecure Is Significant and Growing

Of the 483,878 residents in Sonoma County in 2010, it is estimated that about 50,000, or 9.5%, live below the Federal Poverty Level (FPL) (Table 1). Perhaps more significantly, a study by the California Budget Project found that the estimated minimum income needed to "make ends meet" for a family living in Sonoma County in 2007 ($77,069 for two working parents and two children in 2007) was 3.5 times higher than the Federal Poverty Level.[4] Thus, the "real" poverty rate in Sonoma County is likely significantly higher than the official statistics indicate, meaning that many families who have incomes above the FPL face tough choices when it comes to buying healthy food versus paying for other basic necessities such as rent, transportation, utilities, medicine, and medical care.

Data reported by the Redwood Empire Food Bank (REFB) indicate that the number of food insecure people in the county is significant and growing. REFB and its network of 146 partnering agencies currently provide supplemental food to over 78,000 low income people in Sonoma County each month, or 16.5% of the total population.[5] This represents a 20% increase in the number of people seeking emergency food assistance in each of the last two years.[6] Sixty-one percent of food recipients at REFB live at or below the federal poverty level.[7] The median income of food recipients is $930 per month, while the median monthly rent in Sonoma County is $1,073, demonstrating the challenges low income individuals and families face in meeting basic needs.[8]

Table 1. Poverty, Hunger, and Food Insecurity in Sonoma County.

Total Sonoma County population[9]	483,878
Federal Poverty Level for a family of four[10]	$22,050
Percent of population in poverty[11]	9.5%
Median annual income[12]	$61,985
Number of people served by food banks, per month[13]	78,000
Median monthly income of food recipients at REFB[14]	$930
Median monthly rent in Sonoma County[15]	$1,073

Helping the Economically Insecure Get Access to Food

In addition to the Redwood Empire Food Bank and its network of food pantries, a number of food assistance and charitable feeding programs exist to protect Sonoma County residents from hunger and food insecurity. These programs include the federal food stamp program (now called CalFresh in

California), the National School Lunch and School Breakfast Program, the special supplemental program for Women, Infants and Children (WIC), and various nutrition and meal programs for low income seniors. In 2008, it was estimated that of the over 54,000 Sonoma County residents who were eligible for Food Stamps, the majority (71%) were not enrolled (see Table 2).[16] For the National School Lunch Program, local data indicate that of the 21,362 students eligible, 12% never enrolled.[17] For the WIC program, of the 2,347 pregnant women eligible for services in 2009, 344 (15%) did not enroll.[18]

Education and outreach to increase participation in these programs is one way to assist local low income residents improve their access to healthy food and needed nutritional support. In addition to making presentations at community events and health fairs, the Sonoma County Human Services Department has contracted with local nonprofit agencies to accept CalFresh applications at various locations throughout the county, including at the community health centers. Sonoma County has also recently implemented a new online application system, called Benefits CalWIN, which allows anyone to submit an online application for CalFresh from a computer with internet access.

In addition to being an important source of nutritional support for low income residents, the CalFresh benefits issued are a significant input into the local economy. The amount of CalFresh benefits issued in Sonoma County for the time period from August 2009 through July 2010 totaled $43,000,000, serving a monthly average of approximately 26,374 clients.[19] Increasing participation has the potential to significantly bolster the amount of benefits received locally and dollars circulated into the local economy.

Table 2. Participation in Federal Food Assistance Programs in Sonoma County.

CalFresh[20]	
Number of individuals income eligible for CalFresh, 2008	54,165
Monthly average of individuals participating in CalFresh, 2008	15,954
Percent of individuals eligible but not participating in CalFresh, 2008	71%
Monthly average of individuals participating, 8/2009-7/2010	26,374
Monthly average of individuals participating in CalFresh, YTD 2010, as of October 13, 2010	25,430
National School Lunch Program (NSLP), 2008[21]	
Number of students eligible for Free/Reduced priced (FRP) meals	21,362
Number of students enrolled for Free/Reduced priced (FRP) meals	18,806
Percent of students eligible but not participating in FRP meals	12%
Supplemental Program for Women, Infants, Children (WIC), 2009[22]	
Number of WIC participants, November 2009 (includes pregnant and post-partum women and infants)	11,756
Number of pregnant women eligible for WIC services	2,347
Number of pregnant women eligible, but not receiving WIC services	344
Percent of pregnant women eligible, but not receiving WIC services	15%

Fruit and Vegetable Consumption in Sonoma County

According to the 2009 California Health Interview Survey, conducted by the UCLA Center for Health Policy Research, 58.1% of Sonoma County children ages 0-11 years reported eating 5 or more fruits and vegetables per day, a percentage somewhat higher than state averages. In the same year 17.6% of teens ages 12-17 years reported eating five or more servings of fruits or vegetables a day, somewhat lower than the state average (19.9%).[23] Low income residents in Sonoma County (< 200% of FPL) are less likely to report eating 5 or more fruits and vegetables per day (51%) than those with higher incomes (200+% of FPL) (61%).[24]

Fast Food Consumption in Sonoma County

A majority of Sonoma County residents report regularly (at least once per week) eating fast food, which is often much less costly than healthier food options. Over half (51%) of respondents to the 2009 California

Health Interview Survey in Sonoma County reported they had eaten fast food at least one time in the past week.[25] This compares somewhat favorably to the statewide average, which is 64.7%.

Health Indicators of Poor Nutrition

Overweight and obesity are common indicators of a lack of healthy eating and physical activity and are increasing in Sonoma County. The number of Sonoma County adults (ages 18 years and older) who are obese increased by 52% between 2001 and 2009, from 14.1% in 2001 to 21.4% in 2009. The number of Sonoma County adults who are overweight or obese increased from 48.4% in 2001 to 58% in 2009.[26] The highest rates of overweight and obesity occur among population groups with the highest poverty rates. In 2009, over two-thirds (70%) of low income (<100 FPL) adults reported being overweight or obese compared to 59% of non-low income adults (> 300 FPL).[27]

Poor nutrition can lead to a number of serious health conditions, including iron deficiency anemia, which is a particular problem in Sonoma County. The impact of iron deficiency anemia is of special concern during infancy and early childhood, a time of accelerated brain growth and development. Low iron intake during this critical period can impact children's behavior and have an irreversible detrimental effect on their neurodevelopment.[28] During 2007-2009, low income children in Sonoma County had significantly higher rates of anemia than comparable California children. Rates of iron deficiency anemia were 17.2% for ages 1-2 and 14.7% for ages 3-4 among low income children in Sonoma County compared with 14.8% and 13.0% for California, respectively.[29]

Physical Access to Healthy Food

In addition to affordability or economic access, access to healthy food is also influenced by the physical availability of food stores and markets throughout the county and the quality of food that these stores offer. Based on Standard Industry Code (SIC) classification data made available on the Network for a Healthy California's website, Sonoma County has approximately 175 grocery stores, 87 convenience stores, and 19 fruit and vegetable markets.[30] In 2008, a statewide study by the California Center for Public Health Advocacy assessed the retail availability of healthy food. This study found that Sonoma County has a ratio of 3.29 fast-food restaurants and convenience stores for each supermarket or produce vendor (Table 3).[31] A more detailed local assessment conducted by the Community Activity and Nutrition Coalition (CAN-C) found that this ratio is higher in low income neighborhoods, where residents must often rely on corner markets. These retail stores are primarily outlets for alcohol, cigarettes, and convenience foods and offer few nutritious choices.[32] The ratio in these neighborhoods was 9.0 in Boyes Hot Springs, 7.0 in South Park, 5.3 in Roseland, and 6.0 in the McKinley/Payran neighborhood of Petaluma. Consumers tend to purchase and consume what is most readily accessible and convenient. In neighborhoods with a higher proportion of fast food outlets and convenience stores, the residents are more likely to consume unhealthy foods typically available at such establishments.

Table 3. Ratio of Fast Food Restaurants/Convenience Stores to Supermarkets/Produce Vendors in Sonoma County, 2008.

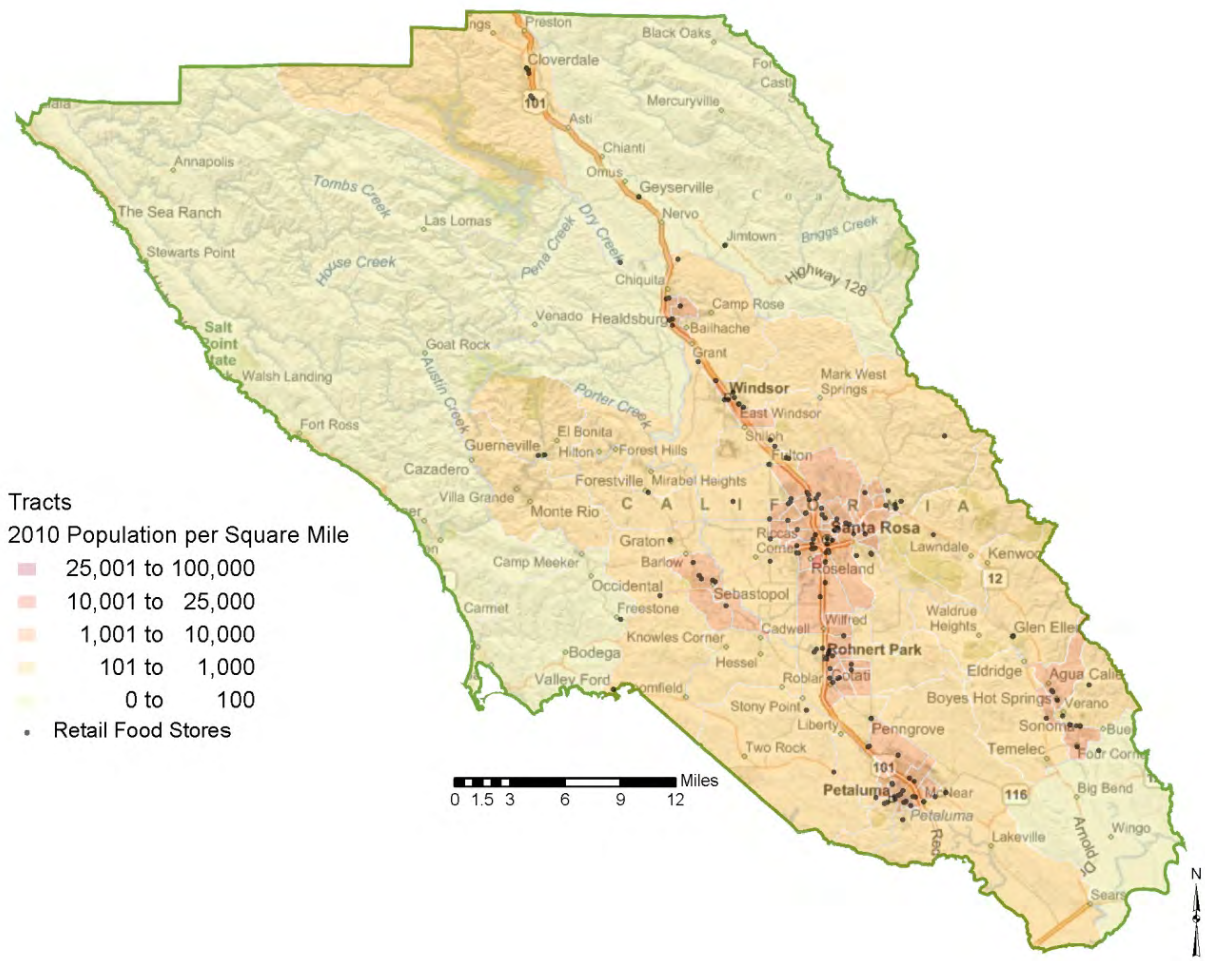
Ratio of Fast Food Restaurants/Convenience Stores to Supermarkets/Produce Vendors, Sonoma County[33]	3.29
Index of Less Healthy to Healthy Food Sources, selected low income communities[34]	
Boyes Hot Springs	9.0
South Park (Santa Rosa)	7.0
Roseland	5.3
McKinley/Payran (Petaluma)	6.0

Mapping Physical Access to Food in Sonoma County

The following five maps provide visual representations of food access points in relation to population density and percentage of population at different poverty levels. They were created using data from Dun & Bradstreet, California Food Retailers grocery store data, American Community Survey data, and census tract level data.

Grocery stores in Sonoma County compared to population density (Map 1). Information on grocery stores was obtained from the California Nutrition Network GIS Map Viewer (www.cnngis.org), which uses data obtained from Dun & Bradstreet, a private company that collects and reports commercial information.[35] Map 1 shows food retail establishments identified by Dun & Bradstreet that are classified as "general grocery" stores. This classification is based on the federal government's Standard Industry Code (SIC) classification and includes the following types of grocery stores: large chain, small chain, grocery (other), warehouse club, and cooperative grocery store.[36] Given this variation in grocery store type, Map 1 presents only a very general overview of grocery availability, but does not allow for a detailed assessment of the quantity, quality, or affordability of groceries available in each neighborhood. The map shows a higher concentration of grocery stores in areas with higher population densities and provides a simple visual representation of areas with less grocery store access.

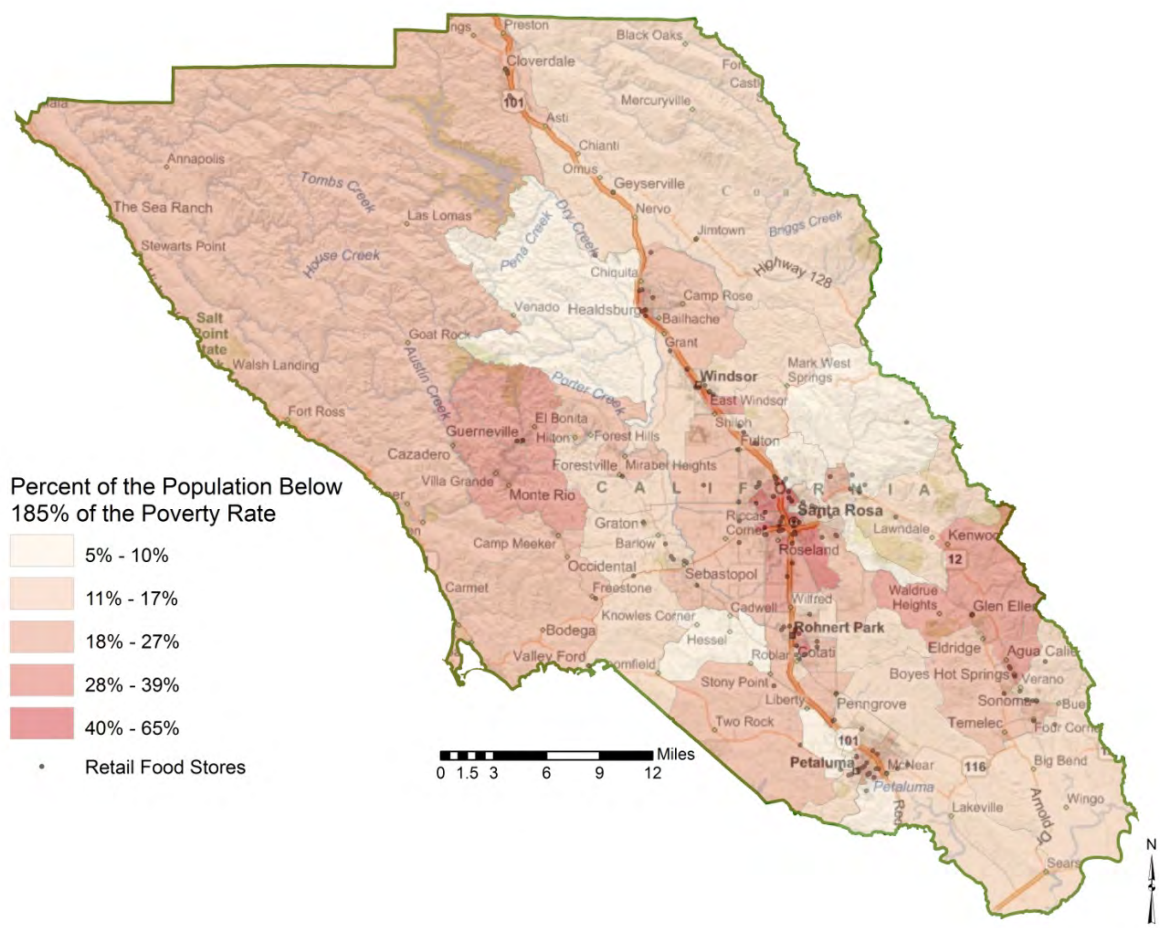
Map 1. Grocery Stores Compared to Population Density.



Source: Dun and Bradstreet, California Food Retailers, 6/2010; American Community Survey 2005-2009, 5-year estimates.

Grocery stores compared to the percentage of people at or below 185% of the Federal Poverty Level (Map 2).[37] As seen in the previous illustration, this map shows that grocery stores are primarily clustered in population centers, but highlights the areas with higher percentages of low income residents (shaded darker red) who likely will have more difficulty affording a healthy diet and arranging transportation to a grocery store if one is not present in the neighborhood.

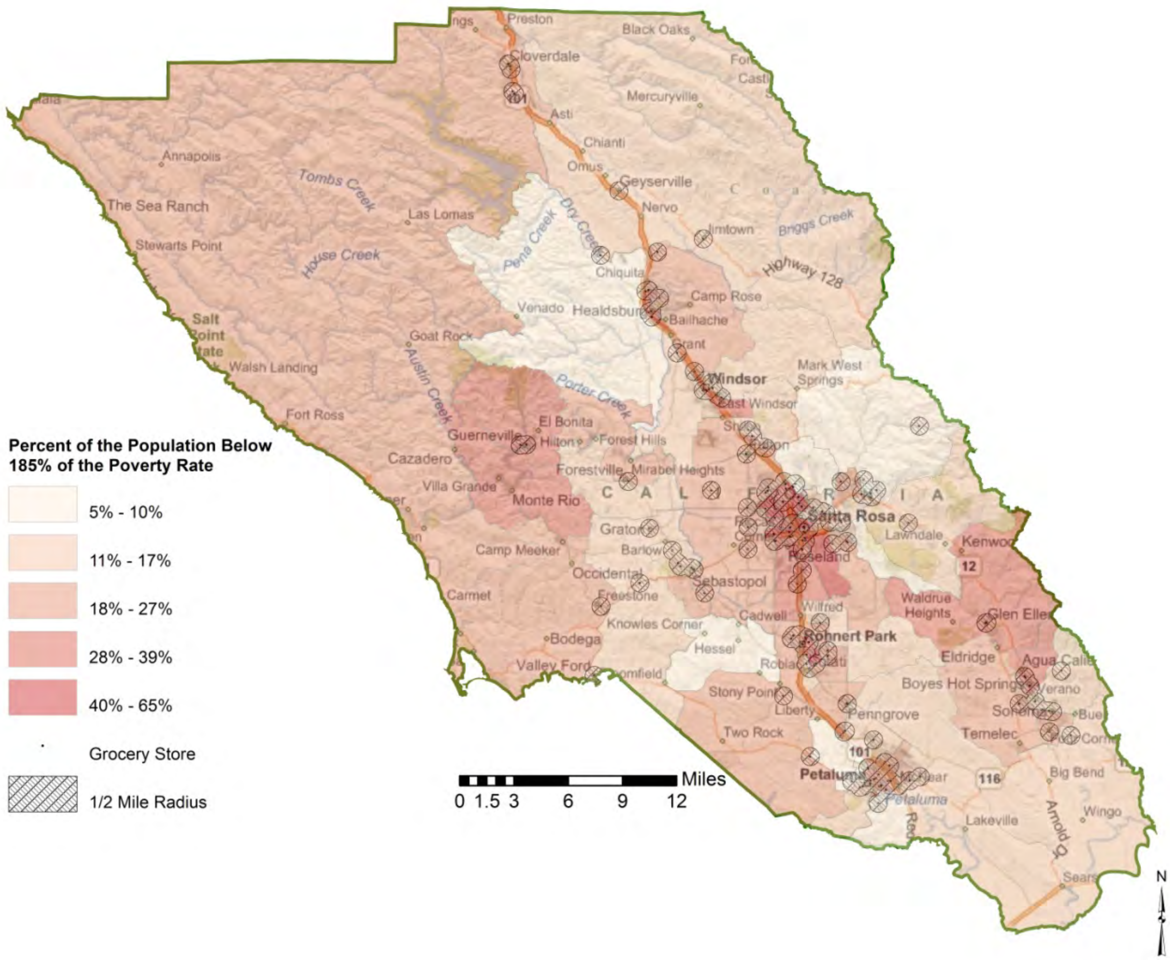
Map 2. Grocery Stores Compared to Population at or below 185% of Poverty.



Source: Dun and Bradstreet, California Food Retailers, 6/2010; American Community Survey 2005-2009, 5-year estimates.

Pedestrian access to grocery stores compared to the percentage of people at or below 185% of Federal Poverty Level (Map 3). The half-mile radius around each grocery store in Map 3 represents an estimated ten-minute walking distance. For those without cars or other transportation, this map helps illustrate those parts of the county where residents would have to walk longer distances in order to access a grocery store. This map does not consider other issues such as topography or public safety that may impact accessibility. Communities without full-service grocery stores are often served by smaller corner markets and/or fast food restaurants that typically offer more highly-processed foods and less fresh fruits and vegetables. The Sonoma County Healthy Food Outlet Project and the Sonoma County Smart Meal Program are two new programs working with local markets and restaurants to improve healthy food options available in areas with limited access to healthy food.[38] The Healthy Food Outlet Project works with food outlets, such as grocery stores and small markets, to increase availability of healthy food options, while promoting customer loyalty and store profits. The Smart Meal Program establishes nutrition requirements specifically designed for restaurant and deli meals. Entrees low in fat, calories, and sodium and that include whole grains, fruits, and vegetables are highlighted with a Smart Meal™ Seal. These programs are working in the following communities: south Santa Rosa, Fetters Hot Springs, Guerneville, and Monte Rio.

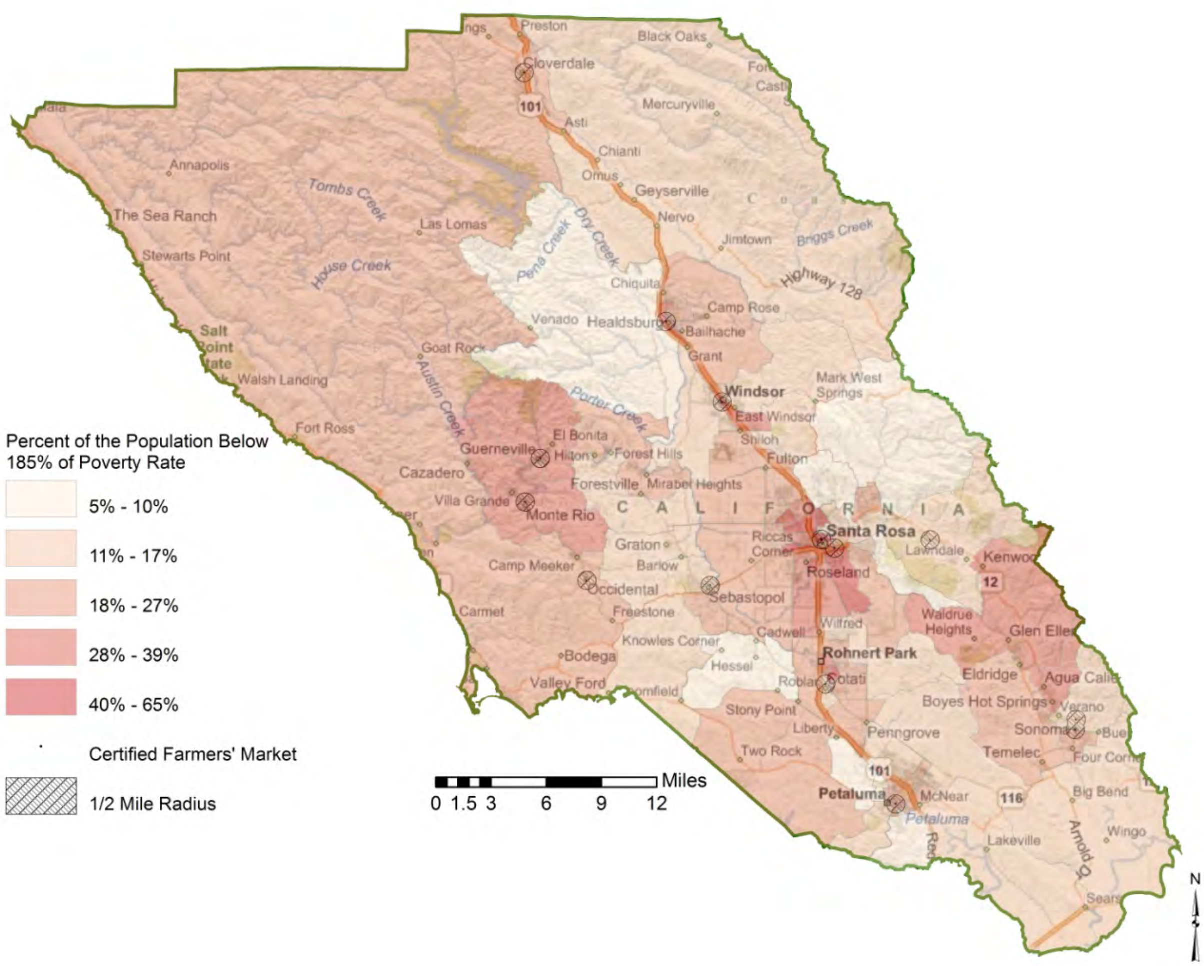
Map 3. Pedestrian Access to Grocery Stores Compared to Population at or below 185% of Poverty.



Source: Dun & Bradstreet, California Food Retailers, 6/2010; American Community Survey 2005-2009, 5-year estimates

Certified farmers' markets in Sonoma County compared to the percentage of people at or below 185% of Federal Poverty Level (Map 4).[39] Other sources of fresh produce include farmers' markets, community supported agriculture (CSA), community gardens, and home gardens. In Sonoma County there are farmers' markets in virtually all regions, including Cloverdale, Cotati, Geyserville, Healdsburg, Oakmont, Occidental, Petaluma, Santa Rosa, Sebastopol, Sonoma, and Windsor. According to a 2010 inventory, there are also 29 CSAs in Sonoma County that bring fresh produce directly from their farm to buyers through delivery or farm pick-up.[40] The half-mile radius around each farmers' market represents an estimated ten-minute walking distance. The map illustrates that farmers' markets are not all within walking distance for the most impoverished communities.

Map 4. Certified Farmers' Markets in Sonoma County Compared to Population in Poverty.



Source: California Department of Agriculture 10/2010; American Community Survey 2005-2009, 5-year estimates

In 2010, there were 13 farmers' markets certified by the Sonoma County Agricultural Commissioner's Office, and there are five additional uncertified markets in the county.[41] Four of these markets operate year-round, while others operate seasonally from April/May through October/November. Farmers become eligible to sell their produce at certified farmers' markets by applying for a Certified Producers Certificate through the Sonoma County Agricultural Commissioner's Office. In 2010, there were 202 Certified Producers in Sonoma County. Certified commodities include eggs, honey, nuts, fruits, vegetables, nursery stock, and cut flowers.[42]

Community garden compared with the percentage of people at or below 185% of Federal Poverty Level (Map 5).[43] While there are a number of community gardens located along the populated Highway 101 corridor, parts of the Sonoma Valley and rural west county regions lack access to community gardens. Since residents living in poverty may be more vulnerable to hunger and food insecurity, cultivating opportunity for food production in these areas could improve residents' diet and nutrition. There has been a growing interest in home, school, and community gardens in Sonoma County since the launch of the iGROW Sonoma initiative in February 2010 (see www.iGROWSonoma.org). The number of community gardens has increased from about 30, when an inventory was conducted in 2009, to 43 as of October 2010.[44] While some of the gardens report waiting lists of up to 14 people, others have plots available to the public. A Food Access Workgroup, which is convened by the Department of Health Services to support iGROW and promote increased access to healthy food in the county, has developed a number of resources to support home, school, and community gardens and serves as a network to support new and existing gardens.

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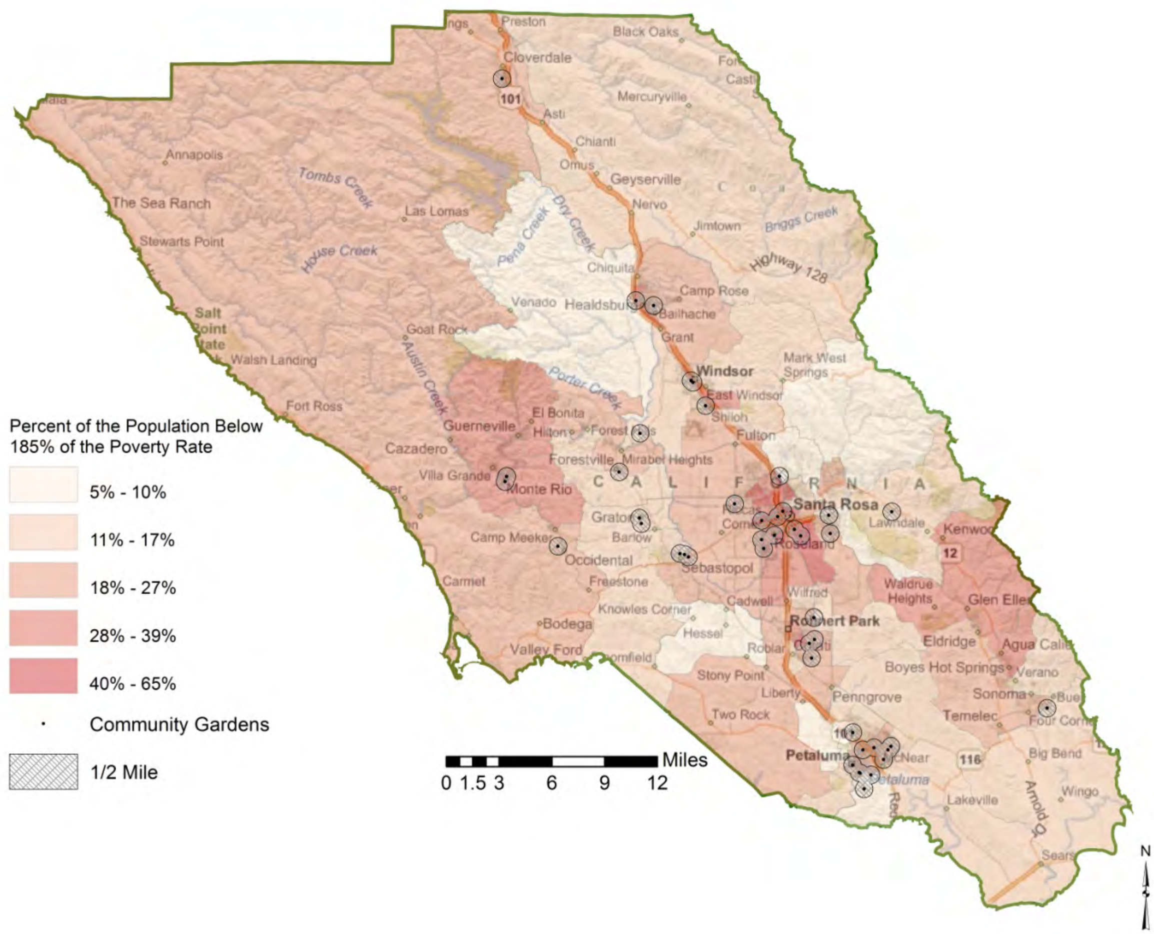
Map 5. Community Gardens in Sonoma County Compared to Population in Poverty.



Source: iGROW website, www.iGROWsonoma.org, (October 2010); American Community Survey 2005-2009, 5-year estimates

Key Findings

- **Hunger and food insecurity are significant and growing concerns in Sonoma County and have long-term health implications**. Due to the high cost of living in Sonoma County, many families struggle to make ends meet, even when employed.

- **Federal and local food assistance programs play a vital role in meeting the food needs for many Sonoma County residents and may be underutilized.** Education and outreach about these programs and how to access benefits can help increase access to healthy food and potentially boost the local economy.

- **Fresh, healthy foods are not consistently available in all communities**. Some neighborhoods (see Table 3) lack access to grocery stores and must rely on smaller markets or fast food restaurants that often have a poor selection of fresh, healthy food. Initiatives like the Healthy Food Outlet Project and the Smart Meal Program can play an important role in expanding healthy food access to areas that currently lack healthy options.

- **Farmers' markets, community supported agriculture, and gardens have grown in popularity.** Consumers in Sonoma County turn to farmers' markets, community supported agriculture, home gardens, and community gardens to increase access to fresh produce not available or affordable through traditional retail channels.

Source: www.sonomauncorked.com

II. Food and Agricultural Literacy

Photo: Sonoma County Farm Bureau

Goal: Residents of all ages are agriculture and food literate. Community members have awareness of local and global implications of their food choices, and the skills and knowledge to acquire or grow, prepare, cook, and preserve healthy food.

What Is Food and Agricultural Literacy?

Food and agricultural literacy implies an understanding of where food comes from, how it is produced and prepared, and the impact of food choices on personal health, the environment, and the vitality of local and global economies. Food and agricultural literacy is acquired through a wide range of experiences at home, in school, on farms, and through cultural and media conversations.

Why Is This Goal Important?

Following World War II, the U.S. food system shifted from local to national and global food sources and the food industry began to develop more processed food products.[45] In addition, the move to two career households has driven consumers to rely more heavily on purchased and processed food rather than preparing food from scratch. An annual report on eating patterns in America by NPD Research Group indicates that in 1972 Americans made 72% of dinners from scratch. In 2008 that had fallen to 57%.[46] This shift away from meals prepared at home has left many consumers with a lack of understanding of how food is grown and produced, how to prepare fresh food, and how their food choices affect their health and the health of the world around them.

Roots of Change, an organization of California leaders and institutions working to establish a sustainable food system by 2030, recently conducted related research through a "systems dynamic mapping" process.[47] One of the conclusions was that public education can be a powerful leverage point for increasing awareness of the food system and bringing about changes in dietary behavior. The Roots of Change organization supports the belief that changes in the local food system may be fueled by changes at the individual level.

In addition, it is clear that having the skills, knowledge, and ability to utilize and prepare fresh produce and make healthy food choices can have an enormous impact on quality and length of life. According to the U.S. Department of Health and Human Services, unhealthy eating and inactivity cause 310,000-580,000 deaths every year and contribute to nearly 1.5 million deaths as a leading risk factor for heart disease, cancer, diabetes, stroke, high blood pressure, and liver disease.[48]

How Is Sonoma County Doing?

There is no easy way to measure food and agricultural literacy. The Food and Fiber Literacy Standards, along with the agricultural literacy curriculum "Project Food, Land and People", developed in the 1990s, is one possible method for measurement. A 2011 study examined the extent to which these benchmarks could measure agriculture literacy.[49]

This chapter looks at two main areas that provide some insight on the level of food and agricultural literacy in Sonoma County: 1) Recent food-related social trends, and 2) Opportunities for residents of all ages to become more food and agriculturally literate.

Trends that Indicate Growing Interest in Food and Agricultural Literacy

The growth of home, school, and community gardens, farmers' markets, and community supported agriculture (CSA) programs in the county reveal a growing interest in consuming local food and connecting with local food sources. In addition to farmers' markets and CSA programs, efforts on the part of many grocery stores and restaurants to promote the use and sale of local foods indicate that growing numbers of local consumers care about where their food comes from. Oliver's Market's "When You Support Us You Support Them" program and Fork and Shovel's efforts connecting local restaurants to local farmers are two examples. Efforts such as these help to further build awareness of the connection between food, local farmers, and the health of our economy and ecosystem. Finally, nonprofit organizations like Transition Town Sebastopol, Go Local and Community Alliance with Family Farmers, which focus on the importance of strengthening local resiliency and the local economy, have helped build awareness of the key role of a strong local food system.

Promoting Food and Agricultural Literacy in K-12 Schools

Studies have noted positive changes in attitudes about fruits and vegetables after students received a combination of direct instruction and hands-on school gardening activities. These studies show that this combination may be effective in influencing behaviors over the long term. This is important because healthy eating habits are more likely to persist into adulthood if established in the elementary years.[50]

Currently there is no comprehensive approach to teaching food and agricultural literacy within the local public schools, or nationwide for that matter. Agricultural and food literacy are not usually part of the curriculum, and there are no state standards for these subjects. Some Sonoma County schools offer lessons and experiences in a school or community garden, nutrition education, and simple cooking. In addition, some schools have after school programs or electives in culinary arts and gardening activities. While Home Economics is no longer part of the middle school curriculum, some middle schools offer an elective class that teaches life skills including basic cooking and nutrition.

Finally, even though all California high school students are required to complete a one-semester Health Studies course, which includes some basic nutrition information, this course requirement may be waived. As a result, it is unclear how many high school students are exposed to health information. Some basic nutrition may also be included in high school Physical Education classes.

National school food program mandate. As part of the *2004 Child Nutrition Reauthorization Act*, the Federal government mandated that each local educational agency that receives funding for United States Department of Agriculture Child Nutrition Programs establish a local school wellness policy no later than July 1, 2006. School wellness polices are required to include goals for nutrition education and physical activity and nutrition guidelines for all food and beverages available on school campuses during the school day. It is up to each school to decide how to implement their wellness policy, and there is no funding associated with this mandate.

Food and agricultural career pathways in high schools. A specialized vocational program is provided through the Regional Occupational Program (ROP), which provides “career pathways” in Hospitality and Culinary Arts and in Agriculture. These programs focus on career training rather than a broad understanding of food and agricultural literacy. The Culinary ROP program offers classes at seven area high schools, none of which are about health or the health aspects of food. The Agriculture ROP program offers classes at six schools. Class offerings range from one to five classes per school (see Table 4). A wide range of courses are offered in the Agriculture ROP program including Landscaping, Viticulture, Floriculture, Advanced Agricultural Science, Agricultural Mechanics, Veterinary Science and Veterinary Medicine, and Plant and Soil Science.

Table 4. High School Food and Agricultural Literacy Programs.

High School	Culinary Arts	Advanced Culinary Arts	Baking & Pastry	Event Planning	Hospitality	Agricultural Pathway
Analy	x					x
Casa Grande		x	x			
El Molino	x		x	x	x	x
Elsie Allen						x
Maria Carillo		x		x		
Petaluma						x
Piner	x	x		x		
Santa Rosa						x
Sonoma Valley	x	x				x
Windsor	x	x	x	x		x

Source: Sonoma County Office of Education Regional Occupation Program[51]

School gardens in Sonoma County. Sonoma County is home to many school garden programs, some long established. Elements of school garden programs may include ecological literacy, the seed to table connection, the preparation and tasting of fresh produce, and exposure to whole foods that may not be served in the home. Some school garden programs also include instruction on cooking fresh produce from the garden, farmers' markets, salad bars, partnerships with local farms, and other strategies to introduce locally grown produce (either from the school's garden or local farmers) into the cafeteria or classroom. A local nonprofit, the School Garden Network of Sonoma County, provides support for the development and sustainability of school garden programs.[52]

The Sonoma County Food System Alliance (SCFSA) is partnering with the School Garden Network, Occidental Arts and Ecology Center (OAEC), and Sonoma State University (SSU) to conduct an extensive Sonoma County School Garden Survey, which will yield key information about school garden programs, what subject areas they are teaching, and their challenges and successes. Preliminary analysis indicates that of the 238 public and private schools that responded to the phone survey, 130

(55%) reported having a school garden. A more comprehensive analysis and summary of these findings is expected to be completed in fall 2011.

Santa Rosa Junior College Programs

Santa Rosa Junior College (SRJC) offers a wide range of certificate programs and Associate of Arts (AA) degrees in the culinary arts, food and nutrition, and agriculture.

Culinary programs. Santa Rosa Junior College offers 5 certificate programs and an AA degree in Culinary Arts. The certificate programs include: Culinary Arts, Baking & Pastry, Front House Operations, Dining Room Service, and Restaurant Management. Like the high school programs, these courses are designed to prepare students for careers in the culinary industry rather than providing basic cooking skills or building food and agricultural literacy.[53]

Agricultural programs**.** Certificate programs are offered in Agribusiness, Animal Science, Equine Science, Floristry, Horticulture, Viticulture Management, and Sustainable Agriculture. AA degrees are offered in Agriculture, Botany, Natural Resource Management, and Sustainable Agriculture.[54] The Sustainable Agriculture major is designed to train farmers and gardeners in the techniques of sustainable food production. It provides a foundation in plant and soil science, integrated pest management, and ecological agriculture, and emphasizes the "how-to" aspects of organic gardening and farming, including tillage, compost production, and crop planning and production.

Foods and Nutrition Program**.** This program provides students the opportunity to gain practical and science-based knowledge about the relationship between food and health. The program goal is for students to distinguish between nutrition fact and myth, and also for students to implement sound nutrition advice to enhance health and lower their risk of chronic diseases. Courses are offered in Elementary Nutrition, Nutrition and Diet Therapy, Child Nutrition, Sports Nutrition, Weight Control, and other nutrition-related areas.[55]

Cooking classes open to all residents**.** The SRJC also offers .5 to 2 credit courses in a range of topics from “How to Cook – a Class for Absolute Beginners” to ethnic cooking, wine appreciation, and cake decorating. Of seventeen courses offered in the Fall 2010 catalogue, five included information on healthy cooking or basic cooking.

Sonoma State University

While there are no Sonoma State University (SSU) programs specifically focused on food and agriculture, a number of faculty are addressing issues related to food, nutrition, and agriculture through Environmental Studies, Biology, Sociology, Geography, Liberal Studies, Psychology, and Nursing. A class in Sustainable Gardening maintains a small on-campus garden. An upper division seminar in the

Hutchins School, called "The Global Food Web," provides an overview on food system issues and includes service learning projects in the community (e.g., in school/community gardens, food banks). In addition, significant efforts are being made by the SSU Food Service staff to increase the use of locally grown and locally processed food in the cafeteria and other campus food outlets, and to educate students about such efforts through large posters in all food outlets.

Other Youth Programs

The Future Farmers of America in Sonoma County. Future Farmers of America (FFA) in Sonoma County is part of a national organization that supports high school students in their agricultural education and farm projects. Members of the FFA in Sonoma County have diverse interests in the food, fiber, and natural resources fields. Their education encompasses science, business, technology, and production agriculture. In Sonoma County there are 1,322 FFA members in chapters at seven high schools: Analy, El Molino, Healdsburg, Elsie Allen, Petaluma, Santa Rosa, and Sonoma Valley.

The 4-H program. This is a youth development program managed by University of California Cooperative Extension. The program is open to boys and girls ages five to 19. An estimated 1,300 youth participate in 4-H in Sonoma County in 29 clubs. Young people in 4-H programs learn about a range of topics related to food and agricultural literacy. These include Animals, Biological Sciences, Health, Consumer and Family Sciences, Environmental Education and Earth Sciences, and Plant Science.

The FARMS Leadership Program through the Center for Land-Based Learning. This program was created to teach the next generation about the cause and effect relationship between agricultural practices and the environment and to create connections with the land. The FARMS program also introduces high school students to the resources and networks that can lead to careers in sustainable agriculture or related environmental sciences.[56] The program currently serves students at eight high schools in Sonoma County: Geyserville, Cloverdale, Rancho Cotati, Summerfield Waldorf, Analy, Casa Grande, El Molino, and Windsor Oaks Academy.

Ag Days at the Sonoma County Fairgrounds. Hosted by the Sonoma County Farm Bureau, this annual event typically attracts 6,000 elementary school children, teachers, and parents.[57] For two days, students, parents, and educators have the opportunity to see farm animals, learn about the source of their food, fiber and flowers, and participate in environmental studies, growing plants, and raising animals.

***Ceres Community Project*.** This program teaches teens ages 13 to 18 about cooking and eating healthy foods by engaging the teens as volunteer chefs.[58] The teens prepare whole food meals for individuals dealing with cancer and other life-threatening illnesses. In 2011 about two hundred young people will participate. The organization also offers free and low cost classes on healthy eating and a free communitywide lecture series.

***Worth our Weight*.** This is a culinary apprenticeship program in Santa Rosa that includes food growing, cooking skills, restaurant management, and leadership development.[59] The program works with about 15 at-risk youth at a time and is primarily designed as a vocational program. Classes are not open to the public.

Other Community Educational Opportunities

For-profit cooking and nutrition schools. Three cooking schools in Sonoma County offer fee based classes for the general public: Ramekins in Sonoma, Relish in Healdsburg, and VIVA in Sebastopol. Baumann College, headquartered in Cotati, is a vocational technical school offering certificate programs for Nutritional Consultants and Natural Chefs, as well as an 8-week program, Nutrition Essentials for Everyone, which is available to the general public.

***Master Gardeners*.** This program of the University of California Cooperative Extension trains volunteers in an intensive three-month training program in plant science and horticulture, soil and water management, pest identification and management, plant selection and care, fruit and landscape trees, xeriscape, and environmentally-sound garden practices.[60] In the year following the training course, interns are required to complete a minimum of 60 hours of volunteer service and 12 hours of continuing education. A new Master Gardener Food Gardening Specialist program was started in the spring of 2010 with the mission of teaching beginning gardeners how to successfully start and maintain food gardens.

Governmental and nonprofit organizations. There are at least several dozen governmental and nonprofit organizations working to strengthen agricultural literacy and promote food growing among Sonoma County residents. Table 5 presents each of these organizations and indicates the areas related to food and agricultural literacy that their programs or services address. The authors recognize this may not be an exhaustive list of all programs related to agricultural and food literacy in Sonoma County, but identifies the breadth of programming available.

Table 5. Local Organizations Working to Strengthen Food and Agricultural Literacy and Categories of Services Offered.

Organization Name	Website	Food Growing	Healthy Cooking	Nutrition	Preserve/ Can	Local/ Season	Youth
California State Grange	www.californiagrange.org/index.html	x				x	x
Community Activity and Nutrition Coalition	www.sonoma-county.org/health/prev/canc.htm			x			
Ceres Community Project	www.ceresproject.org		x	x	x	x	x
Daily Acts	www.dailyacts.org	x			x	x	
Farm Trails	www.farmtrails.org/index.html	x				x	
Fork & Shovel	www.forkandshovel.com/					x	
Go Local	http://sonomacounty.golocal.coop/					x	
Healthy Students Initiative	www.sonomahealthaction.org/hsi			x			x
iGROW	www.igrowsonoma.org	x	x		x	x	
LandPaths	www.landpaths.org	x				x	
Occidental Arts & Ecology Center	www.oaec.org	x		x		x	
Petaluma Bounty	www.petalumabounty.org	x				x	x
Redwood Empire Food Bank	www.refb.org			x			
SRJC Culinary Program	www.santarosa.edu/instruction/culinary-arts		x				
SRJC Sustainable Agriculture Program	www.santarosa.edu/instruction/instructional_departments/agriculture/sustainable_ag/index.shtml	x				x	
School Garden Network	www.schoolgardens.org/	x	x	x		x	x
Slow Food Russian River	www.slowfoodrr.org/index.html	x				x	
Sonoma Ecology Center	www.sonomaecologycenter.org	x				x	x
UCCE Master Gardener Food Specialist Program	http://ucanr.org/sites/scmg/Food_Gardening_Specialists/	x					
West County Community Seed Bank	http://westcountyseedbank.blogspot.com/	x				x	
Worth Our Weight	www.worthourweight.org	x	x				x

Key Findings

- **A number of organizations offer education about where food comes from, the health benefits of eating fresh food, and how to grow, prepare, and preserve food, but these efforts likely reach only a small percentage of the population and are not coordinated for maximum impact.**

- **Only a small percentage of students in Sonoma County schools participate in cooking and nutrition classes as part of their formal education.** All of these classes are electives, and most do not focus on basic healthy cooking skills. Just over half of all schools in Sonoma County report having a garden on campus. A small percentage of students participate in extracurricular activities such as 4-H and FFA, which include food and agricultural literacy among their offerings.

- **While a wide range of cooking classes exist in the county, many are focused on advanced or specialty cooking rather than basic healthy cooking skills**, **and very few are affordable for lower income residents.** Current efforts are strongest in promoting/teaching gardening skills and the benefits of local and seasonal food but much weaker in nutrition and cooking skills.

- **Further research is needed to develop valid measures of food and agricultural literacy and to develop data systems that can track changes in local literacy over time.**

III. Demand for Locally Produced Food

Photo: Inside-Sonoma.com

Goal: Increase the demand for healthy, locally grown and produced food.

What Is Locally Produced Food?

There is no universally accepted definition of local food. For the purpose of this assessment, local food means food that is produced, processed, or manufactured within Sonoma County. This includes food crops that are grown in the county and foods like meat, eggs, dairy, and honey that are the products of animals raised in the county. This definition also includes foods that are manufactured in the county, but may not contain all products grown in the county. While the assessment focuses primarily on food or food products grown or produced in Sonoma County, the authors also recognize the value in exploring and supporting regional food systems that include multiple counties in a state region when needed to achieve economies of scale and scope.

Why Is This Goal Important?

Increased demand for locally grown food means that more residents will be asking for, purchasing, and consuming the fresh produce, meats, and dairy products produced in Sonoma County, creating a stronger supply-demand relationship between local producers and residents. This relationship is necessary for the economic sustainability and growth of Sonoma County's farmers and ranchers whose ability to compete for nonlocal markets is limited by a physical landscape that is not conducive to the kind of large-scale farming and ranching and economies of scale that would enable them to compete effectively against larger operations in other regions. In addition to supporting the overall viability of local agriculture, increased demand may also result in a number of other countywide benefits. First, the creation of new markets often results in improved prices.[61] Second, locally directed spending by consumers has been shown to more than double the number of dollars circulating among businesses in the community.[62] Finally, increased demand means residents are consuming more fresh fruits and vegetables.

How Is Sonoma County Doing?

Potential for Expansion of Local Demand

In order to get an idea of just how much room there is for expansion of local demand, it is useful to consider how much is spent on food annually in Sonoma County compared to the total revenue received annually by local food production enterprises.

County food expenditures. According to the most recent U.S. Economic Census total food expenditures at local food retailers and restaurants in Sonoma County was $4.23 billion in 2007 (Table 6).[63] This does not include food purchases at other venues such as farmers' markets or through CSA's. Much of local food consumption is likely derived from food produced outside Sonoma County.

Table 6. Retail Food Expenditures in Sonoma County, 2007.

Total retail food expenditures, food retailers, and restaurants	$4,233,973,000
Expenditures at food retailers	$2,516,779,000 (59%)
Expenditures at restaurants	$1,717,194,000 (41%)

Source: U.S. Census Bureau, 2007 Economic Census[64]

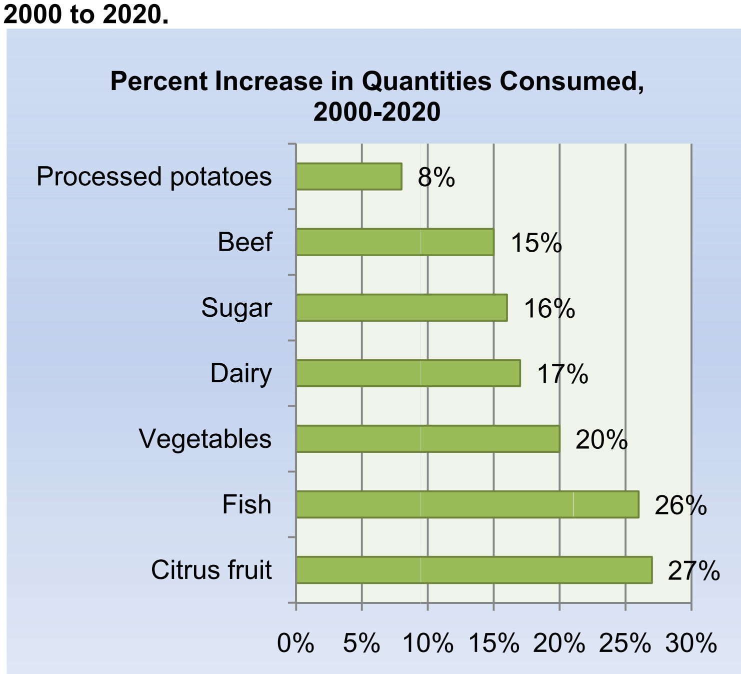
Food production revenue. Local food production revenue represents only a fraction of the $4 billion dollars spent annually on retail food purchases. The Sonoma County Agricultural Commissioner's annual crop report provides information on what is grown and produced in Sonoma County, but available data do not allow tracking of how much of local consumption is produced locally or where local products are shipped. According to the 2010 crop report, total revenue from local food production (farms, ranches, and commercial fishing) was an estimated $173 million in 2010 (does not include wine grapes).[65] According to the most recent data available from the U.S. Economic Census (2007), total revenue from local food manufacturers was an estimated $891 million in 2007.[66] Combined, these 2 sectors of the food system generate over $1 billion of revenue annually in Sonoma County. Although many of these food products are most likely sold to consumers outside the county, this revenue represents, at most, only about ¼ of local retail food expenditures.

Changing Demographics that might Influence Food Demand

Changes in the demographics of the local population can shift the food preferences that drive demand. Recent USDA Economic Research Service (ERS) research has identified three broad demographic trends that will shape future United States food markets: more mature consumers, more diversity, and more people to feed. Sonoma County mirrors this trend with an increasing proportion of residents aged 65 or older and a rapidly increasing Hispanic/Latino population.

More people to feed. According to U.S. Census data, Sonoma County increased in population by almost 43% over the past 20 years, from 338,222 in 1990 to 483,878 in 2010.[67] The sheer increase in population growth will have a significant impact on the food system in Sonoma County. However, population expansion will benefit some commodities more than others because of the changing population composition and related shifts in food preferences.[68] According to USDA Economic Research total consumption of beef, pork, fish, and citrus fruit is projected to increase.[69] Figure 1 below illustrates United States projected consumption growth over the twenty year period, 2000-2020. While this figure illustrates projected consumption growth for the United States, Sonoma County may experience similar consumption growth and have the need to increase production of certain commodities to meet increased demand.

Figure 1. U.S. Projected Consumption Growth, Percent Increase in Quantities Consumed, 2000 to 2020.



Source: Changing U.S. Demographics Influence Eating Habits[70]

Aging population. Sonoma County is experiencing disproportionate growth in the older adult population. Over the past ten years, the percent of persons 65 years old and over grew from 12.6% to 13.7% in

Sonoma County. In fact, according to the most recent Census data, Sonoma County has a higher percentage of older adults than California, 13.7% compared to 11.2% respectively.

Research indicates that older Americans typically eat less food than their younger counterparts due to lower activity levels and energy needs and dine out less frequently.[71] USDA Economic Research Service projections conclude that a maturing population will result in small declines in per capita consumption of fried potatoes, cheese, sugar, beef, and poultry, and possible increases in per capita consumption of eggs, fish, fruits, and vegetables.[72] As Sonoma County produces eggs, fresh produce, and fish, the projected shift in food preferences for the aging population may increase the demand for local products. As the local population matures, the demand for certain foods may shift due to changing preferences, dietary restrictions associated with medical conditions, or the limited finances of those on a fixed income.

Population diversity. Growing ethnic diversity has contributed to shifts in food preferences as well as a notable expansion of the American food repertoire. The ethnic composition of Sonoma County is expected to change dramatically within the next 40 years. Notably, Hispanics are expected to grow from 24.3% of the county's population to over 50% by 2050.[73] Table 7 illustrates the projected population shift over the next forty years.

Table 7. Projected Percent of Population by Ethnicity in Sonoma County, 2011.

	2010 (Est.)	2050 (Est.)	Percent Change
White	66.0%	33.8%	-49.0%
Hispanic	24.3%	50.7%	109%
Asian	4.70%	9.50%	102%
Multi-Race	2.30%	2.10%	-9.64%
Black	1.60%	2.50%	55.0%
American Indian	1.00%	1.30%	30.0%

Source: Sonoma County Indicators, 2011.[74]

As population trends shift nationally and locally, food preferences and the demand for farm products will change accordingly. Research does not indicate whether the projected change in food preferences will increase the consumption of local products and increase the economic viability of local producers.

Barriers to Increasing Local Demand

While it appears that there is room in Sonoma County residents' annual food expenditures for increasing consumption of local products, there are significant barriers to increasing the demand for local products. Conversations with members of the SCFSA identified the following obstacles to increasing the demand for locally produced food in Sonoma County:

- Limited production and availability of locally grown and manufactured products in mainstream retail and food service environments.
- Concern that the higher cost of locally produced fresh food may be prohibitive.
- Lack of awareness of local products and where to get them.

Overcoming Barriers

Price: consumers are willing to pay more for local*.* Concerns for food quality, nutrition, and the environment have been shown to increase one's willingness to pay more for local or organic food (see Table 7).[75] According to a study conducted by the Community Alliance with Family Farmers (CAFF), once given the choice to buy local, consumers will often do so even if the costs are higher.[76] The study was conducted at Oliver's Market in Cotati, as well as at two other locally owned stores in Northern California. Two batches of oranges were offered to customers in two distinct displays, side by side. One display was given a simple sign that read "oranges 99 cents per pound." The second display had a sign that told the story of the grower, discussed the grower's commitment to quality, and identified the price of $1.29 per pound. According to the study, Oliver's Market sold almost twice as many of the $1.29 oranges due to the customers' desire to connect with local farmers.[77] While not a robust study, this shows that at least some consumers are interested in localizing their food purchases and supporting local agriculture.

Awareness: promoting local food*.* A number of efforts are underway to encourage local consumers to learn about and purchase local food products. The *Sonoma County General Plan 2020* calls for promotion of Sonoma County agricultural goods to increase farm profitability and identity awareness of county agricultural products. Policies AR-1 a-g would specifically assist and promote agriculture through advertising and marketing assistance, promote brand recognition and food safety to the consumer, and promote sustainable and organic products in the overall marketing of Sonoma County as a reflection of consumer demand for these foods.[78]

Community Alliance with Family Farmers (CAFF) has created a "Buy Fresh Buy Local" campaign to improve access to local food and raise awareness about the importance of buying local. CAFF has developed the Bay Area Eater's Guide to Local Food that provides information on the diverse fruit and vegetable crops that are produced locally throughout the year, a directory of local growers, farmers' markets, CSAs, and other information on local efforts to support local food and a sustainable food system (www.caff.org). According to the 4th Edition, in Sonoma County, there are 102 growers, grocers, produce stands, specialty stores, restaurants, and caterers identified as partners in the "Buy Fresh, Buy Local" campaign.[79]

Sonoma County Farm Trails (www.farmtrails.org) is a local organization that supports and promotes Sonoma County's diverse agricultural producers and holds an annual weekend event with farm tours, tastings, and opportunities to buy products direct from the farm. The free Farm Trails Map and Guide helps consumers identify the variety of fresh in-season produce that is available on Sonoma County farms and their website has an interactive search feature that allows consumers to locate specific farms and products of interest.

The Sonoma County GoLocal Cooperative (http://sonomacounty.golocal.coop/) is a network of locally owned businesses, citizens, nonprofit organizations, and government agencies working together to build a resilient, thriving, local economy by supporting local, independently owned businesses and promoting sustainable practices. Their "Eat Local" campaign strives to educate the community on the need to support locally owned food producers, markets, and retailers.

Slow Food has several chapters in Sonoma County that are part of an international organization and movement dedicated to a food system that is "good, clean and fair" (www.slowfoodrr.org). Slow Food chapters bring people together to enjoy the pleasures of food produced by local, artisanal producers, so the community can learn to support biodiversity and a sustainable food supply. Slow Food Russian River has developed a partnership with local 4H families to raise, process, and sell Heritage Breed turkeys for local sale at Thanksgiving. They have also been working with a team of volunteers and over 20 local apple farmers to promote and create local demand for the endangered Gravenstein Apple, as well as all Sebastopol-grown apple varieties and local value-added apple products.

Fork and Shovel (www.forkandshovel.com) is a local organization working to build a strong local food network and economy. They help support the demand for local food products by fostering relationships between chefs and other food buyers with farmers, ranchers, and artisan food producers. This is done through a website that allows food producers to share their products with the food buying community.

Key Findings

- **Data are not available to know how much of the food consumed in Sonoma County is grown or produced locally, however it is likely to be a very small percentage.** This is an important area for future data development.

- **There is a large potential market to be tapped if local production was increased and distribution was configured to meet local demand.** Locally directed spending by consumers more than doubles the number of dollars circulating among businesses in the community.

- **The changing population demographics in Sonoma County will alter food preferences and food spending over the next 20 to 40 years.**

- **A number of efforts are underway to encourage local consumers to learn about and purchase local food products.** Ongoing support and coordination among these organizations can support a growing demand for local food products.

IV. Local Production

Photo: Centsationalgirl.com

Goal: Increase local food production and expand markets in order to:

- **Provide consumers with more nutritious foods produced and processed close to home as possible**
- **Create food system resilience and long-term food security**

This section is divided into 2 parts to reflect the dual nature of this goal. Part 1 addresses Local Food Production and Part 2 addresses Food System Resilience.

PART 1: LOCAL FOOD PRODUCTION

What Is Local Food Production?

For the purposes of this assessment, local food means food that is produced or processed within Sonoma County. This includes food crops that are grown in the county, foods like meat, eggs, dairy, and honey that are the products of animals raised in the county, and seafood that is landed on the Sonoma County coast. Food production requires grazing land and cropland, farmers and farm labor, sustainable fisheries, fertility and pest management, seeds or stock, and an adequate water supply.

Why Is This Goal Important?

The vision of the Sonoma County Food System Alliance is that local farms and operations play a primary role in producing the food eaten by Sonoma County residents. Substantial local food production increases access to fresh, nutritious food, creates jobs, and can make the community more resilient to economic, social, and environmental shocks.

How Is Sonoma County Doing?

The following section describes the extent of historic and current food production in the county along with possibilities for expanding production.

Decreasing Significance and Diversity of Food Production

A short history of Sonoma County agriculture in the *1999 Sonoma County Agricultural Commissioner's Crop Report* notes that by 1920, it was the 8th ranking county in the U.S. for agricultural production, and that:

> "The diversity of production has not been matched since then as wine grapes, dairies, prunes, eggs, poultry, apples, cherries, hops, olives, berries, potatoes, asparagus, melons and other vegetables and livestock were produced and processed locally or shipped fresh to the largest market on the West Coast, San Francisco." [80]

Today, Sonoma County ranks 34th in the U.S. for agricultural production, and crop diversity has declined.[81] One of the reasons for this is that better transportation and technological advances in refrigeration created competition for Sonoma County products, first with Central Valley farms and eventually with national and global markets. Also, changing conditions in agricultural markets influenced the crop focus in the county, so that today the most economically important Sonoma County agricultural products are those that are globally or regionally competitive. According to the *2010 Sonoma County Agricultural Commissioner's Crop Report*, wine grapes, milk, poultry and eggs, and livestock are the most valuable agricultural products produced in the county today (Table 8).

Table 8. Annual dollar value and acreage for agricultural and food products in Sonoma County, 2010.

Crops/Products	Acres	Annual dollar value
Wine grapes	59,659	$ 390,448,300
Apples	2,616	$ 5,861,600
Other fruit/nuts	1,450	$ 718,800
Vegetables	710	$ 8,212,200
Market Milk		$ 77,679,100
Misc. Poultry		$ 43,293,300
Eggs and goat milk		$ 20,799,800
Livestock		$ 14,302,200
Apiary products		$ 334,500
Commercial Fish (2009)		$ 1,605,343

Source: Sonoma County Agricultural Crop Report, 2010.[82]

Decrease in Crops for Fresh Sale

Table 9 breaks down the specific crops grown in the county. The largest local food crops are apples and olives, which are generally almost all processed before sale.[83] Processed products have a longer shelf life than fresh, so they can be marketed outside the county. Other crops are sold fresh and don't travel as far: they are most likely to be sold at farmers' markets or to restaurants, food stands, and grocery stores in Sonoma County and the Bay Area. Excluding apples and olives, the total acreage used to grow fresh fruits and vegetables is seen to be fairly small – 710 acres according to the county's 2010 crop report. The 2007 USDA Agricultural Census, which collects data in a different way, reports 919 acres and breaks down the acreage for specific crops as shown in Table 9.

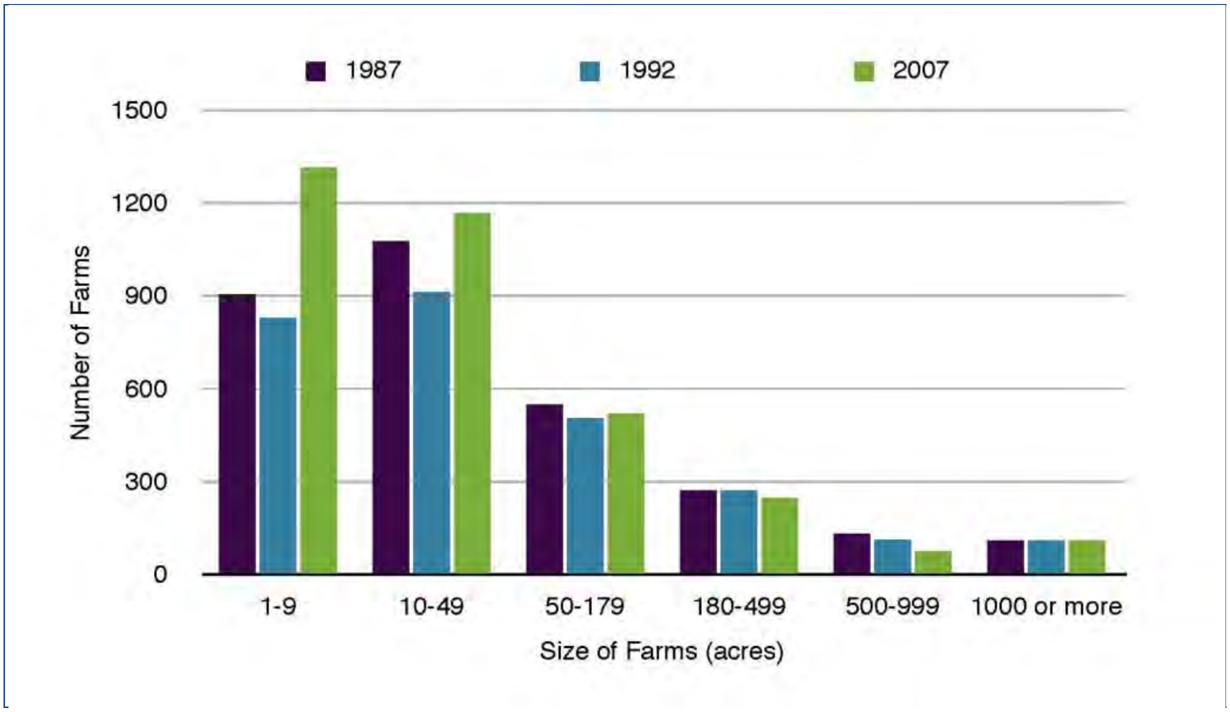
Table 9. Acreage and number of farms of the principal food crops grown in Sonoma County, 2007.

Food Crop	Acres	Number of Farms
Apples	3647[84]	250
Olives	294	62
Tomatoes	162	103
Pumpkins	155	34
Squash	123	49
Pears	104	53
Cantaloupes	74	35
Lettuce	67	64
Potatoes	50	17

Source: USDA Census of Agriculture, 2007. [85]

Within the county there have been some shifts in farm size over the last couple of decades (Figure 2). The number of large farms (over 1,000 acres) stayed about the same between 1987 and 2007, while the number of medium-sized farms (50 to 999 acres) decreased by 12%. However, the number of small farms (less than 50 acres), which decreased in the early 1990's, has risen again recently. By 2007 there were 19% more small farms than in 1987. There is not enough information to know whether this trend indicates a local change, like the breakup of medium-sized apple farms into small-acreage vineyards, or whether it is part of the national trend towards an increase in small organic vegetable farms.[86]

Figure 2. Distribution of farm size by acres in Sonoma County, 1987, 1992, and 2007.



Source: USDA Census of Agriculture, 1987 to 1992, 2007.[87]

Robust Milk and Egg Production

Milk and eggs are produced in the county in quantities that match the consumption levels of residents. However, the largest milk and egg processers in the county, Clover Stornetta and Sunrise Farms, distribute widely over Northern California; their products are not consumed exclusively in Sonoma County. The 420,000 acres of farmland identified as grazing land in the county is used by milk, beef and breeding cows, along with a small number of sheep and goats. An additional estimated 16,000 acres is used to grow field crops of hay and grains to feed animals.[88]

Sonoma County's dairies are recognized for their high-quality milk and the region has a long history of milk production. Dairies have declined in number – down to 69 (in 2008) from 800 at the turn of the century.[89] The average number of cows per dairy is small – 395 in 2008 compared to averages of 1,000 to 3,200 cows for California Central Valley dairies.[90] It costs more to produce milk in Sonoma County than in the Central Valley; its high quality, however, brings in a higher average price.[91] In 2010, Sonoma County dairies produced an estimated 57,211,000 gallons of milk.[92]

Sonoma is still one of the top egg-producing counties in California. Local brands are widely available and carried by supermarkets, so many of the eggs sold and eaten in the county are likely produced close to home. The egg industry is centered in Petaluma, where it has thrived for more than 100 years - at one time Petaluma was known as the greatest poultry-raising region in the world.[93] Eggs from Petaluma are sold throughout Northern California.

In spite of the strong local egg industry, gaps in supermarket shelves after the August 2010 egg recall from a farm in Iowa show that egg imports into the county from other states have become significant. There are concerns that the 2008 passage of Proposition 2, which mandated more room for confined farm animals, will further increase egg imports as consumers look for the lowest price. It has been estimated that Proposition 2 will cause a 10% increase in California-laid egg prices and it is unclear whether county residents will pay more in order to support local egg production.[94]

Meat Producers Thriving, But Limited by Lack of Processing Facilities

The *2010 Agricultural Commissioner's Crop Report* recorded an inventory of 29,923 milk cows, 8,935 beef cows, 17,939 sheep and lambs, 1,040 hogs, 1,797 goats, and 1,832,145 laying hens and pullets in Sonoma County. Broiling chickens are also grown in the county, but their numbers were not reported. While there is a growing interest in small-scale meat production in Sonoma County, there are not enough USDA-inspected slaughterhouses for large animals in the North Bay to process the meat conveniently for local consumption. Sonoma County has one beef processing facility in Petaluma (which is planning to close in the next few years) and a small processing plant for sheep and goats in Occidental. Most animals are trucked out of the county for processing, which is stressful for the animals and costly for ranchers.[95]

Fish Resources Declining

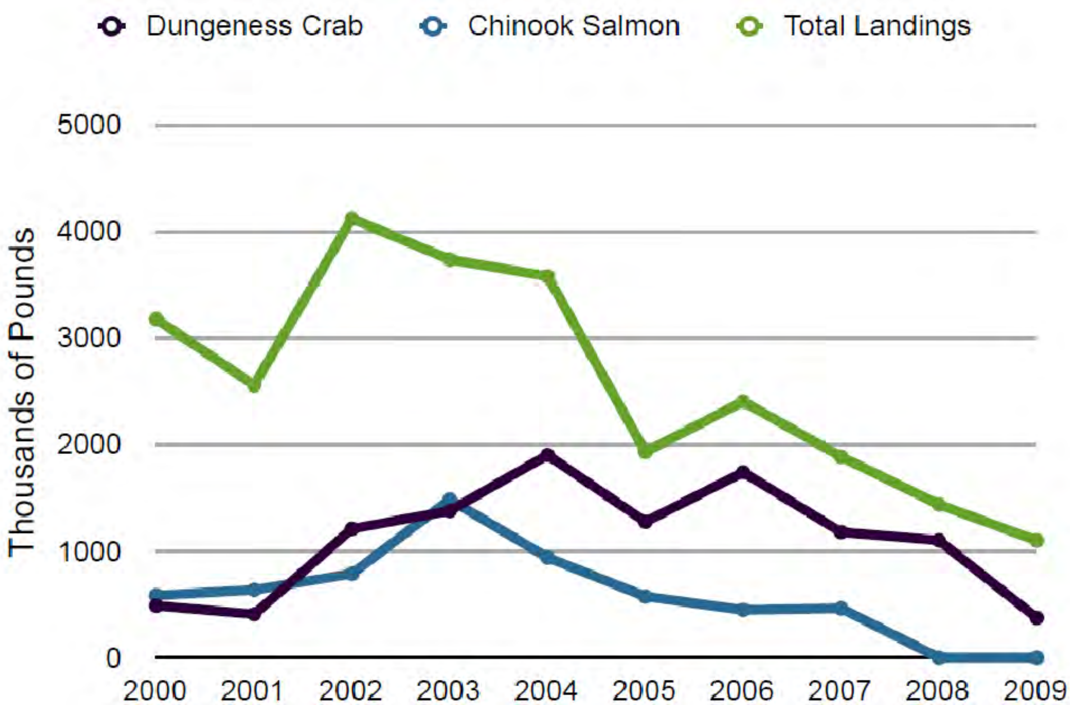
Fish, especially salmon, was an essential food for the Miwok and Pomo inhabitants of Sonoma County and a valuable part of the diet for early Euro-American settlers. Local salmon were plentiful and cheap until the mid 1900's. Records from 1888 report that 183,597 pounds of salmon were caught near Duncans Mills and processed at a nearby cannery.[96]

Today there are very few native wild salmon living in Sonoma County watersheds or coastal areas. Young salmon in their freshwater phase are mostly hatchery fish, while ocean-caught salmon are from the Sacramento River, the Klamath River, or other watersheds. Rockfish, another important commercial fish, have become smaller, a sign of declining population and fishing grounds have moved to deeper waters.[97]

Salmon was historically the most important commercial fish for the Sonoma Coast fishing community, which is based in Bodega Bay. Commercial fishing began after World War I, expanding in the 1950's and again in the 1980's. Salmon populations crashed in the 1980's, and Bodega Bay fishermen were able to diversify to crab and other fish species. Salmon populations rebounded in the 1990's but since then populations have plummeted again, resulting in strict regulations on the fishing industry and on salmon seasons, which have been shortened or cancelled because of environmental problems in the Sacramento Delta and the Klamath River.[98]

Total landings of all kinds of fish declined from 2000 to 2009, as shown in Figure 3, and fishing as a livelihood is now in jeopardy in Bodega Bay.[99] This follows the statewide trend: commercial fishing licenses issued by the state of California declined from 4,289 in 2000 to 2,873 in 2009.[100]

Figure 3. Commercial Seafood Landings at Bodega Bay, 2000 to 2009.



Source: California Department of Fish and Game.[101]

Community and Individually Produced Fruits and Vegetables Increasing

Community and home gardening. In the past few years, there has been a nationwide resurgence in home gardening. Growing food has been especially popular, as indicated by the continuing rise in sales of vegetable seeds.[102] The popularity of food growing was demonstrated locally by the success of the 350 Garden Challenge of May 15 to 16, 2010. County residents were asked to plant food gardens to combat climate change, and more than 600 gardens were created or re-planted.[103]

Home gardeners are often limited by the amount of land they have to convert to garden. Only 48% of Sonoma County residents are homeowners.[104] Another 10% live in rented single-family homes, where they may or may not have access to space for gardening. The remaining 42% of county residents live in attached housing (condos or apartments) and may not have access to garden space.

For residents who cannot garden at home, community gardens provide an option for food growing. As mentioned previously, community gardens have proliferated in Sonoma County, increasing from only a few in 2000 to 43 in 2010, with more planned.[105] Much of the recent growth in community gardening space has been on land owned by churches.

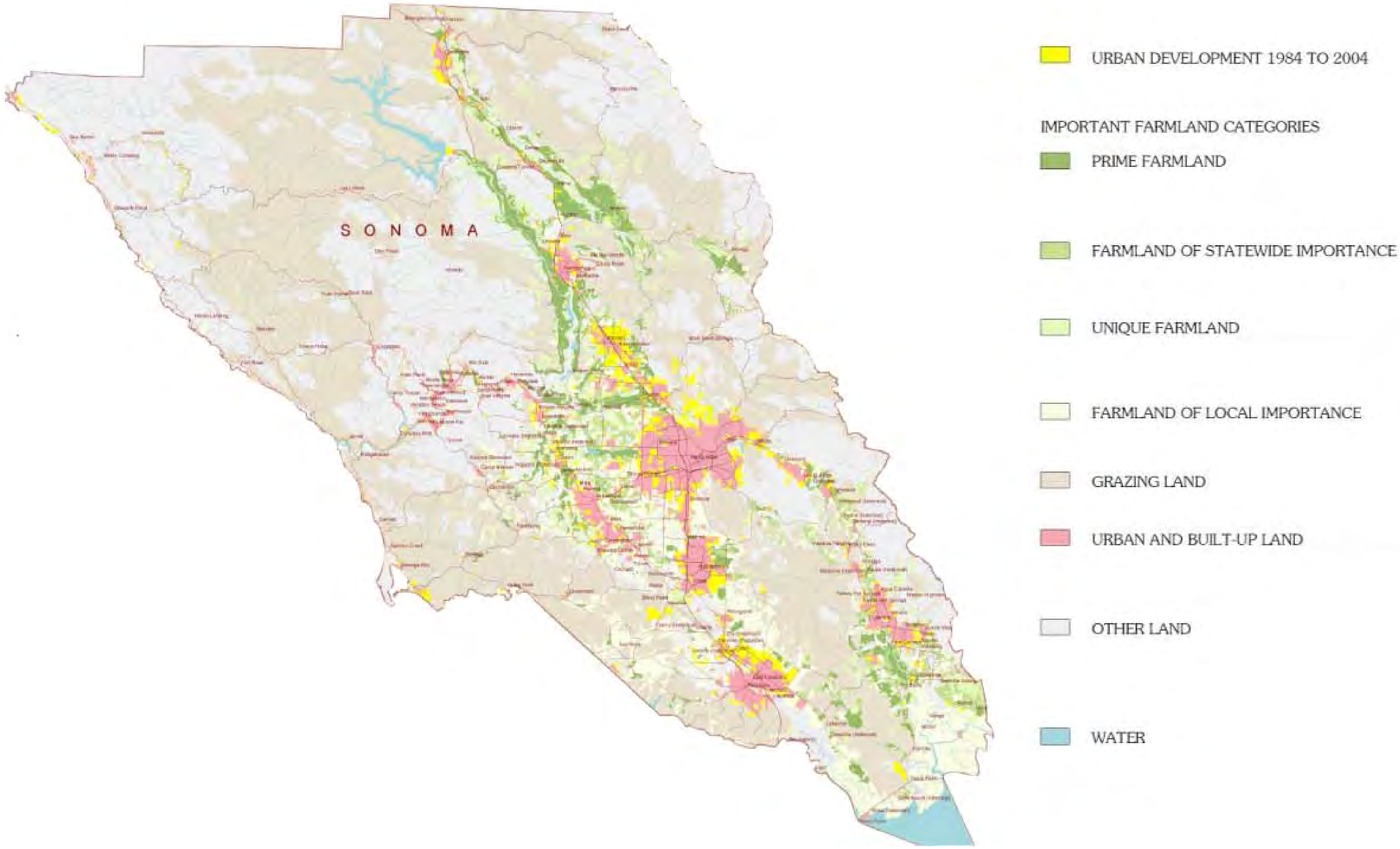
Urban agriculture. In some other parts of the U.S., local governments have not only embraced and facilitated community gardening, but have established urban farms. These serve a range of purposes, from community education about gardening and food processing, to job training and intensive food production. Because urban farms are located where population is dense, they have advantages over more remote farms. They can be used for recycling urban wastes and can market directly and efficiently to consumers.[106] Bayer Farm, a collaborative project between the County, the City of Santa Rosa, and LandPaths, a local nonprofit, is an example of this kind of project.[107]

***County land for food production*.** The Land Use section of the *Sonoma County General Plan 2020* lists as an objective: "Encourage food production as an integral part of institutional land uses on public lands where such uses and lands have the capacity to grow food products." [108] A study approved February 15, 2011 by the Sonoma County Board of Supervisors will look at finding suitable county land to be used for food production by community gardeners, small farmers, and ranchers to meet the needs of Sonoma County residents.[109] In addition to parks and open space, officials will look at property owned by the county Water Agency and land managed by the General Services department.

Limits to Local Food Production

***Declines in available cropland**.* Class I and II soils, the best suited for agricultural use, are mostly found in Sonoma County valleys and basins, which are also where most of the County's population is located.[110] Hilly and steeper lands generally have shallow and lower classification soils and are more suitable for some orchard crops, vineyards, and grazing or for leaving as forest. The *2004 California Farmland Report* states that Sonoma County has 162,148 acres of Important Farmland (suitable for crops), 421,126 acres of potential grazing land, and a total of 583,724 acres of potential agricultural land.[111] Map 6, below, shows where county farmland has been threatened by urbanization, as the population of Sonoma County grew from about 100,000 inhabitants in 1950 to more than 450,000 by 2007. Urbanized areas grew to cover 72,935 acres by 2004, which reduced agricultural land because the largest cities are located in basins containing good soils and farmland.[112]

Figure 6. Sonoma County Region Important Farmland – Urbanization, 1984 to 2004.



Source: California Department of Conservation, Farmland Mapping and Monitoring Program.[113]

Table 10 shows the decline in harvested cropland over this period. Since the 1990's, Urban Growth Boundaries have been adopted in all of the nine cities in the county, helping slow the loss of farmland to urban and suburban development.

Table 10. Historical changes of farmland acreage and agricultural uses in Sonoma County.

	Number of Farms	Land in Farms (acres)	Harvested Cropland (acres)	Grapes (acres)
1950	6259	774,125	115,744	15,323
2007	3429	530,895	91,197	63,949

Source: USDA Census of Agriculture, 1950, 2007[114]

Between 1950 and 2007, the number of farms in Sonoma County dropped by 45%, acreage in farms decreased by 31%, and wine grapes expanded to fill 70% of the county's harvested cropland.[115] Growing wine grapes, because of its profitability, has kept land in agriculture that might otherwise have been developed, but it has also reduced the acreage that is available to grow food crops in the county.

Limited water resources. Only some parts of Sonoma County have sufficient, reliable sources of groundwater. The Water Resources Element of the *Sonoma County General Plan 2020* states that only about a third of the county, mostly in the south and central areas, has substantial groundwater aquifers. Large-scale water users in the other two thirds must rely on surface water.[116] Surface water is also limited, especially during the dry months when water is most needed for irrigation. According to figures from the California Department of Water Resources, agriculture uses about 40% of the developed surface water in the county (from the Russian River, creeks, legal diversions, and releases from dams).[117] It is unlikely that this percentage can increase because the rest of the water is used by growing populations in the cities or reserved for water releases needed by endangered spawning salmon in the fall.

Other factors limiting food production. The supply of skilled farmers could also be a limiting factor for increased food production as the current generation of farmer's age and retire. The average age of Sonoma County farmers is gradually increasing. The average age was 59.4 years in 2007, an increase from 53.7 in 1987.[118] Young farmers may find it difficult to secure affordable fertile land in Sonoma County and, if from a non-farm background, may lack the practical knowledge base and experience to farm successfully. It can take an estimated 3-5 years of growing and marketing experience to learn how to grow vegetables on a small-scale farm.[119]

Potential for Self-Sufficiency in Food Production for Sonoma County

Some food system researchers have developed estimates for how much land is needed to feed one person for a year. Chris Peters of Cornell University concluded that a diet containing a small amount of meat is the most efficient in terms of land use, since meat can be raised on pasture land that may not be suitable for crops or orchards. This diet would need 0.6 acres to feed one person for one year.[120] An Oakland study calculated that it would take 0.022 acres to supply the average person with the amount of vegetables recommended by the USDA.[121] John Jeavons, the director of Ecology Action in Willits, California, has spent decades developing biointensive growing methods that will provide a high-protein vegan diet from only 4,000 square feet of garden per person.[122] Table 11 shows the amount of land that these different methods estimate would be needed to feed the 483,878 residents of Sonoma County. With the current level of production of animal foods, and a shift from growing grapes to growing fruit and vegetables, it might be possible for Sonoma County to produce most of the vegetables, fruit, meat, eggs and milk that is consumed by residents, given the California Farmland Report estimates of 162,148 acres of cropland and 421,126 acres of grazing land in the county.[123] There may not be enough cropland to grow grains to meet local consumption needs.

Table 11. Estimated acreage needed to produce food for Sonoma County residents.

	Types of Diet and Land Required	Land (acres)
Cornell	Mixed pasture and cropland needed to provide a low-meat complete diet.	283,200
Oakland	Vegetables only using irrigated cropland.	10,384
Jeavons	Complete high-protein vegan diet using intensive horticulture methods on irrigated cropland.	43,342

Key Findings

- **Sonoma County has the capacity to produce large amounts of diverse types of food.**

- **In the last hundred years, the variety of food crops produced has decreased to mostly those products that can be distributed and marketed outside the county.** The quantity of food produced has also decreased and has been replaced by wine grapes.

- **Lack of availability and the high cost of cropland, limits to water available for farming, lack of gardening space for county residents, and declining fish populations are some of the barriers to increasing Sonoma County commercial and home food production.** There is potential for expanding urban food production and for increasing the number of farms growing food for county residents.

PART 2: FOOD SYSTEM RESILIENCE

What Is Food System Resilience?

Resilience is defined as the ability of a food system to preserve its function of supplying food in the face of disturbances to the system.[124] Disturbances can be global or local; they can be caused by a catastrophe, for example an earthquake or terrorist event, or they can result from slow change over many years, as is likely to happen with climate change or fossil fuel depletion. A resilient food system is able to recover quickly from sudden disasters and can adapt to long-term change.

Food systems depend upon a wide range of inputs, including weather, natural resources, labor, energy, financing, transportation, markets, and imported food. A resilient system has alternative sources for essential inputs, so that there is not too much reliance on a single source. Some inputs may be local, like water, good weather at critical points in the growing season, or a local market for goods. Others may be nonlocal, such as available farm credit, transportation in and out of the region, commodity prices, or the price of energy.

Resilience is built into a food system when all of its component parts have alternatives. For a food system this means that many types of food are produced by many farmers, processed by many businesses, and distributed using many different outlets and networks. Locally produced food may be less vulnerable to distribution problems than long-distance food since there are so many more possible ways to get it to the consumer. A diversity of financing options, energy sources, labor sources, and methods to transport food help make the food system more secure.

Why Is This Goal Important?

Disturbances to the global or local food system can cause food shortages or increases in price, impacting food security. For example, the failure of the 2008 rice crop in Australia, the result of a decade-long drought, raised the global price of rice and caused it to double in California.[125] Also in 2008, the price of corn and other grains doubled because of the diversion of grain to biofuel production, causing economic stress for Sonoma County dairy farmers, who need to buy grain-based feed for their cattle.[126] Contamination in an egg-packing plant in Iowa in 2010 led to empty shelves in local supermarkets. Slower disturbances, such as overfishing for decades, are more easily adapted to, but in the long run may result in impoverished local food resources.

How Is Sonoma County Doing?

Dependence on food imports makes Sonoma County residents vulnerable to shocks from the global food system and to being cut off from food supplies if transportation is disrupted. Our food system is also vulnerable to energy price hikes, long-term climate change, and potential dangers associated with importing domestic food and feed supplies from outside the county.

Threats to Food System

***Floods and earthquakes**.* The most likely sudden threats to our present food system are earthquakes and floods.[127] If a strong earthquake severed Highway 101, this could have a drastic effect on food transportation. There could also be damage to grocery stores, food storage buildings, and restaurants, which would make them unable to open, leaving residents dependent on whatever food they had stored in their homes and gardens. Flooding can isolate parts of the county for several days. Three days worth of stored food and water is recommended by the Red Cross and Federal Emergency Management Agency (FEMA) to get through a localized emergency of this type, whereas one to two weeks is recommended for a major regional earthquake.[128]

Drought. Recurrence of drought is inevitable in California. Each time a drought has occurred, population and water needs have been higher than they were during the previous drought. Water use in the county is now split between people, agriculture, and the environment, and local water supplies have been more than completely allocated. When droughts occur, all users feel the pinch. Increased resilience to drought will require more efficient use of water and more varied kinds of water storage infrastructure in all parts of the state, including Sonoma County. Water efficiency and conservation practices such as off-stream water storage, dry-farming, rainwater collection and storage, and greywater use are becoming more common in the county.[129]

Energy. Energy prices of nonrenewable fuels are likely to go up in the future.[130] As fuel prices increase, the cost of fertilizers, pesticides, fuel for farm activities, processing, storage, and transportation will go up and make food more expensive. Local, organic food production helps to stabilize food prices during energy price hikes by keeping transportation costs low and reducing dependence on buying synthetic fertilizers and pesticides.[131] About half of Sonoma County's vegetables, fruits, and nuts (excluding wine grapes) are grown organically.

Climate Change. Forecasts for what climate change will mean at a local level are difficult to estimate, and climate models show a lot of uncertainty for the Northern California region. The most likely consequences of climate change for Sonoma County are an increase in hot weather events in the summer, and stronger, wetter rainstorms during the winter. Although overall rainfall may even increase, the rainy season will still be compressed into a few winter months so water storage and efficiency will be key to successful future food production.[132]

Climate change may also affect the availability and price of food that Sonoma County is now importing. Climate models predict the loss of much of the Sierra Nevada snowpack, which provides water for agriculture in the San Joaquin and Sacramento Valleys during the summer.[133] Models also predict changes in the Midwest, which will lower the productivity of grain farming.[134] Other likely food-related impacts from climate change include expansion of crop pest ranges, more frequent extreme weather events, crop failures, the need to switch to more heat-tolerant crops, and changes to the ocean food chain that will reduce fish stocks.

Paths to Increased Resilience

Increasing awareness of threats to our food system has motivated local responses such as more interest in growing local food, in changing agricultural practices to counter climate change, and in managing our water supply more carefully.

Home food growing. There has been a strong increase and interest in home food growing which will help make participating households more food resilient, but because of the limitations in available food crop production acreage in Sonoma County, there will only be a small amount of food from local farms to feed the public in case of the sudden onset of a long-term food challenge due to the limited supply.

Reducing the threat from climate change. Farming practices can help to reduce the carbon dioxide in the atmosphere that is causing climate change. When carbon dioxide is removed from the atmosphere by a biological or chemical process this removal is called carbon sequestration. Carbon is 'sequestered' by being bound up in living plants, or by being stored as organic matter (roots and dead plant material) in the soil. Adding compost to soil and 'no till' farming, which leaves crop roots and residues in the ground to decompose, are the best known currently used methods for increasing the organic matter stored in soils. The Marin Carbon Project has been researching management practices that will increase the carbon stored in managed ecosystems, beginning with rangeland and eventually including farmland and forests.[135] Sequestering carbon in soils will help reverse greenhouse gas emissions as well as provide new economic opportunities for farmers under California's climate legislation.

The Sonoma County Water Agency has developed a strategy for responding to the uncertainty and challenges that climate change will bring to the water supply. The strategy includes encouraging water conservation, increased efficiency by both agricultural and urban users, and developing more water storage.[136]

Emergency planning. Sonoma County's current approach to food crisis preparedness relies on food charity to address ongoing hunger and on having emergency plans to feed people in a natural disaster while ensuring food safety. The county has no specific plan for food system resilience, but the following existing programs help to protect the local food system.

During a disaster, agencies of the U.S. Department of Agriculture (USDA) ensure that people have enough to eat. The Food and Nutrition Service distributes commodity food to mass feeding sites and directly to households. These commodity foods are stockpiled by the USDA for times when normal distribution channels like grocery stores are unable to function.

At the county level, the Emergency Management Division of the Department of Emergency Services is responsible for planning, coordination, recovery, and mitigation activities related to emergencies and disasters. It considers the major threats to the county to be earthquakes, floods/winter storms, drought, landslides, and fires near cities.

There are other nongovernment organizations that contribute to food relief and management during times of disaster in Sonoma County, including the Sonoma County Chapter of the American Red Cross, members of the National Voluntary Organizations Active in Disasters such as the Salvation Army, homeowner groups, and media.

Outside of disasters and catastrophic crisis, Sonoma County Department of Health Services serves to protect the food supply at the retail level. Environmental health specialists provide a range of essential food and restaurant regulatory services.[137]

Sonoma County's day-to-day emergency food system is based on food charity – collection of food by privately-funded food banks and distribution to those in need. The largest food bank in the area, the Redwood Empire Food Bank, serves more than 78,000 hungry people a month.[138] The Food Bank has also been collaborating with school districts for the last five summers to feed lunch to thousands of low income school children around the county as district summer school programs have been cut.[139]

Key Findings

- **Since most food in Sonoma County is likely imported, residents are vulnerable to price increases, contamination problems, or transportation disruptions that originate outside the county and over which the county has no control.**

- **Sonoma County is prepared for emergency response to a sudden local disruption in the flow of food supplies, but may not be well enough prepared for large scale or slow-moving crises.**

V. Local Distribution and Processing

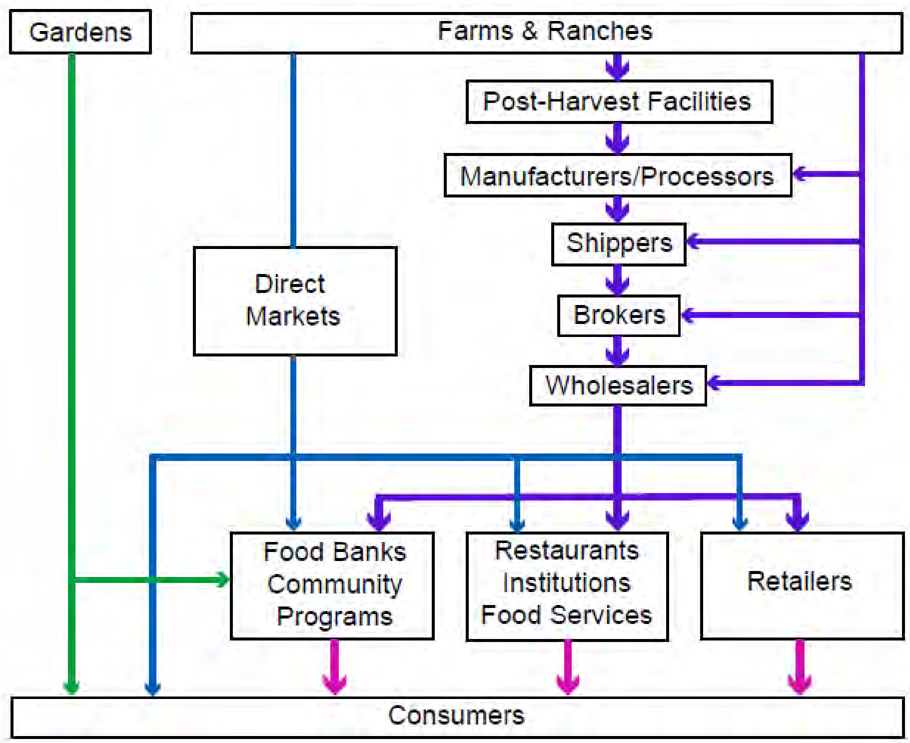
Photo: ww.watchsonomacounty.com

Goal: Sonoma County has a local distribution and processing system that effectively connects local producers, manufacturers, processors, vendors and consumers.

What Is Food Distribution and Processing?

Food distribution and processing consists of all the networks and processes that allow food to be transformed from its original state at the place of production (e.g. slaughterhouses, manufacturers, vegetable packing plants) and moved to the consumer via points of access, such as, wholesale brokers, retailers (e.g. grocery stores, restaurants, caterers), institutions (e.g. hospitals, schools, correctional facilities), food banks, and direct markets (e.g. community supported agriculture, farmers' markets, roadside stands). Figure 4 outlines the various channels for food distribution and processing.

Figure 4. Food Distribution and Processing Channels.



Why Is This Goal Important?

Distribution and processing are vital parts of the food system enabling food producers to remain viable and to more readily sell their products to a wider base of consumers. Efficient distribution and processing also allow customers access to a wider variety of food products. Customers are becoming more interested in purchasing locally produced food in order to reduce their environmental footprint (i.e., "food miles"), to know where their food comes from (food safety concerns), and to support the local economy. Although the food distribution and processing system in the United States has become increasingly centralized, some researchers suggest that developing local distribution and processing systems can create efficiencies that lead to lower prices for consumers, more income for farmers, and a stronger local economy.[140]

How Is Sonoma County Doing?

Current Regional and Local Food Distribution

The centralization of food distribution is a major obstacle to closing the gap between local farmers and local consumers. Larger, global companies such as Sysco distribute food (most of it coming from out of the area) throughout the North Coast region, but there are also a few local and regional distribution businesses that serve Sonoma County. These companies typically aggregate commodities produced locally or elsewhere and transport them to food outlets. Andy's Produce Market, Coastline Distributors Incorporated, Oliver's Market, Terra Sonoma, Sonoma Organics, Sonoma County Growers Exchange, Veritable Vegetable, and Green Leaf are some of the locally and regionally operating distributors. The amount of aggregated “local” produce varies seasonally and is not currently being tracked in a quantifiable way.[141]

Emerging Efforts to Increase Distribution of Local and Regional Foods

Despite growing interest in purchasing local foods, consumers and buyers do not often have enough information on what local products are available and where or how to access them. According to research conducted by CAFF, many small and mid-sized farmers and ranchers have difficulty selling their products to processors, retailers, and food service operators because of high distribution costs, low prices, limited product availability to meet the demand of large buyers, and storage and transportation issues. There are a number of emerging efforts to address these obstacles. These are described below:

Online Distribution. More recently, online distribution services specializing in regional foods have emerged, such as the local Fork and Shovel, which works with local farmers and chefs, and FarmsReach.com, an online resource for learning about and finding local food in the Bay Area. These services are attempting to increase farmer access to new markets and to help larger volume buyers get access to regional foods. In studying the needs of regional farms, FarmsReach found, however, that farms need more than just an efficient marketplace. They identified an urgent need to help farms prepare for market with tools to assist with pricing, packing, food safety compliance, planning, and group purchasing.[142] These services for farmers could be part of a regional food hub, but these online systems have yet to find a way to finance their businesses.

Regional Food Hubs. In California, several organizations have formed the California Network of Regional Food Hubs, with shared common goals of serving small to mid-sized farmers and supporting the growth of regional food systems. The network plans to offer a platform for coordination between food hubs to increase efficiency and optimize profits for farmers while increasing access to nutritious affordable foods in all communities across the state.[143] The network is currently run by a nine-member advisory council including Orfalea Foundation, ALBA Organics, California Center for Cooperative Development, Swanton Berry Farm, San Mateo County Health System, Ojai Pixie Growers Association, San Diego Unified School District, and Urban and Environmental Policy Institute.

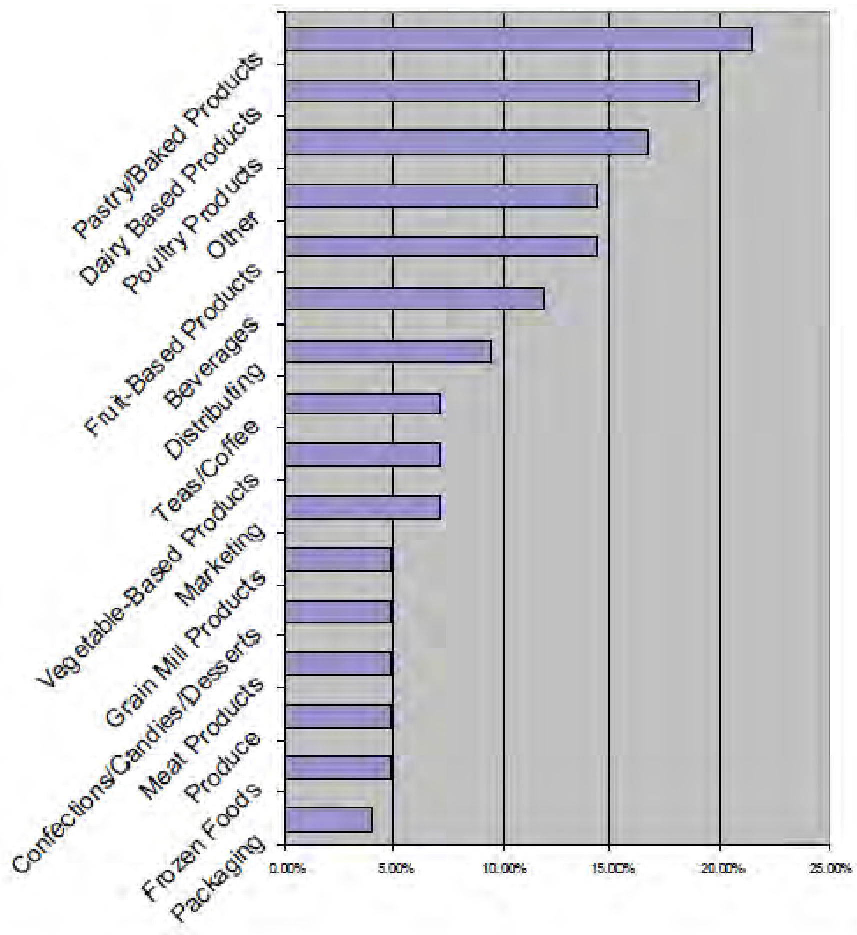
To address some of these distribution issues in Sonoma County, in July 2010 CAFF was awarded a grant from the U.S. Department of Agriculture (USDA) to assess the feasibility of building relationships with major distributors and local retail markets, with the goal of building sales and increasing the volume of fresh local products from small and medium-sized family farmers and ranchers in Sonoma County. As a part of this project, CAFF is exploring the possibility of creating a regional “hub” system to open access to large buyers in Sonoma County, three neighboring counties, and surrounding areas. The proposed hub could provide daily aggregation and distribution of local products to meet local demand. The findings of the CAFF USDA feasibility study will help identify options and opportunities for improving the distribution and processing infrastructure in Sonoma County and the North Coast Region. Study results will be released after the final report is completed in summer 2011.

Wholesale refers to the sale of products in large quantities to distributors, retailers, or any other party except for the consumer. In a recent survey of the 142 food processors in the county, 77% of respondents said they utilize wholesale as a method for distribution.[144] Almost 50% of respondents said they utilize local and regional retail sales for distribution.[145] Numerous gaps in data currently exist, and estimates are not available for the number of post-harvest storage facilities, shippers, and brokers in the county. Additional research and data are needed to better understand the role of wholesale in the local food system.

Breakdown of Food Processors in Sonoma County

The *2009 Sonoma County Food Processing Industry Report* illustrates the breakdown of the primary operations of food processors in Sonoma County (Figure 5 below). According to the report, pastry and baked products, dairy-based products, poultry products, and fruit-based products together accounted for 71% of the 43 operations surveyed. It also reveals the large number of artisan bakeries and other sweets processors and olive oil processors.

Figure 5. Primary Operations of Food Processors in Sonoma County, 2009.



Source: Sonoma County Food Processing Industry Report, 2009.[146]

Apple Production Decline: the Interrelationship between Production and Processing

Once known as the "Gravenstein Capitol" of the World, Sonoma County apple production and processing have declined with time. In 1958, there were 40 apple processors in Sonoma County. Today, the county has two remaining apple processors, Manzana Products, located north of Sebastopol, and Ratzlaff Ranch, located in Occidental. In 2010, nearly 90% of harvested apples were processed. Processed apples receive a much lower price per acre than fresh fruit, $877 per acre compared to $7,144 per acre.[147]

In the 1980's the local apple co-op sold its two canneries in Sebastopol to Vacu Dry. Vacu Dry encouraged apple farmers to grow the Rome variety of apples because they dry well. They successfully marketed dried apples for several years, but in the 1990's Vacu Dry decided to sell the plant to a large Washington processor.[148] This change left the apple farmers with crops they couldn't afford to harvest because they had no convenient place to dry the apples. Community Alliance with Family Farmers convened a meeting of famers to discuss this shift. Alternative apple outlets were discussed, but none wanted such large quantities of one variety.[149] The sale of the canneries in the 1980's made it prohibitive for local farmers to retrieve their previous co-op structure. This accelerated the removal of orchards in west Sonoma County and the planting of grapes.

Pressing Need for Local Meat Processing

There is a growing demand from ranchers for local meat processing facilities in Sonoma County. Selling locally produced meat requires a USDA-inspected harvest and processing facility within a cost-effective distance to the livestock producer. The last remaining beef slaughterhouse in the Bay Area is Rancho Veal, a more than 90 year old Petaluma slaughterhouse that services many of the north county's grass-fed beef and dairy ranchers. Rancho Veal's aging owners will eventually retire and the cattle producing region along the North Coast will have to find a replacement processing plant or encourage someone to buy the property and keep it as a processing facility. Local ranchers have expressed interest in buying Rancho Veal to retain a slaughterhouse for local beef producers.

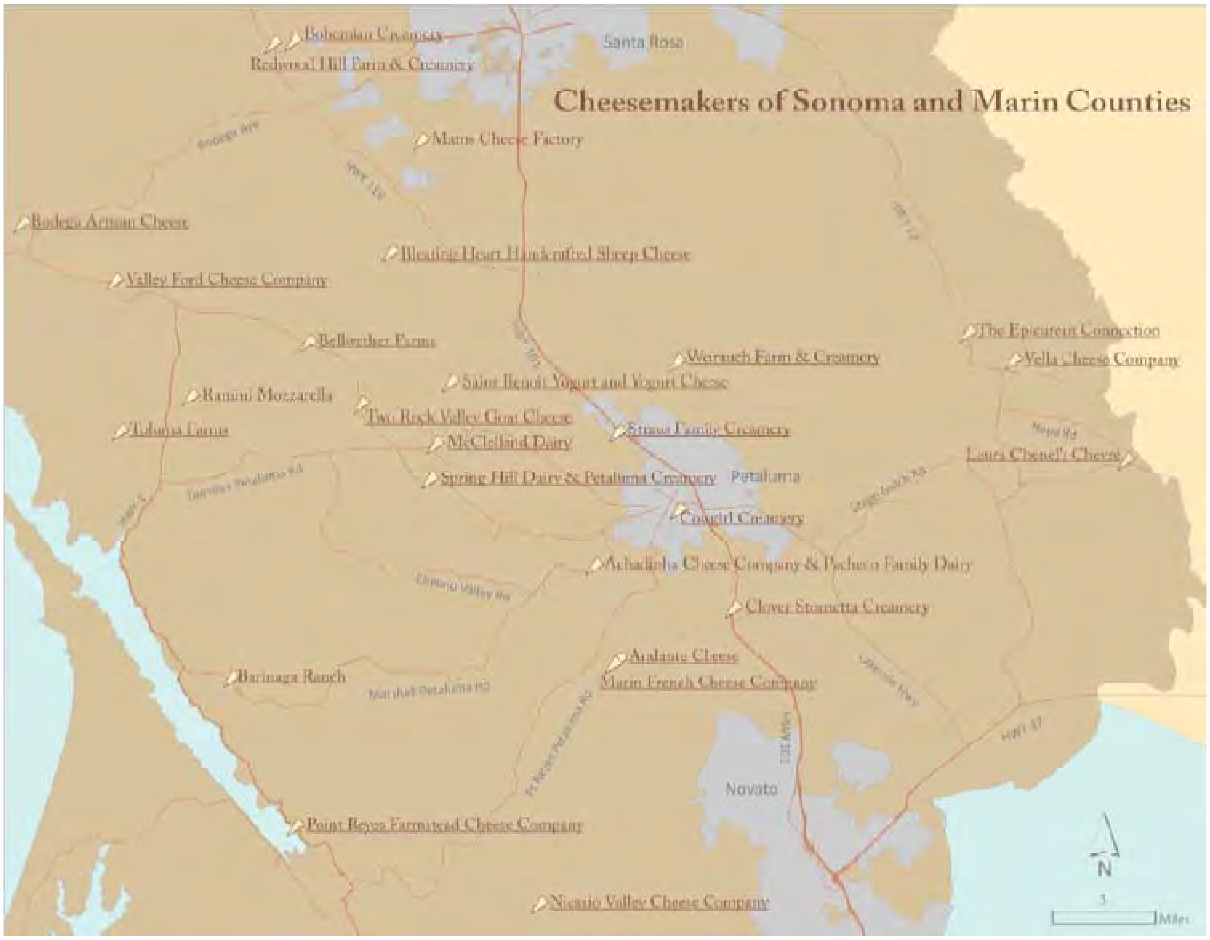
Emerging Opportunities for Local Meat Processing

A 2009 research study conducted by University of California Cooperative Extension (UCCE) outlines the capacity and feasibility of creating a modern small-scale multi-species harvest and meat processing plant for the North Coast of California. The study examined the feasibility of creating a new facility to serve as a model for an integrated, efficient, and economically successful regional meat industry based on a modern New Zealand slaughterhouse design. In just a few decades, New Zealand transitioned from a large, centralized meatpacking system to focusing on small, clean, efficient slaughterhouses dispersed throughout the country. The research examined facilities design and cost, potential livestock supply, niche market demand, and an economic analysis of a niche meats processing facility.[150] The research study concluded that livestock sales volumes are more than adequate to support the proposed processing facility along with continuation of sales through traditional markets. Sixty-one percent of the ranchers surveyed in the study rated the access/availability of slaughter and processing facilities as "very deficient".[151] On average, the surveyed ranchers reported a one-way transport time of 97 minutes to travel to a slaughter processing facility. According to the UCCE study results, the establishment of a new processing facility would not only meet the demand for local processing, but would create additional positive economic impacts. These impacts will be detailed further in Chapter Six of this report.

Production of Cheese and Fermented Milk Products Thriving

The production of cheese and fermented milk products is a growing industry that continues to create jobs, employing 303 people full-time and 29 part-time in Marin and Sonoma counties. Over 22,000 acres in the two counties are dedicated to dairy production that includes cheese and fermented milk products.[152] Map 7 represents the general location of the dairies and creameries in both counties.

Map 7. Cheesemakers of Sonoma and Marin Counties, 2011.



Source: Coming of Age: The Status of North Bay Artisan Cheesemaking, 2011.[153]

The North Bay has the largest concentration of artisan cheesemakers in the state. As defined by the American Cheese Society (ACS) the work “artisan” or “artisanal” implies that a cheese is produced primarily by hand, in small batches, with particular attention paid to the tradition of the cheesemakers’ art, using as little mechanization as possible. Farmstead cheese is artisan cheese, but an artisan cheese is not necessarily a farmstead cheese. In order for a cheese to be classified as “farmstead,” the cheese must be made with milk from the farmer’s own herd, or lock, on the farm where the animals are raised. Table 12 shows the characteristics of North Bay creameries.

Table 12: North Bay Creamery Characteristics.

Farmstead		Artisan		Industrial	
Small 10-100 gallon batch Under 25,000 lbs/year	5	*Small* 10-100 gallon batch Under 25,000 lbs/year	2	*Small* 1,500-3,000 gallon batch Under 75,000 lbs/year	0
Medium 100-400 gallon batch Under 100,000 lbs/year	4	*Medium* 100-400 gallon batch Under 100,000 lbs/year	2	*Medium* 3,000-5,000 gallon batch Under 1,300,000 lbs/year	1
Large 400-1,500 gallon batch Under 400,000 lbs/year	1	*Large* 400-1,500 gallon batch Under 400,000 lbs/year	5	*Large* Over 5,000 gallon batch Everything else	2
Total	**10**		**9**		**3**

Source: Coming of Age: The Status of North Bay Artisan Cheesemaking, 2011.[154]

Cheesemakers. Sonoma and Marin counties house twenty-two commercial licensed cheese plants, with four more planning to begin production. The longest continuously operating cheese company in the U.S., Marin French Cheese, has been in business since 1865, while the newest, Nicasio Valley Cheese Company, started in 2010.[155] In 2010, the North Bay produced 7,918,570 pounds and 95 different varieties of cheese. In total, the North Bay's farmstead and artisan cheeses production is approximately 3% of the total specialty cheese production for the state.[156]

Creameries. Five local creameries, including Redwood Hill Farm and Creamery, Straus Family Creamery, Clover Stornetta Farms, Sain Benoit Yogurt, and Bellwether Farms, make their own fermented milk products such as kefir, yogurts, and yogurt cheese.[157] In addition, Wallaby Yogurt Company, located in Napa County, purchases 100% of their milk for yogurt production from six family dairies in Sonoma and Marin counties.

Milk suppliers. In order to manufacture the reported amount of cheese, in 2010, Sonoma and Marin produced 117,722,586 total pounds of milk used for cheese production. In the North Bay, 54% of Sonoma and Marin county artisan cheesemakers supply their own milk, 23% supply but supplement their own by buying from other local dairies, and 23% do not operate a dairy and purchase all of their milk for cheese production from local or regional dairies.[158]

Key Findings

- **Sonoma County has limited infrastructure for processing and distribution of local products.** Especially lacking is a multi-species meat processing facility.

- **There are a growing number of cheese producers in Sonoma County and surrounding areas thanks to excellent pasture and climate.**

- **There is a need to develop and train more farmers to develop sufficient supply to meet the demands of large buyers.**

VI. Economic Viability

Photo: Sonoma.net

Goal: Farming and food system work are economically viable and respected occupations.

What Is Economic Viability in Farming and Food System Work?

Economic viability in the food system refers to the long-term sustainability of businesses or operations that have some role in the food system. This begins with the farmers, ranchers, and fishers who produce the raw food products and includes all the various processors, distributors, retailers, and other businesses that have a role in delivering food to the consumer. While economic viability often refers to the profitability of a business, it is also impacted by a range of issues in the larger economy, environment, and political system that influence the ability of a business to thrive.

Why Is This Goal Important?

Local farmers and food producers face many challenges to developing and managing profitable businesses. Sonoma County Food System Alliance members identified a number of common barriers to expansion of local food production that are also supported by research:[159]

- Capacity limitations constrain small, local growers who cannot meet demands for high volumes, consistent quality, timely deliveries, and out-of-season availability
- Significant costs of direct marketing and on-farm processing
- Lack of infrastructure related to distribution of local food
- Limited farmer expertise and training
- Regulatory uncertainties and burdens
- The high cost of land, labor, and water

Helping local farmers and producers increase their economic viability is critical if Sonoma County is to achieve the SCFSA vision of a food system where local farms and operations play a primary role in producing food that is consumed locally. In this time of national and international economic recession, supporting local farmers and local food businesses is increasingly recognized as a powerful opportunity to jumpstart the local economy.[160] Research demonstrates that locally directed spending by consumers more than doubles the number of dollars circulating among businesses in the community, creating a local stimulus effect.[161] For example, a study examining the economic impact of localizing Detroit's food system concluded that shifting 20% of food spending to local purchases would increase annual economic output by nearly half a billion dollars. This would create 4,700 more jobs, paying $125 million more in earnings, and the city would receive nearly $20 million more in business taxes each year.[162] According to another recent report examining business community food enterprises, every dollar spent at a locally owned food grocer contributes two to four times as many economic benefits as does a dollar spent at a non-locally owned food business.[163] In addition, in the current global food system, approximately 73 cents of every U.S. dollar spent on food goes to distribution, including advertising, trucking, packaging, refrigeration, and others involved in this process.[164] Studies prove that a local food business can reduce distribution costs to 20 cents on the dollar.[165] This can result in lower prices for consumers and increased income for farmers.

How Is Sonoma County Doing?

Many Farmers Likely Not Relying on Farm Sales as Primary Income

According to data from the 2007 Census of Agriculture, average net farm income for all farms in Sonoma County was $23,671, with a large percentage of farms (43%) reporting sales of less than $10,000 per year (see Table 13). This low level of income indicates that many farmers are likely not relying on their farm sales as a primary source of income.

Table 13. Farms, by Value of Sales, in Sonoma County, 2007.

Number of Farms by value of sales	
Total	3,429 (100%)
< $10,000	1,479 (43%)
$10,000 - $24,999	558 (16%)
$25,000 - $49,999	352 (10%)
$50,000 - $ 99,999	334 (10%)
$100,000 - $249,000	318 (9%)
≥ $250,000	388 (11%)
Average net farm income	**$23,671**

Source: 2007 Census of Agriculture, Sonoma County.[166]

Table 14 shows the distribution of Sonoma County farms by selected characteristics of the principal operator. Of the 3,439 farms reported in 2007, over half of them (53%) indicated a primary occupation other than farming. This reinforces the income data shown above, and demonstrates that many farmers need to supplement farm income from other sources.

Thirty percent (30%) of farms report value of sales over $50,000, a relatively high figure, which may reflect the significant amount of Sonoma County farm acreage devoted to grapes for wine production. The 2007 Census of Agriculture data do not provide a breakdown of farm sales by primary crop or commodity group.

Profile of Farm Operators Changing

Also seen in Table 14, the large majority of farms (80%) reported a male as the primary operator in 2007. However, from 1997 to 2007, the proportion of female prime operators increased from 14% to 20%.[167] The number or minority operated farms has increased 211% in Sonoma County over the past 15 years, increasing from 131 farms in 1992 to 408 total farm operations in 2007, representing 12% of all farms. According to available data, the most growth has occurred in the Hispanic/Latino population, from 67 Hispanic/Latino operated farms in 1992 to 298 in 2007, an increase of 345%.[168] The average age of the principal operator was reported to be 59.4 years of age in 2007, mirroring a national trend in the aging of farm operators over time. The average age for Sonoma County farmers has increased by 5.7 years over the past twenty years.

Table 14. Number of Farms, by Principal Operator Characteristics in Sonoma County, 2007.

Farms, by Primary Occupation of Principal Operator	
Farming	1,621 (47%)
Other	1,808 (53%)
Farms, by Gender of Principal Operator	
Male	2,738 (80%)
Female	691 (20%)
Farms, by Race/Ethnicity of Principal operator	3,429 (100%)
Hispanic/Latino	298 (9%)
Asian	51 (1.5%)
American Indian	59 (2%)
African American	No Data
Total minority	408 (12%)
Average Age of Principal Operator	**59.4**

Source: 2007 Census of Agriculture, Sonoma County.[169]

Local Food Processing's Effect on Local Economy

As discussed in previous chapters, prospective and growing local food industries influence the economic viability of local farmers, local food manufacturers, and the overall local economy. As the local food processing industry expands, there will be an increase in the demand for workers, both skilled and unskilled.

***Effects of artisan cheese making*.** The growing artisan cheese industry in the North Bay has already employed 303 full-time employees and, of those surveyed, 63% were in some stage of building or expanding their cheese plants and creameries.[170] As a result, eight different local electrical, plumbing, and dairy contraction contractors and companies were hired to complete these development projects.[171]

***Economic projections of proposed meat processing facility*.** The meat processing feasibility study discussed in Chapter Five included an analysis of the projected economic impacts of the proposed processing facility. The study used the software program IMPLAN, which utilizes input-output analysis, to take into account the ripple effects of the economic activity in the 10-county region associated with the increased values of meat processing and livestock production attributed to the proposed facility. The study estimated that the gross value of livestock sales in the region would increase from $15.8 million to $29 million annually, and that the processing facility would produce $58.2 million of slaughtered and processed meat. The economic analysis also determined that the establishment of the processing facility would generate an additional 682 full-time equivalent jobs, labor income would rise to a net $16 million, and the total value added to the regional economy would be an estimated $23 million.[172]

There Are a Number of Organizations Involved in Promoting Farm Viability

A number of local organizations are working within the county and regionally to increase the competitiveness and profitability of local farmers and producers and to support the development of new market opportunities.

University of California Cooperative Extension (UCCE). UCCE, in partnership with the County of Sonoma, offers a range of services and programs that maintain and increase the sustainability of agriculture and natural resources in Sonoma County. UCCE staff offer Sonoma County landowners help in the following areas of agricultural viability:

- Provide information to grape growers on the biology, current monitoring techniques and control strategies for European Grapevine Moth by conducting research field trials on new insect monitoring techniques and control strategies using conventional and organically registered insecticides.
- Work with county agencies and grower organizations to develop a county-based program that permits active frost protection system installation and operation.
- Help local producers with olive oil, apple, berry, and vegetable production techniques to improve yields and quality, lower costs, and help local growers with organic and sustainable practices that are scientifically valid.
- Educate landowners about the Coho salmon recovery plan, the importance of their collaboration, and the need for Coho recovery such that long term stability in water resources can sustain agriculture, fish, and the people in the county.
- Work with rangeland owners and managers to increase ecosystem services that provide both ecological and economical returns to residents and the environment.
- Focus on environmental, economic, and social issues affecting the county's youth, families, and communities.

Sonoma County Farm Bureau. Founded in 1917 by concerned farmers and ranchers, the Farm Bureau is a grassroots organization that brings the agricultural community together to work on issues that affect the viability of farming. The Farm Bureau's mission is to represent, protect, and advance the economic and social interests of farmers and to preserve Sonoma County farmland and the county's rich agricultural heritage. Today, much of Sonoma County Farm Bureau's work is focused on teaching the urban population, particularly school children, about the importance of agriculture to Sonoma County's economy, open space, and lifestyle.

Commodity specific groups. In addition to the Farm Bureau, there are a number of groups that focus on the promotion of specific commodity groups, such as the Western United Dairyman, or groups that promote the winegrape and apple industries.

California FarmLink. The mission of FarmLink is to build family farming and conserve farmland in California. FarmLink offers a variety of free and low cost programs and services for farms and farmers such as:

- A land linking program that matches retiring farmers and landowners with beginning and aspiring farmers, promoting continued agricultural production and the protection of farmland.
- Farmer advocacy to support better local, state, and national programs and policies to support small, beginning, and underserved farmers.
- Workshops and technical assistance throughout the state of California.
- A Farm Opportunities Loan Program that provides low-interest agricultural guaranteed loans to farmers who may not be immediately bankable by traditional lenders. Applicants are provided with technical assistance in putting together a strong loan package, as well as continued coaching and support in order to ensure the long-term sustainability of their farm business.
- Intergenerational farm transition assistance to address the goals of parents, on-farm children or heirs, and children or heirs who are not interested in living or working on the farm in the future.
- An individual development accounts (IDA) program that helps farmers save money and build equity in order to buy an asset for their farm or to put a down payment on land. Each year, FarmLink hosts a variety of farmer/rancher workshops, varying from farm finance expo's to value-added production workshops.

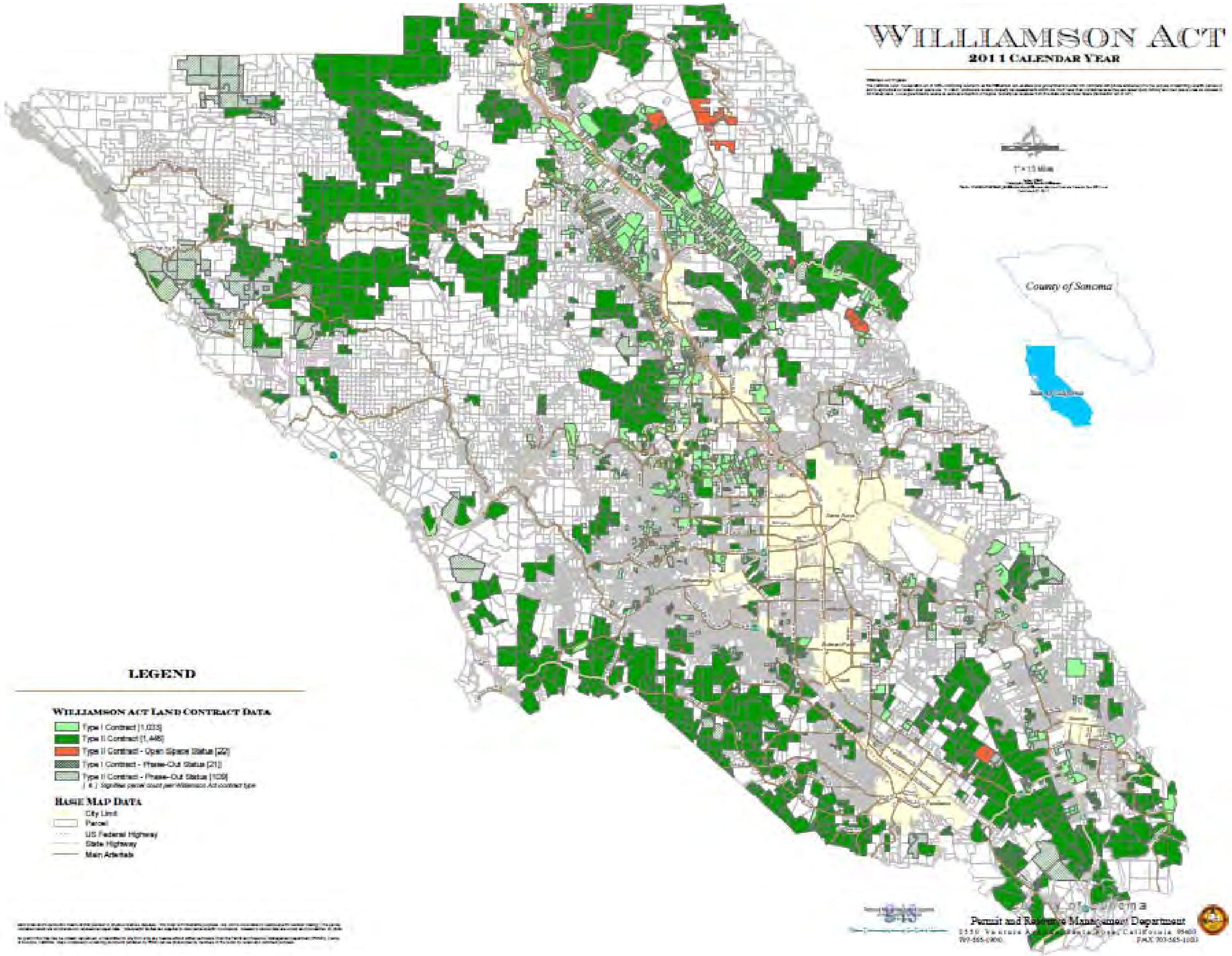
FarmLink has four regional outreach staff covering the state, with one dedicated specifically to the North Coast region. Outreach staff work directly with farmers and ranchers in their regions, providing assistance in all of the above mentioned areas.

***Community Alliance with Family Farmers (CAFF)*. ** CAFF was founded in 1978 to foster family-scale agriculture that cares for the land, sustains local economies, and promotes social justice. As mentioned previously, CAFF is currently working on a USDA-funded planning project to study the feasibility of establishing an aggregation center for locally grown foods in the North Coast of California. This project has potential to improve economic viability of local farm operations by creating a single point of purchase and sale for locally grown farm products enabling buyers to purchase source-verified agricultural products from small farmers in the North Coast region with ease. The second goal of the project is to create new markets for family farmers in the region, which could help generate greater profits for producers, adding value to their products by aggregating and marketing them as locally grown. Study results will be released after the final report is completed in summer 2011.

Sonoma County Agricultural Preservation and Open Space District (The District). The District was founded in 1990 to permanently protect the diverse agricultural, natural resource, and scenic open space lands for future generations. It features a broad range of programs to help Sonoma County fulfill its goals of preserving the land and providing open spaces for generations to enjoy, including a matching grants program and the Small Farms Initiative. With the Small Farms Initiative, the District leases land to farmers who grow vegetables, flowers, herbs, and berries. The leases ensure that some lands zoned for agriculture are preserved for that purpose and allow access for farmers who may not otherwise be able to find land to lease or buy. This initiative aims to promote the continued viability of agricultural lands in Sonoma County by keeping land in agriculture.

***The California Land Conservation Act of 1965**.* Commonly referred to as the Williamson Act, this legislation enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agriculture or related open space use. In return, landowners receive property tax assessments that are much lower than normal because they are based on farming and open space uses as opposed to full market value. Local governments have historically received an annual subvention, or financial support, of a portion of the forgone property tax revenues from the state via the Open Space Subvention Act of 1971, which was enacted on January 1, 1972, to provide for the partial replacement of local property tax revenue foregone as a result of participation in the California Land Conservation (Williamson) Act and other enforceable open space restriction programs. In 2009 Sonoma County received over $430,000 in subvention revenue from the state. As of January 2011, there are 2,661 parcels located within the Agricultural Preserves under Williamson Act contracts in Sonoma County comprising a total of 295,383 acres or approximately 29% of the 1,008,563 total acres in the county.[173] Map 8 identifies 2011 Williamson Act land in Sonoma County.

Map 8: Williamson Act Land in Sonoma County, 2011.



Key Findings

- **A large percentage of farm businesses in Sonoma County are small operations, with 43% reporting annual incomes of less than $10,000.**

- **Local small growers have capacity limitations that make it difficult to meet demand for high volumes, consistent quality, and timely deliveries.**

- **Sonoma County has limited infrastructure for processing and distribution of local products, which challenges the economic viability of local farm and ranch operations.**

- **Investing in local distribution and processing facilities could bring significant economic benefit to Sonoma County, through new jobs, recirculation of sales dollars locally, and increased sales tax revenues to municipalities**

VII. Opportunities for Food System and Farm Workers

Photo: photobucket.com/image/farm%20workers

Goal: There are meaningful livelihoods and opportunities for all food system and farm workers.

What Are Meaningful Livelihoods and Opportunities?

Meaningful livelihoods and opportunities refer to the ability of food system and farm workers to obtain a quality of life that can support and sustain their well being and that of their families. This includes access to fair wages and benefits, safe working conditions, and opportunities for economic self-sufficiency. Food system and farm workers include everyone employed in the business of growing, processing, and distributing food, including those who work in food preparation and service.

Why Is This Goal Important?

A meaningful livelihood is about basic equity for people working in the food and agriculture industries. The SCFSA vision seeks “a healthy life for all members of our community” and this includes those in traditionally low-wage industries such as food and agriculture. A key aspect of a meaningful livelihood is earning a “living wage,” or the minimum wage necessary to meet basic needs, such as food, clothing, and housing. Other important aspects include whether workers have safe working conditions, health insurance, access to affordable housing, and long-term opportunities to develop businesses or progress in their careers. A food system is truly sustainable only if each part of the food system, from seed to table and back to soil, is environmentally regenerative, economically viable, and supports a healthy life for all members of the community, including food system and farm workers.

How Is Sonoma County Doing?

Wages for Most food System and Farm Workers Below County Average

The U.S. Bureau of Labor Statistics (BLS) provides data on employment and average annual wages for Sonoma County as part of its Occupational Employment Statistics. Although a specific data category does not exist for “food system related jobs” within the occupation codes used by the BLS, Table 15 summarizes the employment and average wage estimates for occupation categories most directly related to production, processing, and distribution activities within the food system.

Table 15 shows a total of 176,960 jobs for Sonoma County as of May 2009, with an average annual wage of $47,110 across all occupations. Of the total jobs in the county, approximately 12% (or 21,688) are in occupations related to the food system, with the largest percent being in the lowest paid occupations related to food preparation and serving. Except for a small group of food-related managers, who earn higher than the average annual wage for Sonoma County, most food system and farm workers earn significantly less than the county average, with an annual average of $22,820 per year for food preparation and serving occupations, $25,270 for farming, fishing and forestry workers, and $26,574 for other food production workers. These reported food system worker wages are close to the Federal Poverty Level for a family of 4 reported ($22,050) in Chapter One of this assessment.[174]

Moreover, farm workers are the only employees in California who don't receive overtime after eight hours per day or 40 hours per week.[175] Overtime for farm workers currently starts at 10 hours per day or 60 hours per week. Farm workers' exclusion from the Fair Labor Standards Act of 1938, the law governing overtime for employees, is seen by workers rights activists as a violation and form of racism. Legislation introduced to extend overtime pay to farm workers who work more than 8 hours a day was vetoed by the California Governor on July 28, 2010.[176]

Table 15. Employment and Annual Average Wage Estimates, Total and by Food System Occupations in Sonoma County, May 2009.

Occupation Code	Occupation Title	Employment	Mean Annual Wages
00-0000	**All Occupations**	**176,960**	**$47,110**
35-0000	**Food Preparation and Serving Related Occupations**	**17,120**	**$22,820**
35-1011	Chefs and head cooks	220	$49,310
35-1012	First-line supervisors of food preparation and serving workers	1,240	$31,540
35-2011	Cooks, fast food	1,260	$19,000
35-2012	Cooks, institution and cafeteria	330	$30,760
35-2014	Cooks, restaurant	1,280	$26,210
35-2015	Cooks, short order	210	$23,630
35-2019	Cooks, all other	40	$29,450
35-2021	Food preparation workers	1,380	$21,850
35-3011	Bartenders	750	$24,420
35-3021	Combined food preparation and serving workers, including fast food	3,240	$20,550
35-3022	Counter attendants	820	$19,800
35-3031	Waiters and waitresses	3,550	$22,230
35-3041	Food servers, nonrestaurant	140	$23,410
35-9011	Dining room, cafeteria attendants, bartender helpers	980	$19,460
35-9021	Dishwashers	1,130	$20,550
35-9031	Hosts and hostesses	500	$20,290
35-9099	Food preparation and serving, other	8	$18,330
45-0000	**Farming, Fishing and Forestry Occupations**	**2,200**	**$25,270**
45-1011	First-line supervisors of farming, fishing, forestry workers	170	$41,450
45-2091	Agricultural equipment operators	180	$33,540
45-2092	Farmworkers and laborers, crop, nursery, and greenhouse	1,660	$22,440
45-2093	Farmworkers: farm and ranch animals	110	$24,430
	Food-related Managers	**498**	**$50,301**
11-9011	Farm, Ranch, and Other Agricultural Managers	8	$73,040
11-9051	Food Service Managers	490	$49,930
	Food Production, Other	**1,870**	**$26,574**
51-3011	Baker	260	$30,620
51-3021	Butchers and Meat Cutters	370	$30,670
51-3021	Meat, Poultry, and Fish Cutters and Trimmers	160	$25,950
51-3092	Food Batchmakers	820	$24,450
51-3093	Food Cooking Machine Operators and Tenders	260	$23,780
	Food System Employment - Total	**21,688 (12.3%)**	

Source: Bureau of Labor Statistics, Occupational Employment Statistics[177]

Beyond Wages: Other Needed Improvements in Farm and Food Service Livelihoods and Opportunities

In addition to the concerns about low wages received by farm and food services workers, initial conversations with members of the SCFSA identified the following issues to be considered when working to improve the livelihoods and opportunities for farm and food system workers in Sonoma County:

- Access to health insurance and other benefits
- Access to affordable housing and transportation
- Safe working conditions and protection from hazards, such as exposure to pesticides
- Regulations restricting use of farm interns and volunteers
- Seasonal unemployment, lack of year-round work, and use of labor contractors
- Opportunities for farm laborers to become independent farmers
- Immigration laws
- 10-hour work day and 60-hour work week before receiving overtime pay

Farm Labor Practices: Opportunities and Trends Revealed by California Institute of Rural Studies

Benefits offered by different kinds of farms. While data are not readily available on these issues for Sonoma County farm operations, a recent study by the California Institute for Rural Studies (CIRS) provides useful baseline information on farm labor conditions for organic farms in California, including a comparison to findings reported previously from the Farm Employers Labor Service (FELS) annual wage and benefit survey for California growers.[178] These statewide studies confirm the relatively low wages reported by the BLS for farm workers, but also show that a significant number of farm operations in the state report offering some level of benefits to their employees. Table 16 shows that, in general, organic growers appear to offer better wages and are more likely to offer profit sharing or bonuses and food from the farm compared with those operations responding to the FELS survey, which included nonorganic farms as well. The respondents to the FELS survey were more likely to report offering health insurance, paid time off, retirement plans, and employee manuals.

Table 16. Farm Labor Conditions on California Farms.[179]

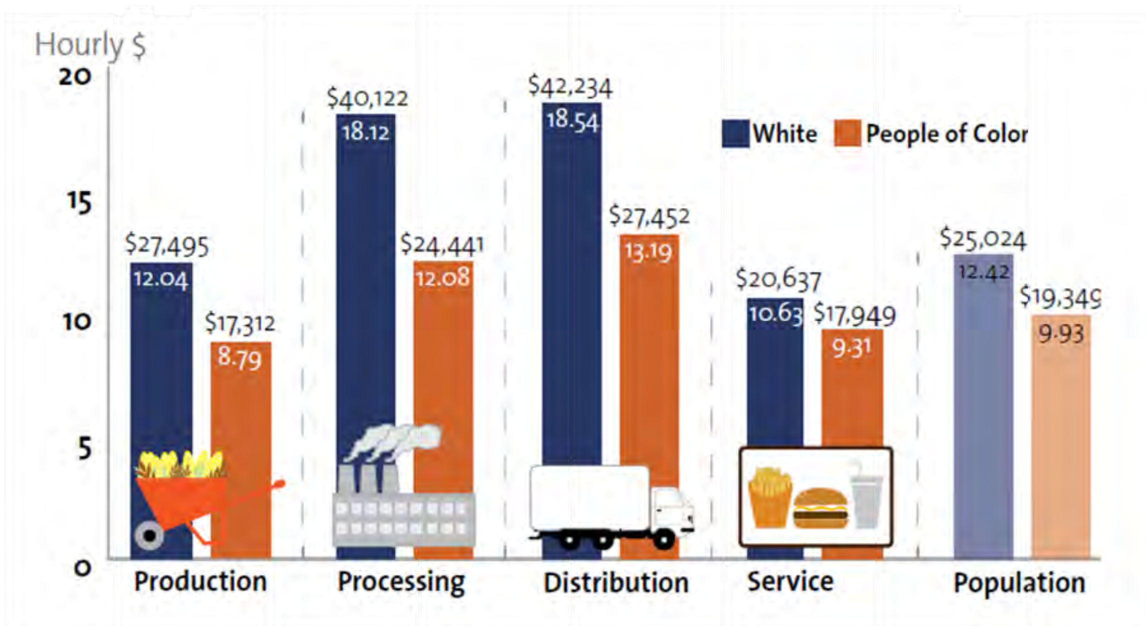
Wages/Benefits	FELS[180]	Organic Growers[181]
Hourly wage: Supervisor	$15.90	$16.18-$20.25
Hourly wage: Entry-level fieldworker	$7.91	$8.21
Hourly wage: Fieldworkers with most seniority	$8.54	$10.55
Health care: Employee only	46%	36%
Health care: Family	45%	23%
Paid time off (PTO)	68%	57%
Average days PTO	6.1	9.7
Profit-sharing/bonus	43%	71%
Retirement/pension	27%	19%
Housing	28%	28%
Utilities paid	20%	37%
Farm products	16%	72%
Employee manual	62%	46%

Beneficial effects of positive labor conditions. Other key findings from this study included an association between positive farm labor conditions and increased five- and ten-year employee retention rates. Benefits most closely associated with retention include bonuses/profit-sharing, housing assistance, personal loans, food from the farm, and paid time off. Respondents to the CIRS study also reported high levels of interest in some sort of "fair labor" certification or labeling program that would provide price premiums and market differentiation for growers offering good farm labor conditions. CIRS provides a range of services and technical assistance to help farm employers improve conditions for farm workers while improving economic viability. For example, their publication, *Beyond Basic Compensation*, provides information on a range of strategies growers can use, such as profit sharing, bonuses, and employee ownership.[182]

Inequities Related to Race, Gender, and Class

Economic inequities. Food workers suffer from high rates of food insecurity, malnutrition and hunger. In California, 45 percent of surveyed agricultural workers were food insecure, and nearly half were on food stamps.[183] In addition, people of color in the U.S. typically make less than whites, hold fewer management positions, and are concentrated in low-wage and more vulnerable jobs in the food system. Workers of color earn 20% less than their white counterparts for equal work, and for women, every dollar a white male worker earns, women of color earn around half that amount.[184] Whites dominate high-wage professional and management occupations with three out of every four managers in the food system being white. Fifty percent of food production workers are people of color working low wage jobs. This includes farm workers, 65% of whom are Latino.[185] Figure 6 illustrates the median hourly and annual racial wage gaps in the four identified food sectors.

Figure 6: Racial Wage Gap in the Four Food Sectors in the United States, 2008.



Source: The Color of Food[186]

Working condition inequities. In addition to low wages, farmworkers have a higher rate of toxic chemical injuries than workers in any other sector of the U.S. economy, with an estimated 300,000 farmworkers suffering from pesticide poisoning annually.[187] Service workers in the restaurant industry have also been reported to face unfair labor practices ranging from employers withholding wages to not getting paid for overtime. In addition, many sectors of the food chain are excluded from the protections of federal labor laws. This includes farmworkers, tipped minimum wage workers such as those in restaurants, and the formerly incarcerated.[188]

Recommendations for Further Research

Understanding more about wages, benefits, working conditions, and opportunities for local farm and food system workers is an important area for future research in Sonoma County. The SCFSA might consider partnering with CIRS or other experienced labor research organizations to develop better local data. A number of local organizations are working to support food system and farm worker conditions and rights. Organizations such as the Graton Day Labor Center, North Bay Labor Council, North Bay Organizing Committee, United Food and Community Workers, United Farm Workers, Hotel Employee and Restaurant Workers, and Living Wage Coalition, for example, could become partners in researching existing working conditions and identifying opportunities for improvement.

Key Findings

- **The low wages reported for farm and food system workers in Sonoma County suggest that many workers or families will have to take multiple jobs to make ends meet.** These pressures reduce the amount of time that workers have to rest, spend with their families and contribute to community life.

- **Improved benefits and conditions for workers can increase economic viability.** A growing body of research shows ways that farm or food system employers can increase the viability of their operations by offering a range of benefits that help to develop a skilled, stable, and satisfied workforce.

- **Better data is needed on wages, benefits, and working conditions associated with farm and food system workers in Sonoma County so as to identify opportunities to improve the health and well-being of these workers and their families.**

- **Farm worker overtime laws need to be revisited at the statewide level.**

VIII. Environmental Regeneration

Photo: sonomacounty.golocal.coop/businesses/sonoma_compost

Goal: Local agriculture, food production, distribution, consumption, and food waste management are part of a food system that regenerates nature.

What Is a Regenerative Food System?

Global food production has caused major changes in the natural world. Ten percent of the Earth's land surface is now used for growing crops, another 20% is rangeland, and 75% of fisheries are being fished "at or beyond their sustainable capacity."[189] Much of this food production is not sustainable, let alone regenerative. An ideal regenerative food system would provide food to meet current needs, while stewarding resources and mitigating harmful impacts on watersheds and wildlife. It would build rather than lose soil, treat 'wastes' as resources rather than liabilities, sequester more greenhouse gases than it emits, and enhance the health of the people who eat the food that the system produces.

Why Is This Goal Important?

The environmental costs of unsustainable farming are paid for by all, since we are all both consumers of food and dwellers in the environment. Commonly referred to as externalities, these costs may include pollution of water bodies, loss of soil and farmland, loss of pollinators, drop in biodiversity, ecosystem fragmentation and collapse, buildup of harmful chemicals in the air, water, soil and our bodies, buildup of polluting wastes, and increased greenhouse gas emissions. Regenerative agriculture improves nature's ability to provide ecosystem services, increase biodiversity, and sequester carbon in plants and soil. Through our consumer choices we can support regenerative agriculture world-wide and help to improve the health of ecosystems and people in many parts of the world. By supporting regenerative agriculture in Sonoma County, we can ensure that we continue to live in a healthy, productive and beautiful place.

How Is Sonoma County Doing?

The cumulative environmental impacts of agriculture in Sonoma County are not tracked, but a picture of the current sustainability of local agriculture can be sketched by taking a look at a few indicators. The impact that agriculture can have on the environment is common to many other kinds of human activities: pollution, emission of greenhouse gases, and loss of biodiversity from changes in land and water use. Some of these impacts can be estimated fairly directly, others can only be inferred. Most of the negative environmental impacts of the food that we eat in Sonoma County occur somewhere else since we import so much of our food. Estimating the damage to the environment from these imports is beyond the scope of this assessment. We will only consider here some impacts of local agriculture such as pesticide use, water pollution, habitat damage, greenhouse gas emissions, and the problem of food waste disposal, as well as the beneficial practice of organic farming.

Pesticide Use

About 2,150,000 pounds of pesticides were applied in 2009 in rural and urban areas in Sonoma County.[190] Most were used on wine grapes (1,995,710 pounds), on public and private landscaping, and on clearing right of ways (41,730 pounds). Table 17 illustrates the amount and toxicities of the five most commonly used pesticides in Sonoma County. Many other compounds (some much more toxic than those listed) are used in smaller amounts in county agriculture. Generally the greatest danger of harm from these is to the workers who apply them.[191] Sonoma County falls somewhere in the middle of California counties in terms of pesticide use. Fresno County, at the high end, used 27,818,431 pounds of pesticides in 2009. Napa County used 1,542,060, while at the low end, 63,136 pounds were used in Marin and only 5,701 pounds were used in San Francisco County.

Table 17. Five most common pesticides used in Sonoma County: total pounds applied, uses, and toxicities, 2009.

Pesticide	Pounds	Application	Use	Toxicity[192]
Sulfur	1,445,258	wine grapes, apples, peaches	fungicide	not listed
Petroleum Distillates	129,518	wine grapes, apples, pears	pesticide	not listed
Mineral Oil	72,194	wine grapes, public health, apples	pesticide, mosquito control	slight toxicity
1,3-Dichloropropene	70,049	wine grapes	nematicide	acute toxicity, carcinogen
Glyphosate (Roundup)	64,682	wine grapes, right of ways, landscapes	herbicide	slight toxicity

Source: California Department of Pesticide Regulation and Pesticide Action Network.[193]

Water Pollution and Erosion

Agriculture is one of many human activities in the county that cause water pollution. As required by the Federal Clean Water Act, California publishes a list every two years (called the 303(d) list) of water bodies that are impaired by pollution of different kinds, and most of the streams and other water bodies in Sonoma County are on this list.[194] Almost all streams in the county, in both rural and urban areas, are impacted for sediment (from soil erosion) and for temperature (from loss of overhanging vegetation or low water flows).

Urban runoff, roads, logging, and agriculture are all sources of problems for watersheds, but we will focus here only on problems that are related to food system production. The following examples detail the impact of farming on two important county water bodies for which careful studies have been carried out.

The Estero Americano, a tidal estuary that flows into the ocean south of Bodega Bay, is surrounded by grassy hills that are prime grazing land, much of it in multi-generational farms raising livestock and chickens and producing dairy products. Agricultural activities have caused erosion, and soil washed into the Estero is filling it in and changing its shape and ecology. Animal waste also makes its way into the Estero in storm-water runoff and adds nitrogen and bacteria which have a negative effect on aquatic life. The Gold Ridge Resource Conservation District is working with farmers around the Estero to change long-held habits such as allowing livestock access to streams and improving manure treatment to reduce nitrogen runoff.[195]

The Russian River has the largest water catchment area in the county, covering 1,485 square miles. The middle reach of the River runs through miles of vineyards, while the lower end passes through forests. Many of its tributaries flow through cities; its largest and most polluted tributary, the Laguna de Santa Rosa, is located in the middle of dairy grazing lands and receives water from urban creeks. The Russian River is listed by the state of California as impacted for bacteria, sediment, temperature, and mercury.[196] Sources of the River's pollution are a complicated mix of urban runoff, logging, rural residential activities, and agriculture. Some of the known impacts to the Russian River and its tributary streams due to agriculture are listed here:

- ***Sediment runoff:*** When stream vegetation is removed, steep slopes planted, or fields or dirt roads are too close to the riparian zone, disturbed soil is washed into streams. This is a particular problem for the endangered salmon species of the Russian River because sediment tends to reduce oxygen in the water and fills in the deeper pools in the river in which young salmon shelter. Young salmon need clear water to find food and spawning adults need to lay their eggs in bare gravel. The Agricultural Commissioner's Office has printed a handbook explaining best management practices for vineyards to reduce sediment runoff into streams.[197]

- ***Temperature change:*** When streamside trees and shrubs are cut down to accommodate crops and roads, and the shading they provide is lost, stream water temperature rises, causing conditions that are fatal to young salmon and other aquatic life. In order to mitigate this effect and protect the area next to the stream (the riparian zone) the *Sonoma County General Plan 2020* requires a minimum 25 feet of planted area between the top of a stream bank and a field. However, this only applies to new plantings, and many activities, such as turning heavy equipment, are still allowed in this buffer zone.[198]

- ***Water quantity:*** Drainage systems in vineyards along the Russian River and its tributaries remove rainwater quickly from fields, which increases flood probability downstream in the rainy months and reduces summer flows, since rainfall is given less opportunity to soak into the ground to be released in the dry months.[199] Also, vineyards' use of water for frost protection in the spring and irrigation in the summer can draw down small streams to the point where fish cannot survive. An ordinance is being drafted that requires Sonoma County operators to have a state-approved water management plan in place demonstrating that the frost protection operation does not result in a reduction in stream flow.[200]

Finding common ground to solve water problems is difficult. A recent report by the California Roundtable on Water and Food Supply (a broad-based, multi-stakeholder group), called *Agricultural Water Stewardship*, attempts to reach consensus on these important issues. The report contains a list of general recommendations for farmers and policy makers around agricultural water use.[201]

Biodiversity

According to a recent collaborative paper on global limits in the scientific journal *Nature*, loss of biodiversity is the most advanced of all of the global environmental crises now happening.[202] Extinction of plant and animal species is occurring worldwide at more than 100 times the historical rate, and the most important contributing factor is the loss or degradation of habitat. Many kinds of land use contribute to this crisis, but irrigated crop agriculture, because of its intensive use of land, is one of the major players. Cultivating large areas in a single crop simplifies the ecosystem and removes habitat niches for most plants and many animals, even before the farmer eradicates 'weeds' and 'pests'.

Likely impact of different crops. Food-crop producing farms in Sonoma County have a minimal impact on habitat because of their low total acreage, small size, and crop diversity. Around half of them are also organic, which means that they don't use toxic pesticides. Wine grape-growing is likely to have a larger impact on Sonoma County biodiversity than food-growing because of the much larger acreage involved in this industry and large total use of pesticides.

Dairy grazing lands support vernal pool species. Sonoma County has a number of listed endangered species, most of which are declining in population because of loss or degradation of their habitat. For one type of wetland habitat though, agriculture and endangered species have been found to co-exist fairly well. The Santa Rosa Plain between the Highway 101 urban corridor and the Laguna de Santa Rosa has areas of unusual wetlands called vernal pools. These wetlands are home to species which are on both federal and state endangered species lists, such as several kinds of vernal pool flowers and the California Tiger Salamander. The main threat to the vernal pool species has been the spread of urban development, which drains and paves over the wetlands where they live. Grazing is a much more benign land use, and vernal pool species still survive on dairy lands in the Santa Rosa Plain.[203]

Effect of erosion and water quantity on fish populations*.* The best-known Sonoma County endangered species are coho and Chinook salmon, and steelhead trout. These are 'anadromous' fish that need to live in both freshwater and the ocean during different parts of their life cycle. Survival of one of these species in a water body is an indicator of the health of water quality and quantity. All of the anadromous fish species native to Sonoma County are threatened or endangered because of the condition of the streams in which they live.

What landowners can do to mitigate effects. There are many ways landowners can support native plants and wildlife in populated and developed areas. One of the most beneficial is to protect riparian zones and make sure that they are planted with thriving native vegetation. A narrow fringe of native plants along a stream will support native insects and birds, while wider riparian corridors allow larger species to hunt and travel through the landscape.[204] Sonoma County and neighboring jurisdictions encourage but do not require landowners to allow their stream banks to support native vegetation. Fencing is another hazard and impediment for wildlife. Wildlife-friendly fencing has been developed that allows wild animals to move over and under it, while keeping domestic animals in. Use of this fencing is encouraged by the *Sonoma County General Plan 2020* for areas identified as Habitat Connectivity Corridors.[205]

Crop diversity is helpful in supporting a diverse mix of insects, birds, and other small animals, but native plants host many more species than crop plants, which are usually non-native. Keeping a diverse selection of native plants near crops can provide pollinators with food and host plants. The North Coast Chapter of CAFF helps farmers plant different kinds of hedgerows for use as windbreaks, to reduce sediments and nutrient flow into waterways, increase beneficial insect populations, and increase overall ecological diversity.[206] The County's three Resource Conservation Districts (Sotoyome, Gold Ridge, and Southern Sonoma County) also encourage farmers and ranchers to plant hedgerows and to follow other practices that foster biodiversity.

Climate Change and Energy Use

In 2008 Sonoma County's Climate Protection Campaign (CPC) calculated that the largest source of greenhouse gases from agriculture was methane from livestock operations. The CPC's Community

Climate Action Plan, which analyzed the different kinds of greenhouse gas emissions in Sonoma County, estimated that in 2005 methane and nitrous oxide emitted by livestock and manure decomposition made up the bulk of agricultural sector emissions and 11% of the County's emissions.[207]

The CPC Action Plan found that local agricultural emissions were hard to calculate, but identified opportunities to reduce emissions in "soil and irrigation practices, composting agricultural waste, methane capture and dairy energy production, biomass fuel production, processing and operational efficiency, carbon dioxide sequestration, and land use and agricultural policies."[208] The recommended actions to sequester greenhouse gases include no-till organic farming, restoration of riparian habitat, diversifying vegetation around farms, and leaving forests intact.

Organic Agriculture

Organic farming builds soil, fosters biodiversity, and sequesters carbon.[209] In order to sell products as organic, Sonoma County producers must comply with both state and federal regulations.[210] The federal definition of organic is: "A production system that responds to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity."[211]

According to the 2009 Sonoma County crop report, there were 188 local growers of organic foods.[212] Typically small in size (less than 50 acres), but very diverse, Sonoma County organic farms produced 130 different commodities in 2009. To produce organic meat and dairy, 11,352 acres (3% of total grazing lands) were used for organic grazing, and 3,749 acres were used to raise organic grain and forage crops. More than 50% of acreage used to raise fruits (excluding winegrapes) and nuts in Sonoma County is certified organic, and 46% of local vegetables were grown organically in 2009. Some farmers use organic practices in their farming but opt not to become certified organic due to the cost of the certification process.

A little over 1% of vineyards in Sonoma County are organic. To address environmental problems and encourage organic winegrowing, the Sonoma County Winegrape Commission offers education and support groups for Organic Producers, Integrated Pest Management, and the California-Wide Code of Sustainable Winegrowing.[213]

Food Waste Management

Food waste occurs at several stages of the food production and consumption cycle. Jonathan Bloom, the author of the book *American Wasteland*, estimates that as much as 50% of edible food produced in the U.S. is thrown away.[214] Growing this wasted food uses an estimated 25% of the total annual fresh water used in the U.S., 4% of national energy consumption, and produces greenhouse gases as it decomposes in landfills.[215]

The following are points in the production and consumption cycle where food is likely to be lost.[216]

- Crops are left in the field because of bad weather, imperfections or labor shortage – it is estimated that from 5 to 20% of all crops in the U.S. are left to rot in place or plowed under.[217]

- Even though federal and state 'Good Samaritan' laws protect grocers from liability for illness from donated food, many stores choose to throw food out rather than donate it. A 2006 USDA study reported that supermarkets routinely throw out 5 to 9% of perishable foods.[218]

- Commercial kitchens throw away between 4 to 10% of the food that they buy.[219] A study by the U.K. Sustainable Restaurant Association showed that 30% of food waste from restaurants is uneaten food from customers' plates.[220]

- Refrigerator clutter: Up to 25% of the food that people buy and take home may end up getting thrown out.[221]

According to a 2007 report by the Sonoma County Waste Management Agency (SCWMA), food waste makes up about 21% (or 78,750 tons in 2007) of the compostable waste collected in the county from industrial, commercial, and residential sources.[222] This category, as defined by SCWMA, includes wasted edible food, food scraps from preparing and processing food, and some industrial processing wastes like grape pomace, the solid remains of wine grapes left over after pressing.

Sonoma Compost, a private company based at the county landfill near Petaluma, began composting yard waste in 1993 and started accepting plant-based food scraps in household yard waste bins in 2007. The finished compost is sold to local gardeners, landscapers, and growers. Pilot projects were started by the cities of Healdsburg and Sebastopol in 2010 to collect food waste from restaurants and other food outlets for Sonoma Compost to recycle into compost.[223]

Most Food Consumed in the County is Imported

Despite the beneficial environmental practices of many food producers in Sonoma County, most of the food that county residents eat comes from somewhere else, and much of that food is produced in ways that deplete soil, pollute, and cause damage to habitat. In considering the environmental impact of the Sonoma County food system, it is important to recognize our share in adding to the environmental impacts of the larger American and global food systems. Buying and consuming locally produced food in Sonoma County is generally an environmentally positive act because local farms and ranches are small and diverse, many of them are organic, and transportation from farm to plate is minimal.

Key Findings

- **Most of the water bodies in Sonoma County are on the state list as impaired due to pollution, including tidal estuaries and the Russian River.** Agriculture has a role in helping to find a solution to this problem.

- **Cumulative environmental impacts of agriculture in Sonoma County are not tracked.**

- **Loss of riparian habitat and other areas of native vegetation are important contributors to biodiversity loss in the County.**

- **Gases from livestock are the biggest contributor from agriculture to greenhouse gases in Sonoma County.**

- **Food imported into Sonoma County probably has a bigger environmental impact than the food produced in Sonoma County.**

IX. Conclusion

Photo: blogs.davenportlibrary.com/reference/2009/12/backyard-chickens/

This report highlights significant trends in the Sonoma County food system. For each of the 8 goals of the Sonoma County Food System Alliance (SCFSA), the document provides a review of existing data, trends, and issues to assist the community in assessing gaps, assets, and opportunities for collective action. It is anticipated that, over time, this assessment will stimulate thought and action about the Sonoma County food system, contribute to dialogue, and lead to creative collaboration and collective action.

Shifting any large-scale system takes dedication and time. This assessment provides baseline information to identify needs and opportunities to build a system to truly serve Sonoma County's changing food, health, economic, and environmental needs. As the linkages between food production, the environment, public health, and economic resilience become more visible, Sonoma County can be in the forefront of a growing movement to create a healthy and viable local food system for its residents.

Readers interested in continuing the food system dialogue in Sonoma County are encouraged to become involved in the work and activities of the Sonoma County Food System Alliance. Please visit the website, http://aginnovations.org/alliances/sonoma/, to view updated information, activities, and recommendations. With community input, commitment, and collaboration, Sonoma County can create a strong, healthy, and sustainable food system for future generations.

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[222] Sonoma County Waste Management Agency, *Waste Characterization Study: Final Report*, 2007. The definition of Food in this study is: "Food means food material resulting from the processing, storage, preparation, cooking, handling, or consumption of food. This includes material from industrial, commercial, or residential sources. Examples include discarded meat scraps, dairy products, egg shells, fruit or vegetable peels, and other food items from homes, stores, and restaurants. Also includes grape pomace and other processed residues or materials from canneries, wineries, or other industrial sources."

[223] Clark Mason, "Emerging trend: Turning commercial food waste into valuable compost," *The Press Democrat,* December 30, 2009, http://www.pressdemocrat.com/article/20091230/articles/912309960?p=1&tc=pg.

The Sonoma County Food System Alliance (SCFSA) is a forum for diverse stakeholders, such as food producers and distributors, food security organizations, public health advocates, and other community leaders, to work on increasing access to healthy food in Sonoma County and to envision, advocate for, and create a vibrant local food system in Sonoma County. SCFSA is part of a California network of county alliances and statewide roundtables that allow for consensus actions and policy recommendations from food and agriculture stakeholders. Ag Innovations Network is the convener/facilitator of SCFSA, and its mission is to promote the long-term health of the food system and in particular, of agricultural production, by facilitating critical dialogues within the food system, and between food system stakeholders and the wider public.

Ag Innovations Network
101 Morris Street, Suite 212
Sebastopol, CA 95472
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http://aginnovations.org/alliances/sonoma/

Proposed Agricultural Buffer Policy for Santa Barbara County

Santa Barbara County Ag Futures Alliance
February 2010

About the Santa Barbara County Ag Futures Alliance

The Santa Barbara County Ag Futures Alliance is a unique volunteer collaboration between leaders from agriculture, environmental, and community interests who have come together to "promote the long-term viability of agriculture in Santa Barbara County while addressing environmental and social concerns through an alliance that values dialogue and collaboration."

The Alliance was formed in 2007 when leaders from the Santa Barbara County Farm Bureau and the Environmental Defense Center invited a small group of growers, environmentalists, and community activists to meet at the Alma Rosa Winery in Buellton. Their invitation was simple: we can do a better job promoting agriculture and protecting the environment by working together.

The first year of the Alliance was devoted to building trust and mutual understanding between members through the development of the group's "Constitution." This document lays out the principles that guide an effective collaboration between agriculture, environment, and community interests.

Since then, the Alliance has been immersed in the question of how to protect Santa Barbara County's unique and valuable agriculture land and heritage. The focus ultimately turned to the challenge of conflicting land uses at the urban/ag boundary and resulted in the development of a "Proposed Agricultural Land Buffer Ordinance." Work on this proposal was completed in January 2010.

The Alliance is part of the statewide Ag Futures and Food Systems Alliances sponsored by Ag Innovations Network (AIN). The Alliance gratefully recognizes the financial support for its work provided by Roots of Change (http://rocfund.org), AIN, and local donors.

Alliance Members[1]

Robert Abbott, Abbott Ranch
Deborah Brasket, Santa Barbara County Action Network
Teri Bontrager, Santa Barbara County Farm Bureau
Eric Cárdenas, Orfalea Foundation
David Cleveland, Environmental Studies, UC Santa Barbara
Bonnie Crouse, UC Santa Barbara Dining Services
Jennifer Dolan, League of Women Voters Santa Maria Valley
Larry Lahr, Rincon Corporation
Christina McGinnis, OPEN Program, Environmental Defense Center
Kevin Merrill, Central Coast Wine Growers
Jim Poett, Rancho San Julian
Chris Thompson, Given Farms

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[1] Organization names provided for reference only. Members serve as individuals

February 4, 2009

Re: Agricultural Buffer Policy for Santa Barbara County

To All Interested Parties:

The Ag Futures Alliance of Santa Barbara County (AFA) is pleased to provide to you this copy of the proposed draft of an Agricultural Buffer Policy for Santa Barbara County, which members of the Alliance adopted by consensus in January 2010. This Draft is the culmination of many months of work by the members of our AFA, involving research, field studies, and hours of deliberation. It is the hope of the AFA that by developing and distributing this Draft, there will be momentum started which will result in the successful implementation of an Ag Buffer Policy in Santa Barbara.

An Ag Buffer Policy is intended to benefit agriculturalists that have operations adjacent to a proposed development project, such as a residential neighborhood or commercial center. The Ag Buffer will help ensure growers and ranchers that future conflicts are avoided with their future urban neighbors by requiring developers to create protective areas in their projects that will provide buffers from noise, dust, light, and odor that are generated from ordinary agricultural operations. The buffers will also provide the agricultural operations further protection from trespass, litter, pets, and pests generated by the urban uses.

Founded jointly in 2007 by the Santa Barbara County Farm Bureau and the Environmental Defense Center, Santa Barbara County AFA is an alliance consisting of agricultural, environmental, and community leaders that have the common goal to promote and preserve agriculture in Santa Barbara County, while maintaining a healthy environment. We believe that through collaboration versus confrontation, the difficult issues facing local agriculture can be more productively resolved.

The Santa Barbara County AFA appreciates your interest in this draft Agricultural Buffer Policy, and your input towards a successful implementation.

Respectfully,

SANTA BARBARA COUNTY AG FUTURES ALLIANCE

Proposed Agriculture Buffer Policy

1. Purpose/goal of policy

The County of Santa Barbara has stated that the continued use of agriculturally zoned property for agricultural operations is a high priority. When development is located adjacent to agricultural land, it has the potential to create conflicts due to abutting incompatible land use(s). To address this concern, the County has created the following agricultural buffer policy 1) to protect land that is currently agriculturally zoned, 2) to promote a long-term perspective in land use planning, and, 3) to increase the compatibility of proposed non-agricultural land uses when they are located adjacent to agricultural uses.

This policy is intended to provide all stakeholders with technical information, assistance, and tools in order to incorporate buffers into land use projects.

Agricultural buffers will help to address the following issues:

Noise and night time lighting

A. Reduce nuisance from a variety of agricultural sources such as bird frightening devices, pumps, heavy equipment, wind machines, night harvesting and other night operations. etc.
B. Reduces local neighbor conflict and complaints to governmental agencies.

Dust

A. Creates distance or screening for dust to settle out before affecting homes or people.

Trespass/Vandalism/Theft/Litter/Liability

A. Helps reduce the negative impact people and pets can have on agricultural property.
B. Helps reduce the impact that stray livestock can have on neighboring properties.

Pesticide Use

A. Helps reduce potential impacts of pesticide use for non-target areas, including homes, schools, and other urban areas to further protect public health and safety.
B. Maintains the feasibility of pesticide use as an agricultural tool.
C. Reduces local neighbor conflict and complaints to agricultural and government agencies.

Other Pest Control Measures

A. Helps maintain the use of agricultural rodent control measures.
B. Reduces the likelihood of accidental poisoning of pets.

Agricultural Burns

A. Helps maintain agricultural burning as a management tool. (Otherwise, burns may be prohibited or further regulated if dwellings are built close to agricultural property.)
B. Protects the public health and safety.

Beekeepers

A. Helps preserve the use of bees for honey production and pollination. (Otherwise, beekeepers may be forced to move hives out of agricultural areas due to close proximity to urban areas.)
B. Protects the public health and safety from bees searching for food and water.

Erosion and Development Impacts

A. Reduces the potential for sources of soil erosion from development activities to affect agricultural lands.
B. Reduces impacts on agriculture from flooding and siltation.
C. Reduces potential incidences of storm water runoff and mudslides onto developed areas by acting as a bio-filter or filter strip.
D. Reduces impacts of urban runoff pollution on agricultural land.

Harborage and introduction of agricultural disease and pests

A. Protects agriculture by reducing the incidences of insects, diseases and/or unwanted pests or plants moving from residential areas to adjacent agriculture.

Other sources of land use conflict unique to certain situations.

A. Provides buffer to reduce impacts to schools or other such sensitive land uses from ongoing necessary agricultural operations.

2. Policy Application and Procedure

Proposed development projects (hereafter referred to as the Referral Project[s]) shall be required to contain appropriate buffers [defined in item 3 of this policy] when they have the potential to create conflicts with adjacent agricultural land. All Referral Projects located adjacent to land zoned for agriculture shall provide an agricultural buffer/agricultural transition area.

This policy applies when Referral Projects are proposed adjacent to agriculturally-zoned land in 1) active or potentially active agricultural production, including rangeland, crop or orchard production; or 2) is classified by the California Department of Conservation Important Farmland Inventory as Prime, Statewide Importance, or Unique/Local Importance farmland. All annexation proposals shall incorporate provisions of this policy to further protect any adjacent agriculturally zoned parcels from potential impacts.

Application

The Agricultural Planner, considering established buffer distance ranges and all relevant factors, shall make buffer determinations on a case-by-case basis.

Several factors (described in detail below) including the nature of the land use proposal, site specific non-crop factors, type and potential extent of agricultural use, and existing zoning, are the most significant considerations in determining where significant land use conflicts may occur and what types of buffers are appropriate.

Nature of the Proposal

Specific factors related to the Referral Project shall be evaluated including, but not limited to: parcel size, configuration, density of development, and intended type of land use. Certain types of developments, such as residential dwellings or schools, may need larger buffers than for commercial or industrial development proposals. The Agricultural Planner, in conjunction with the Development Review planner, shall conduct an on-site evaluation with the Project applicant and/or agent of the Developer. Abutting agricultural operators shall be contacted whenever possible to discuss perceived conflicts.

Site Specific Non-Crop Factors

Various site-specific factors shall be evaluated in land use conflict determinations and subsequent recommendations for buffer requirements. These include, but are not limited to: topography, prevailing wind direction, riparian corridors or protected vegetative areas, soil type, location of existing roads, and the extent of existing development. Drainage, shading, vegetation, and erosion control shall be considered in the establishment of an agricultural buffer area, and made beneficial to the adjacent agricultural use.

Agricultural Use

A. Extent: Existing agricultural use shall be evaluated for potential land use conflict.
B. Type: Farming practices vary considerably by type of agricultural use; recommended buffers shall be related to the type of current and potential agricultural use possibly impacted by the Referral Project.
C. Historical/Current/Future: An evaluation shall be made concerning the suitability of a particular parcel or area for certain types of agricultural uses, and *all potential* commercially viable agricultural uses shall be considered when determining buffer types and width.

Zoning

This Buffer Policy is applicable to Referral Projects adjacent to agriculturally zoned properties; properties that are actively farmed but are not ag-zoned are not addressed by this policy.

Procedure:

A. The Planning and Development, Development Review Department shall forward all Referral Projects with any potential to create impacts to agriculture for consultation with the County's Agricultural Planner(s). If the Project is adjacent to agricultural land, the Project will automatically be forwarded for review. The Agricultural Planner(s) will review the Project application and provide written input to the assigned Development Review planner, along with application recommendations that include: buffer type, width, maintenance requirements, and detailed reasoning for stated recommendations. Adjacent agricultural landowners shall be notified and consulted.

B. In the event of a dispute on buffer policy application procedures, the matter will be referred to the Planning Director of the Development Review Department for recommendation to the County's decision-makers.

C. Under no circumstances will the agricultural buffer policy be waived for zone changes and subdivisions if it is determined that a Referral Project has the potential to impact agriculture. However, certain exceptions may be granted **only for individual** Single Family Residences under the restrictions described in item 3d of this policy.

D. The County's Agricultural Planner shall be available for testimony at public hearings to support buffer requirements upon the request of the Board of Supervisors, Planning Commission, Subdivision Review Board, Planning and Development Department, LAFCO, or city government.

3. Physical parameters of buffers

Buffer General Guidelines

Buffer(s) shall be placed on the developer's property and will be recorded as the distance from the agricultural property line.

- Determinations made in accordance with this policy shall be based on all relevant site and project criteria, practical knowledge of agricultural practices, technical literature, contact with other professionals, industry, government agencies, and training.
- The proposed Referral Project shall be considered for determining buffer type and width. The overall intensity of the proposed Project, potential for conflict, and any potential for future expansion shall be considered.
- Pre-application meetings shall be encouraged to inform applicants of the buffer policy and potential restrictions on proposed Projects located adjacent to agricultural uses so designs can incorporate recommendations early on.
- Applicants for developments near ag zoned land are required to attend an initial informational meeting with the county agricultural planners (and adjacent agricultural landowners/operators if possible).
- The agricultural planners shall recommend specific buffer distances and components (and associated supporting documentation).
- Vegetative parts of the buffer shall be appropriate for the surrounding landscape, and under no circumstances shall exotic invasives or aggressively

reseeding plants be used. Vegetative buffers shall also consider pollinator-attracting plants where possible.

- Existing dwellings or other development adjacent to agricultural uses may already negatively impact agriculture. Buffers shall specifically address reducing future or additional impacts from development.
- The surrounding agricultural zoning and uses (particularly if parcels are in "production agriculture") should be considered, as well as *any* projections for potential intensification of agricultural uses, given the specific site factors of the agricultural land that would be affected by the Referral Project.
- The County shall ensure that the responsible party for maintaining and monitoring buffer requirements for Referral Projects will do so in perpetuity via a conservation easement or deed restriction. Conditions shall be imposed such that these maintenance requirements are clearly defined and monitorable by County staff on, at a minimum, a bi-annual basis. If a Homeowners Association (HA) is designated as responsible for buffer maintenance, this shall be made a condition of project approval such that the HA cannot change this maintenance/monitoring requirement and responsibility.
- Maintenance within the buffer shall be accomplished to minimize nuisances to agriculture and shall include vertebrate eradication, invasive weed abatement, and control of crop-threatening insects where necessary. Integrated Pest Management practices shall be incorporated where possible.
- No parks, bike paths, or other public uses shall be allowed to serve as buffers due to potential conflicts with agricultural uses.
- When determining buffer widths, it should not be assumed that existing features on the agricultural property, such as trees, will remain.
- Buffer distances may be reduced from the 300' starting point median *only* if it can be clearly demonstrated that topographic or other significant overriding conditions would reduce the potential for impacts, and the proposed alternative is found to provide equal or greater protection to surrounding agricultural uses; e.g. a protected riparian corridor on the farm's property line could merit a reduction in buffer width determination.
- No modification of the buffer requirement shall be granted unless it can be clearly demonstrated that no agricultural land uses would be affected by that modification or as described in *Exceptions* below.

Buffer Components

The County may include any combination of the following land uses toward the fulfillment of the agricultural buffer requirement[2]:

Open space/greenbelt
Vegetative screen / hedgerows (provided recommended landscaping is not a water-intensive). Required buffer vegetation shall not interfere with safety requirements for leafy greens or other sensitive agricultural crops. [See Appendix 1 for guidelines].
River, creek, lakes, ponds, streams, rivers, or flood plains
Roadways and power line rights-of-way
Hillside / landscaped berm, valleys, cliffs, natural berms or rises
Airport runway or clear area
Cemeteries
Railroad tracks / Utility corridor
Irrigation canals, drainage swales
Storm retention ponds
Non-habitable accessory structures (e.g., barns, stables, garages, and corrals).
Walls, fences (non-scalable).

Note: Stabilization of an "edge condition" between agricultural zoned lands and more urbanized uses is the goal for all buffers. If no existing topographical or permanent land use feature exists (as noted above), a combination of land uses [based on individual site features as determined by the agricultural planner] shall be required that fulfills the buffer requirement, and if appropriate, a "non-scalable" dividing wall or fence.

If buffer components listed above exist adjacent to the proposed development site, and fulfill recommended buffer requirements, no additional buffer components shall be required.

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[2] Uses other than those listed must be approved as serving agricultural buffer requirements by the agricultural planner in conjunction with discretionary land use approvals. Once the buffer is specifically defined for individual discretionary projects, a condition shall be placed on the Referral Project that shall be recorded with the property title and the project conditions of approval (e.g., mitigation measures) that describes the contents of the buffer and maintenance/monitoring requirements. No modifications of recorded conditions of approval shall be allowed.

Buffer Width Determinations

The width of the buffer shall be determined based on a combination of factors depending on site/surrounding characteristics. A range is provided to encourage buffer recommendations that take into account individual site characteristics rather than providing a "one size fits all" solution.

Agricultural practices associated with the production of crops are the most important contributing factor to land use conflict when development occurs in close proximity to agricultural areas. Therefore, buffer widths shall be determined, along with the consideration of permanent site characteristics (topography, prevailing wind), by the current *AND POTENTIAL* agricultural use of that land. Discretionary reviews shall consider the potential for all parcels to intensify production agricultural uses (e.g., rangeland to vineyards, etc.) based on individual site characteristics, and shall incorporate this into buffer recommendation.

The following factors shall be considered for potential agricultural uses:

- Water
- Slope
- Prevailing Wind
- Soil Type
- Microclimate Crop Suitability
- Elevation

Two agricultural use classes are defined herein: intensive or potentially intensive agricultural use, and limited agricultural use. Distance ranges for these classes are provided in Table 1:

Table 1

Buffer Distances Determined by Potential Agricultural Uses	
Type of Agricultural Use	**Buffer Distance Range**
Intensive or Potentially Intensive Agricultural Use: • Vineyards • Irrigated Orchards • Irrigated Vegetables and Berries Irrigated Forage and Field Crops • Wholesale Nurseries • Greenhouses • Dry farm field and grain crops, orchards and vineyards	200-600 feet
Limited Use Category: Rangeland/pasture	50-200 feet (rangeland pasture only)

Source: San Luis Obispo County (modified)

Exceptions

The buffer determination process shall begin with an assessment of site-specific characteristics (e.g. topographic features, prevailing wind). If these characteristics are 1) of a permanent nature and 2) mitigate potentially intensive agricultural use, then lesser widths may be applied. The buffer shall start with a median width of 300 feet (except for Rangeland/pasture, as noted in Table 1), which shall be adjusted depending on individual site characteristics. If no other developable land is available on the parcel other than where the buffer would be required, or the buffer implementation would present an undue hardship on the landowner of a single-family residence site **as specifically defined below**, exceptions to this policy may apply.

A. Purpose and intent

The purpose and intent of this exception is to allow relief from the strict application of the provisions of this agricultural buffer policy where, because of exceptional conditions (e.g., the location, shape, size, surroundings, or topography, or other extraordinary situation or condition of the subject property), the literal enforcement of this policy would impose practical difficulties.

B. Applicability

The provisions of this Section shall apply to all zones except agricultural.

C. Contents of application

An application for an exception to this policy shall be submitted in compliance with Chapter XX.XX (Permit Application Filing and Processing) and Article II, Chapter XX.XX[3]

D. Processing

1. In the Inland or Coastal area, the Department may refuse to accept for processing any application for exception the Director finds to be inconsistent with the Comprehensive Plan or LCP.
2. At least one noticed public hearing shall be held on the requested exception that either approves, conditionally approves, or denies the request.
3. Notice of the time and place of the hearing shall be given and the hearing shall be conducted in compliance with Chapter 35.106 (Noticing and Public Hearings).
4. The Hearing Body (either the Planning Commission or the Board of Supervisors), in approving the exception may require conditions as deemed reasonable and necessary to promote the purpose and intent of this buffer policy and the public health, safety, and welfare.
5. The action on the buffer policy exception is subject to appeal as applicable in compliance with Chapter 35.102 (Appeals) of the LUDC and the LCP.

[3] Final ordinance to reference specific chapters and pages.

6. Prior to the issuance of any planning permit required to effectuate the approved exception to this policy, the applicant shall agree, in writing, to comply with all conditions imposed by the review authority in the granting of the exception, and shall agree to record a deed restriction in perpetuity that prohibits complaints or claims regarding any agricultural conflicts unless unlawful practices are occurring on the adjacent property.

E. Findings required for approval

An exception to this policy shall be approved or conditionally approved only if the Hearing Body makes all of the following findings:

1. Findings required for all buffer policy exceptions:

A. Due to special circumstances applicable to the subject property, including either location, shape, size, surroundings, or topography, the strict application of the buffer policy deprives the subject property of privileges enjoyed by other property in the vicinity and under similar zone classification that are subject to the buffer policy.

B. The granting of the exception shall not constitute a grant of special privileges inconsistent with the limitations upon other property in the vicinity and zone in which the property is situated.

C. The granting of the exception will not be in conflict with the purpose and intent of the County's Land Use and Development Code or the Comprehensive Plan or Local Coastal Plan.

D. Any exception granted shall be consistent with historic development patterns (e.g., for infill projects), and would apply only to more urbanized areas of the County.

Specific Situational Issues

1. The Agricultural Planner will not recommend the specific type of plant material or construction material for a wall or fence for screening purposes, but may state objectives and/or limitations in their official recommendations to the Development Review planner.
2. Organic farming practices will not typically influence buffer recommendations, as it cannot be assumed that organic farming practices will always occur in the future for a particular area.
3. Proposed heavy industrial land uses adjacent to agricultural areas may present significant land use conflict that would call for mitigation measures beyond the scope of this policy. Heavy industrial use will be evaluated on a case-by-case basis through the normal referral process.
4. Buffers will only affect the location of proposed occupied structures. Existing occupied structures within the buffer zone are considered home sites and are unaffected by this policy. If a home preexisting within the buffer zone is, for

whatever reason, destroyed, it may subsequently be replaced in accordance with existing County policies and zoning without restrictions from this buffer policy.

5. When considering future intensification, farm or rangeland that cannot be feasibly intensified due to topography, soil characteristics, or lack of water supply, may receive reduced buffer recommendations with proper documentation.
6. As a general guideline, any farmland designated by the California Department of Conservation Important Farmland Inventory as Prime, Statewide Importance, Unique or Local Importance, with topographic characteristics adequate for irrigated row-crop, tree or and berry farming shall be a consideration for maximizing the buffer width of a Referral Project.
7. The BOS may authorize the abandonment and reuse of buffer areas if agricultural uses on all adjacent parcels within a 200-foot radius of the project site have permanently ceased, and the land use designations for those parcels do not contain agricultural zoning.

Disclosure

The agricultural buffer document and associated conditions of approval will be duly recorded in the chain of title of the subject property (In conjunction with the mechanism chosen to enforce buffer requirements [e.g., conservation easement or deed restriction].

###

Appendix 1. Example of Vegetative Buffer

A. Two staggered rows of trees and shrubs characterized by evergreen foliage extending from the base of the plant to the crown should be planted. Fast growing or water-intensive plants with a short life span should be discouraged. No turf should be allowed due to excessive water requirements.

B. Trees and shrubs should be vigorous, drought tolerant and at least 6-feet in height at the time of installation.

C. Vegetative buffers should be designed to attract pollinators.

D. Plant height should vary in order to capture drift within 4-feet of ground application.

E. A mature height of 15-feet or more should be required for each tree.

F. To ensure adequate coverage, two staggered rows should be located 5-feet apart and consist of minimum 5 gallon plants at least 6-feet tall planted 10-feet on center.

G. Alternative spacing between rows may be required to accommodate the needs of specific plant species.

Final Report Project 5: Building Sustainable Farming Systems through Grower & Consumer Outreach
Attachment1:

SIPCertified.org Website

Social Media

Facebook

Twitter

Advertisements

California Grocers Wine Advertorial

Food & Wine Magazine

SIP Program Materials

SIP Brochure

SIP Wine Tasting Map

Winery Sign

Wine Labels Featuring the SIP Certified Sustainable Seal

SIP Certified Winery Billboard

National Sustainable Agriculture Information Service
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Life Cycle Assessment in Agricultural Systems

By Rachel F. Greenhut (USDA-ARS), Rex Dufour (NCAT), Alissa M. Kendall (UC Davis), Emma B. Strong (UC Davis), and Kerri L. Steenwerth (USDA ARS)

Consumers and society in general are becoming more aware of the environmental impacts of our manufacturing and agriculture. This publication introduces an environmental impact analysis tool called Life Cycle Assessment. LCA can be used to identify and quantify environmental impacts so that they may be more efficiently addressed. The first sections explain how LCA can be used to evaluate agricultural systems, suggesting ways to interpret and apply LCA findings to one's own farming system. Section III discusses LCA applications in farming and gives an overview of a well-known LCA agricultural case study from Sweden that compares organic and conventional milk production (Cederberg and Mattsson, 2000). Section IV describes several recent and ongoing LCA studies for almonds, wine grapes, wine, honey, tomatoes, and corn/bean systems. Useful resources are listed in the appendices.

Contents

The National Sustainable Agriculture Information Service, ATTRA *(www.attra.ncat.org)*, was developed and is managed by the National Center for Appropriate Technology (NCAT). The project is funded through a cooperative agreement with the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT website (*www.ncat.org/sarc_current.php*) for more information on our other sustainable agriculture and energy projects.

I. Introduction

The agricultural sector faces mounting pressure to increase productivity, reduce costs while maintaining product quality, and respond to regulatory and market shifts. This publication discusses Life Cycle Assessment (LCA), a tool to help growers and policymakers understand the full environmental impacts of an agricultural production system, identifying ways growers can improve overall efficiency. Use of this tool may open up new "green marketing" opportunities and even lead to reduced overall costs through better utilization of energy, equipment, and agrochemical resources.

LCA is defined by the International Organization for Standardization (ISO) as a tool to analyze the potential environmental impacts of products at all stages in their life cycle. Products can be goods or services, ranging from electricity to consumables to waste management strategies (ISO Standards). LCA examines a product's entire life cycle beginning with extraction of natural resources and continuing through production of materials, product parts, and the product itself, to the use of the product, packaging, and recycling or final disposal (see Figure 1). Materials transport and energy production within the supply chain are tracked throughout the life cycle and often contribute significantly to the overall environmental impact.

LCA is more than a carbon foot-printing tool because it attempts to quantify all environmental impacts associated with the life cycle of a particular product. These impacts include use of natural resources and land, as well as the release of environmental contaminants to the soil, air, and water. LCA identifies ways that various practices contribute to the overall environmental impact of the production system. The assessment illuminates strengths as well as opportunities for improvement.

II. Types of LCA and How They Work

Life cycle assessment is used for a wide variety of disciplines and purposes. Major corporations all over the world are undertaking LCA (in-house or third-party studies) to evaluate the environmental impacts of processes associated with a particular product. Certification of these products for LCA-based labels can help compare the relative environmental impacts of competing prod-

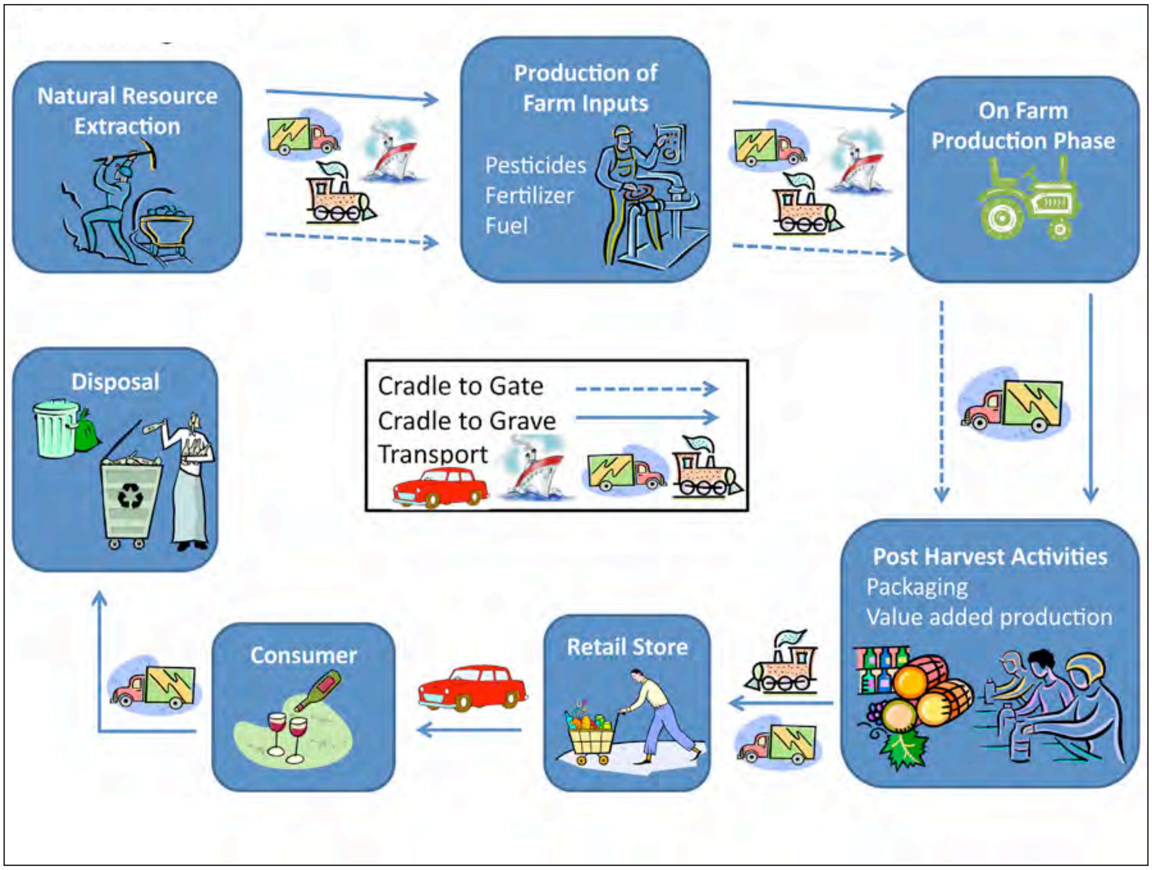


Figure 1. **Life Cycle Assessment Phases, Cradle-to-Gate and Cradle-to-Grave**

Figure 1 depicts a simplified life cycle assessment (LCA) of wine. Environmental impacts are quantified from all life cycle phases. These phases include raw material extraction, on-farm production methods (see Figure 3, page 11), and production and use of materials like fertilizers, pesticides, and fuel. Depending on the goal of the LCA, the assessment can end at wine grape delivery to the winery (cradle-to-gate) or it can be followed through wine production, consumption, and disposal of the wine bottle (cradle-to-grave). See Table 1. Environmental impacts related to transport at all life cycle phases are tracked as well.

ucts. LCA also has major roles in integrated waste management and pollution studies.

The objectives of a particular LCA will determine the appropriate method to use. LCA methods can be determined by asking three questions:

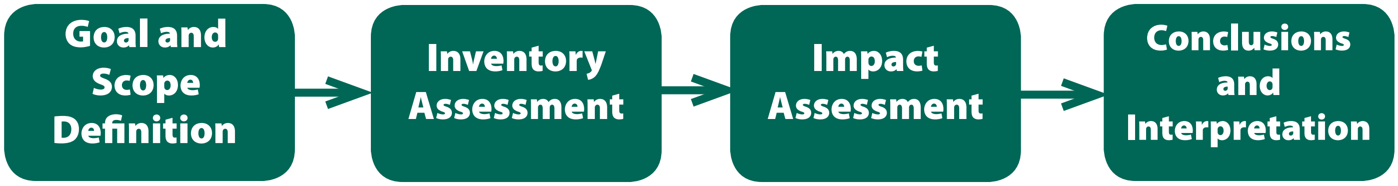
1) Are you evaluating a single product or process, or are you evaluating and comparing multiple products and processes?

2) Where are the boundaries that define the beginning and the end of the system?

3) Is it your objective to evaluate the current state of the system or is it to predict the impact of alternative production methods? A brief comparison and definition of different LCA methods are presented in Table 1.

A life cycle cost analysis can be completed alongside an environmental impact LCA in order to consider the financial costs as well as the environmental impacts of each alternative. Life cycle cost analysis accounts for all costs incurred during the lifetime of a product. Costs include those associated with purchases, production, operation and maintenance, labor, disposal, and occasionally externalities such as pollution damage costs incurred by third parties. Consideration is given for who carries the financial burden (the producer, the user, or a third party), as well as whether the costs are near, or in the future, or spread out over time (for example, installing solar panels has a high initial expense but energy costs are reduced and over the long term can be cost-saving).

Table 1. Life Cycle Assessment Methods	
The LCA method is determined based on the number of production chains or systems being evaluated (Comparative or Stand-alone?), the scope (Cradle-to-Gate or Cradle-to-Grave?), and the objectives of the study (Attributional or Consequential?). Multiple methods in combination may be appropriate for a single LCA. For example, a cradle-to-grave LCA can be either stand-alone or comparative, depending on the number of systems evaluated. Definitions are given here, as well as examples for industrial manufacture and for agriculture.	
1) Is the purpose of the assessment to evaluate a single product/process or to compare multiple products and processes?	
Stand-Alone LCA	**Comparative LCA**
This LCA method analyzes a single product to identify the life cycle components, known as "hotspots," that contribute most to the environmental impacts.	This LCA method determines the benefits and trade-offs between two or more comparable products.
Industrial Example: Which life cycle phase (bottle manufacturing, syrup production, transport, refrigeration, etc.) of Soda "XXX" has greatest environmental impact?	***Industrial Example:*** Comparing the environmental impacts of paper vs. plastic grocery bags.
Agricultural Example: Which part of compost production contributes the most to the environmental impact?	***Agricultural Example:*** Comparing the environmental impacts of using compost vs. fertilizer.
2) Where are the boundaries that define the beginning and the end of the systems?	
Attributional LCA (the most common type of LCA)	**Consequential LCA**
This LCA method looks at the environmental impacts of a system in its current state.	This LCA method estimates how pollution and resources may shift within a system in response to hypothetical changes. Because these changes are not yet enacted, the consequential LCA is based heavily on educated assumptions.
Industrial Example: Based on current California transportation systems, is the environmental impact greater for commuting from point A to point B by bus or train?	***Industrial Example:*** If California High Speed Rail is built, what will be the environmental impact of commuting from point A to point B by rail vs. bus?
Agricultural Example: Based on current production processes, what are the environmental impacts of beef production?	***Agricultural Example:*** How would the environmental impacts of beef production change if the co-product from corn ethanol production (dried distillers grain with solubles) is used for feed? (How would that change affect the total land requirements)?
3) Is the objective to evaluate the current system or to predict the impacts of alternative production methods?	
Cradle-to-Grave (Useful for consumers and the industries)	**Cradle-to-Gate** (Useful for companies with no control over a product once it leaves their facility)
This LCA method considers the entire life cycle of the system, including raw material extraction, production, use, and final disposal.	This LCA method considers a product's life cycle up to the point that the product leaves the manufacturer's or producer's "gate."
Industrial Example: Cell phone — life cycle begins with extraction of raw materials used to produce the phone and battery, and includes consumer use (charging phone). End boundary is when the cell phone is thrown away and ends up in a landfill or other disposal site.	***Industrial Example:*** Cell phone — the life cycle end boundary occurs at the cell-phone manufacturing plant gate.
Agricultural Example: Wine follows the life cycle from mineral mining and fertilizer production through field cultivation, wine-making and bottling, consumer use of wine, and final recycling or disposal of glass bottle.	***Agricultural Example:*** Wine grapes — the life cycle end boundary occurs when harvested grapes leave the farm gate for delivery to the winery. This is useful for growers to identify the environmental impacts of their system.



Life Cycle Assessment has four main components. These components are often interdependent, as the results of one component will inform how other components are completed.

This type of combined analysis is especially useful for comparing alternatives that serve the same purpose but differ in the initial and/or operating costs. A life cycle cost analysis can also be useful during the design phase of a system in order to estimate the costs of compared alternatives and to select the design with the lowest overall costs. Combining LCA (excluding labor) with a life cycle cost analysis gives businesses the ability to validate or compare the financial benefits of alternatives that may reduce environmental impacts.

LCA Components

The main components of any LCA are 1) Goal and Scope Definition, 2) Life Cycle Inventory, 3) Impact Assessment, and 4) Conclusions and Interpretation. During the Goal and Scope Definition stage, the system boundaries are set and a process flow diagram is constructed to identify material and energy inputs and outputs for the system. The inputs and outputs are quantified during the Life Cycle Inventory phase. The environmental impacts of these outputs are estimated during the Impact Assessment phase, after which Interpretation of the results can occur. These four components are defined below.

Goal and Scope Definition

The Goal defines the purpose and method of life cycle assessment that will be used in a given study, including its audience, application, and objectives. The Scope defines the function of the product, the functional unit (see opposite), the system boundaries, and any data requirements, assumptions, or limitations.

The system boundaries identify which life cycle stages and parts of associated systems are included in the LCA. See Cradle-to-Grave vs. Cradle-to-Gate in Table 1 for an example of system boundaries. Geographic, time-related or environmental boundaries may also be included. Environmental impacts associated with workers and their labor are often excluded, such as the impacts associated with the transport of workers from their homes to the workplace.

System boundaries greatly influence the findings of an LCA. For example, many refrigerated products have high energy use associated with the consumer-use phase (home refrigeration). Exclusion of the use phase in an LCA of a refrigerated product, therefore, may lead the LCA practitioner to miss an important component of the overall environmental impact. On the other hand, the LCA practitioner may have little interest in the use phase of the refrigerated product if the audience of the study is not consumers or consumer interest groups.

Inventory Assessment

The inventory assessment of an LCA is essentially the data collection phase. Typical system inputs are energy and material use, and typical outputs are products, co-products (defined below), waste, and emissions to the air, water, and soil. All the necessary inputs and outputs across the product life cycle are gathered and quantified.

Public and private databases are used extensively in the inventory phase of most LCAs. Existing life cycle inventory datasets from many previously studied systems are available (see Appendix B) and are often utilized by LCA practitioners as a data source for subsystems found within the larger system studied. For example, the life cycles of energy production methods (fuel, electricity, etc.) have

Functional Unit: Definitions and Nuances

The functional unit in Life Cycle Assessment allows for comparison of alternative products and services (Guinée et al. 2002). The functional unit is a measure of the service provided by the product. For example, the functional unit for an LCA comparing compact fluorescent to incandescent light bulbs might be 1,000 hours of light, at 800 lumens. In agriculture, functional units are often expressed as weight or volume of the crop or on a per-area basis (see descriptions below).

In LCA, environmental impacts and resource consumption are conveyed relative to the selected functional unit, thus providing a reference for comparison. For example, a grower might be interested in energy use per acre or per ton of product. The choice of functional unit significantly influences the findings of an LCA, especially in the multifunctional systems found in agriculture. Functional units used in agricultural LCAs can be classified according to three main categories: 1) quantity of the product, or crop yield, 2) land area, or 3) stored energy (e.g., calories in food). Each of these is described briefly below:

1) Quantity of the Product
Environmental impacts can be calculated based on a set amount of product produced, or impact per product quantity (e.g., per ton). Product quantity functional units identify the most efficient production methods in terms of lowest impact per product weight or volume.

2) Land Area
Environmental impacts can be calculated based on the amount of land area used in creating the product, or impact per land area (i.e., per acre). Employment of both mass and land area functional units is typical in agricultural LCAs. Land area is rarely used independently.

3) Stored Energy
Environmental impacts can be calculated based on the amount of chemical energy bound in the final product, or based on the impact per unit energy associated with final product. In an agricultural LCA, these are the calories stored in the harvested crop. This functional unit is less common in agricultural LCAs due to the complex functions of food to deliver nutrients as well as energy. However, stored energy has been used as a functional unit to evaluate corn ethanol production systems, where stored energy is the product of interest.

— Cerutti et al 2011

been studied extensively and these datasets can be used in other LCAs where energy use is required.

Many systems studied in LCA produce multiple products, known as co-products. For example, the logging industry's main product may be board wood but co-products often include woodchips or sawdust. In LCA, environmental impacts should be allocated to the main product and co-products. Allocation of environmental impacts occurs in various ways and is often based on the mass or volume of the co-product. For example, environmental impacts related to the transportation of goods can be distributed across all products transported in one truck or train based on a product's mass.

Impact Assessment

The impact assessment phase of an LCA translates the inventory data into meaningful values, called environmental indicators, which inform us about the environmental impacts of a product or system. LCA practitioners choose appropriate indicators for their particular study. Indicators are unlike inventory data that measure weights of materials or emissions and joules of energy. Instead, indicators simplify large datasets by categorizing and scoring inventory data using a sort of point system for easy comparison.

Global warming is one common environmental impact and the corresponding environmental indicator is global warming potential (GWP). GWP translates nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) emissions data gathered during inventory assessment into to their CO_2-equivalents, and calculates the potential of the total greenhouse gas (GHG) emissions to change the earth's average temperature (by trapping radiation in the atmosphere) over a specific time span, commonly 100 years. The GWP over 100 years for carbon dioxide is 1. For methane, the GWP is 25 and for nitrous oxide it is 298. In other words, the GWP of nitrous oxide is 298 times more powerful than carbon dioxide. Impact assessment can further transform GWP into scores relating to the broader impacts of global warming, including loss of biodiversity, loss of crops, and damage to humans. Broader impact scores are more comprehensible and often more relevant for decision makers.

Water quality is another environmental impact category, expressed as a metric to assess an aquatic ecosystem's ability to support organisms as well as human needs. Indicators of water quality include nutrient levels like phosphorus and nitrogen. Other environmental impact categories can estimate how many people will be made ill or die due to the production of a product, or give similar equivalents for destruction of habitat, etc. Table 2 gives more examples of environmental impact categories and examples of measurable environmental indicators (also know"inventory data").

Conclusions and Interpretation

The conclusions and interpretation phase identifies "hotspots" in the life cycle of a given product or comparison of several alternative products. Hotspots indicate where the use of alternative practices or goods will minimize the overall environmental impacts of the product in question. When LCAs are made available to the public, they can be useful for groups such as farmers, policy makers, and consumers only if details about how the LCA was done are reported with the results. Users such as farmers can evaluate their own production systems for hotspots identified in an LCA. See Appendix C for suggestions on interpreting a completed LCA to apply the findings to one's own system.

III. Life Cycle Assessment in Agriculture

The environmental impacts and hotspots of an agricultural production system can differ depending on many factors. First, a wide range of management practices exist, and selection can vary depending on the cropping system (for example, perennial or annual), grower preferences and market trends (for example, organic or conventional). Second, a system depends on site-specific factors including climate, water availability, soil type, topography, cultivar selection, operation size, and land use history.

For example, perennial cropping systems differ from annual systems in many ways. Perennial crops (e.g., fruit and nut crops) remain in place for successive years and frequently utilize permanent cover crops, no-till systems, and drip irrigation. In annual cropping systems, the whole system tends to be tilled, re-planted, and fertilized every year. For example, the National Agricultural Statistics Services reported average nitrogen application (lbs per acre) to be 140 for corn (2010), 142 for tomatoes (2010), and 23 for wine grapes (2009).

The agricultural flow diagram on page 11 shows how the production system of an agricultural product and the environmental system may interact (Figure 3).

Agricultural Case Study: Conventional vs. Organic Milk

When conducting an LCA, environmental impacts that have strong effects on the production system or on the environment are known as hotspots. This study of milk production identifies hotspots in the production system (Cederberg and Mattsson, 2000).

Table 2. Environmental Impacts and Examples of Environmental Indicators (Associated Inventory Data)	
Environmental impacts are defined as the consequences of pollution or resource use. Environmental Indicators (often called "potentials") are used with life cycle inventory data to quantify environmental impacts. In any given life cycle assessment, the Goal and Scope determine the specific suite of environmental impacts and indicators that will be used. This table lists some common environmental impacts and the associated environmental indicators that are used in agricultural LCAs. This list is not a complete inventory of such associations.	
Environmental Impacts	**Examples of Environmental Indicators (Associated Inventory Data)**
Natural Resources	
Abiotic resource depletion	Crude oil, mineral fertilizer (NPK), water
Biotic resource depletion	Wood for construction
Ecological Impacts	
Global warming	CO_2, CH_4 and N_2O emissions from fuel combustion
Depletion of stratospheric ozone	Methyl bromide used as a soil fumigant
Acidification	Sulfur dioxide emissions from a coal power plant
Eutrophication	Discharge of detergents containing phosphates
Habitat alterations and biodiversity impacts	Land use change
Human Health Impacts	
Toxicological impacts	Heavy metal accumulation

— Modified from Baumann and Tillman (2004) and Haas et al. (2000).

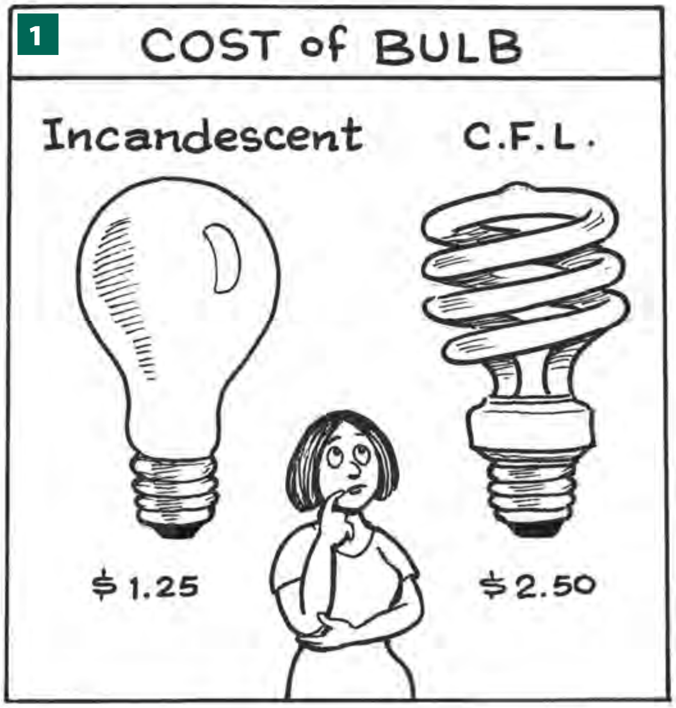
Goal and Scope Definition

Goal and Scope of Life Cycle Assessment for Conventional vs. Organic Milk Production. The study's goal was to determine if milk production systems with high input of resources ("conventional") have a greater environmental impact than systems with low inputs ("organic") achieved by using local fodder and plant nutrients.

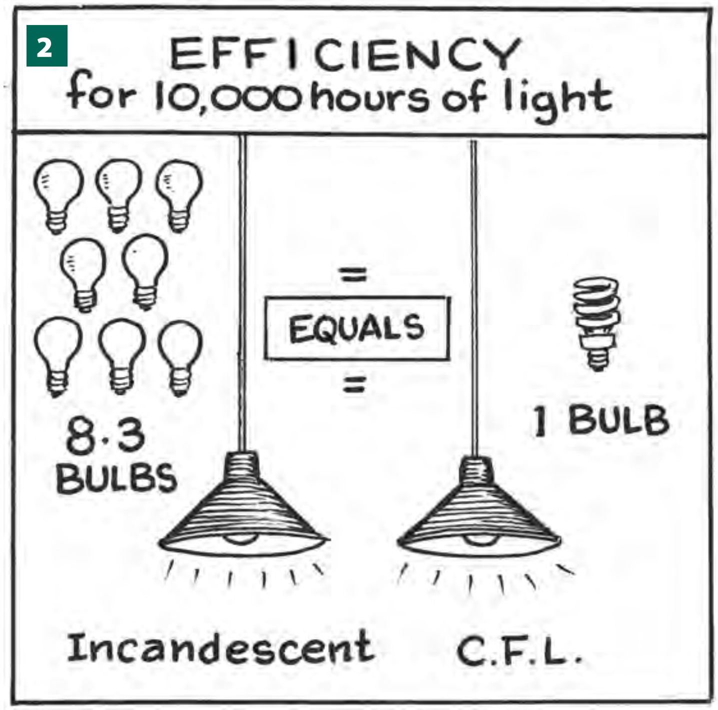
Functional Unit and Time Frame. The functional unit was a measure of the energy in the milk leaving the farm gate. The exact functional unit was 1000 kg of milk (corrected to account for the fat and protein content of the milk). The time frame was one year.

System Boundaries. The system begins with the production of farm inputs like pesticides, fertilizer, and seed necessary to produce the food for the dairy cows. The system includes the dairy cows housed in dairy farms with organic or conventional practices. It ends after transport of the milk off the farm. Only the organic farm included the production of pea fodder, while only the conventional farm included fertilizer and pesticides in the production of grain fodder.

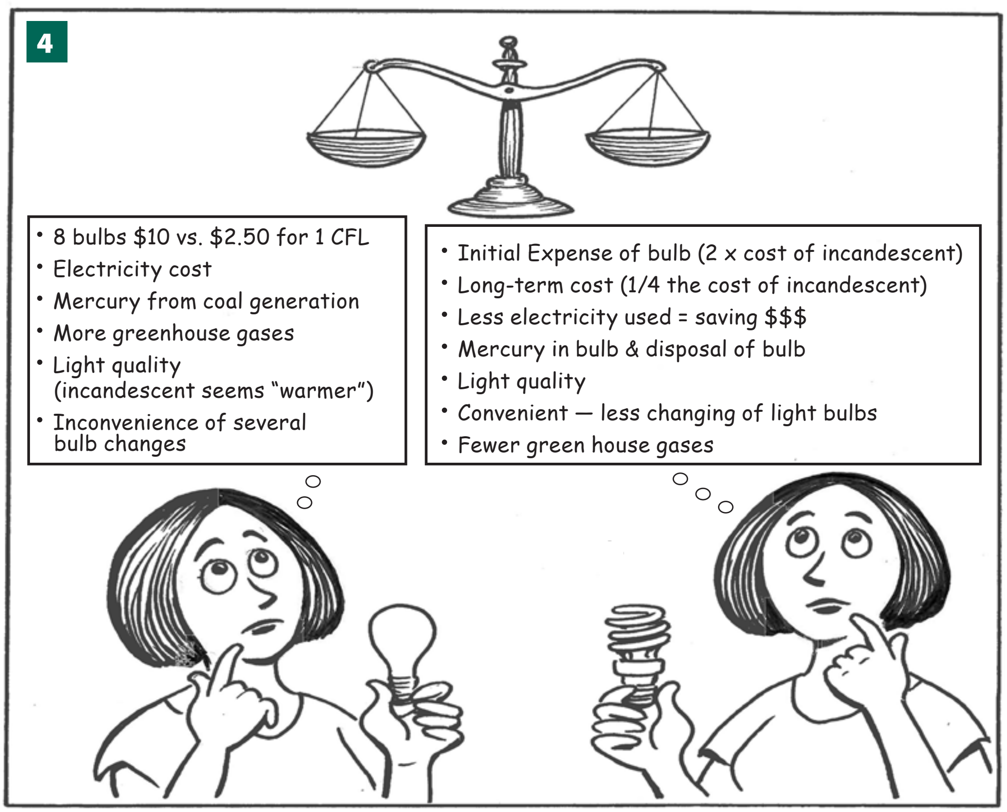
Buildings and machinery were excluded because they were similar in both conventional and organic farming systems. Allocation of environmental impacts among co-products was also necessary. For exam-



LCA-type calculations are used in daily life by consumers, but these calculations are not as detailed as one would find in a real LCA. For example, if you're shopping for a light bulb, there are many choices available. But in the price range of most consumers, the choice boils down to either using a compact fluorescent bulb (CFL) or an incandescent bulb. If you are simply looking at price, the choice is simple: the incandescent…..

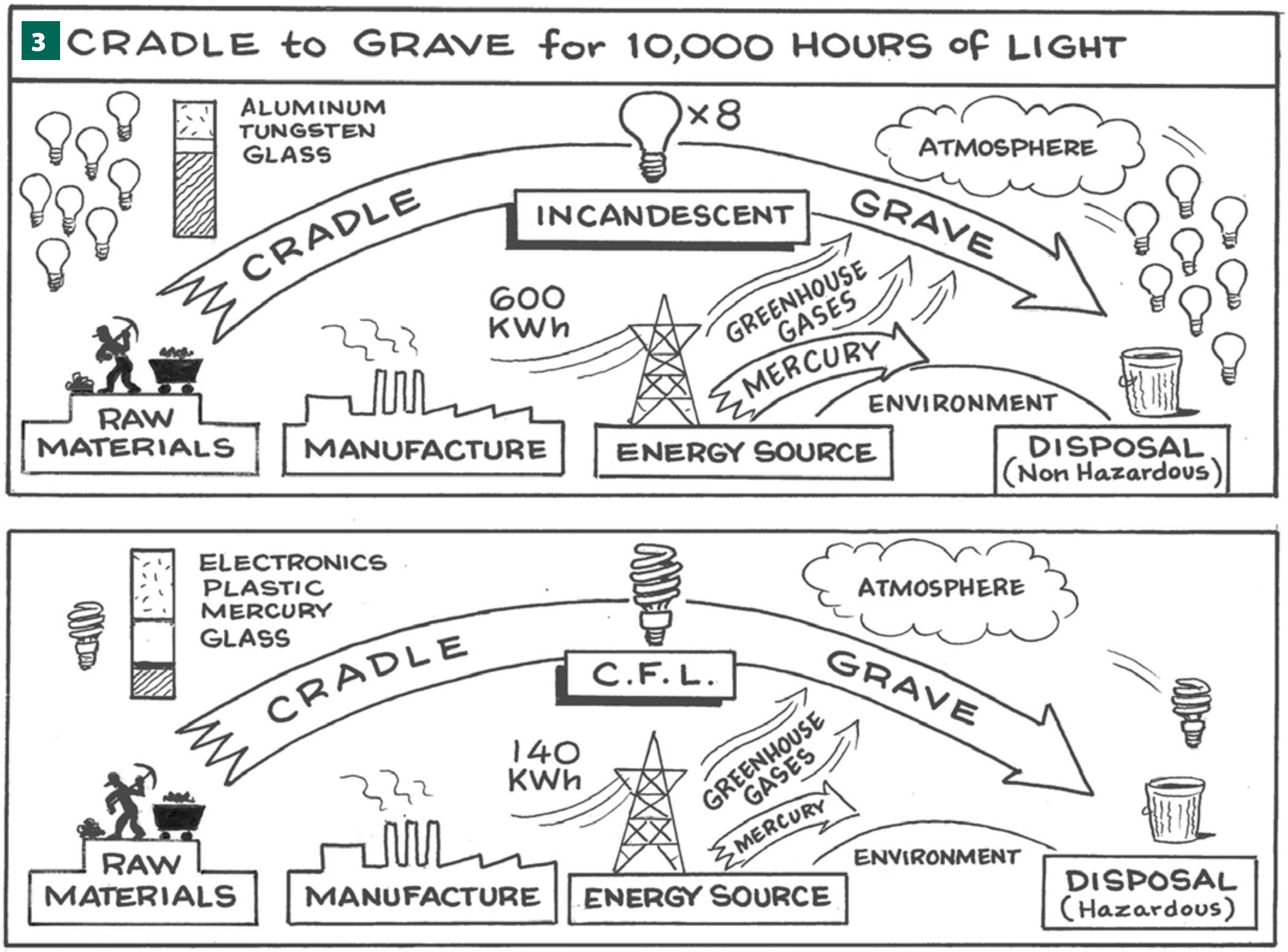


….However, more information about the cost over the "life span" of the bulbs shows the situation in a very different light. It would take more than eight incandescent bulbs to equal the typical compact fluorescent bulb (CFL) lifetime of 10,000 hours. So because it lasts so long, the CFL is far from being twice as expensive as an incandescent bulb. The CFL is actually roughly one-quarter the cost of an incandescent bulb.



Consumers and society in general are becoming more aware of the environmental impacts of our manufacturing and agriculture.

Life Cycle Assessment is a tool that can be used to identify and quantify environmental impacts so that they may be more efficiently addressed.



….An even closer look at the manufacture of incandescent and compact fluorescent (CFL) light bulbs and the energy use required of the bulbs and their disposal, reveals that CFLs — although more efficient energy-wise — are considered hazardous waste due to the small amount of mercury they contain.

However, due to the greater energy use accruing to incandescent bulb use if the energy supply comes from coal, there is actually ***more*** mercury emitted into the environment from the use of the less efficient incandescent bulbs, compared to the mercury contained in the CFL. Until very recently, 50% of energy in the U.S. has been from coal, although this has presently dipped to 34% due to low natural gas prices.

Compared to the CFL, the incandescent bulbs' energy use emits additional green house gases.

Sustainability encompasses the concept of stewardship—the responsible management of resource use—and can be defined as having three dimensions, also known as the "Three E's" of sustainability: Economics, Social Equity, and the Environment (UN General Assembly, 2005). The vitality of both the economy and society depend on maintaining a healthy environment, which is often the focal point for improving sustainability.

ple, both systems produced meat and milk. The distribution of the energy and protein needed for a dairy cow to produce the milk, maintain herself, and support her pregnancy led to allocation of environmental impacts across these two products (85% to milk, 15% to meat). Manure production was not treated as an output product because it stayed "on-farm" and was used for fertilizer on both the organic and conventional farms. So no allocation was necessary for manure.

Inventory Assessment

Data were collected from two relatively large dairy farms in western Sweden that follow a current commercial production scheme.

Impact Assessment

Environmental Impacts and Indicators Used in LCA for Conventional vs. Organic Milk Production. In order to address the Goal and Scope, several environmental indicators were selected to evaluate the conventional and organic milk production systems: resource consumption (energy, material and land use), human health (toxicity via pesticide use), and ecological consequences (global warming, acidification, eutrophication, photo-oxidant formation, and depletion of stratospheric ozone).

Conclusions and Interpretation

Interpretation and Hotspots. Of the environmental impacts selected above, several were identified as hotspots.

Resource Use in Conventional vs. Organic Milk Production. Energy use was a hotspot identified in this LCA. Primary energy sources included coal, crude oil, natural gas, natural uranium, and hydropower, and were expressed as MegaJoules (MJ) per functional unit. The use of primary energy was 3550 MJ per functional unit (1000 kg of milk) in the conventional system and 2511 MJ per functional unit in the organic system. The greater use of concentrated feed and synthetic fertilizers in conventional milk production contributed to greater energy use in conventional systems.

It is also possible to look at the different kinds of energy that compose the total energy used by the two farming systems. For example, coal use was nearly four times greater (4.87 vs. 1.23 MJ per functional unit) in conventional than organic milk production due mainly to refining components (mainly drying beet fibers) in the feed concentrate, which was fed to cows in conventional milk production. In contrast, electrical energy consumption was greater per functional unit in organic than conventional milk production. Identifying the relative contributions of these energy sources to the other environmental impacts can help farmers evaluate which practices and goods to use in their production system.

Nutrient use represented another hotspot. Phosphorus is a limited global resource, and its conservation and judicious application is becoming paramount in agriculture. In both milk production systems, phosphorus was applied almost exclusively as fertilizer for fodder. The amount of phosphorus used per functional unit was nearly three times greater in the conventional than in the organic milk production system. This was attributed to the applied fertilizer in feed imported to the farm.

Soil phosphorus levels in the conventional system were also greater than in the organic system. This suggests that phosphorus use was less efficient in the conventional system, and that accumulation and subsequent leaching of plant-available phosphorus from soil could occur, contributing to downstream eutrophication in streams, lakes, and oceans. (See Ecological Consequences, below.)

Human Health in Conventional vs. Organic Milk Production. Pesticide application was identified as a hotspot contributing to long-term toxicity of the environment and production system. The conventional system used the pesticides monocrotofos and endosulfan for insect control during soybean production. The conventional system applied 118 g of pesticides per functional unit, whereas the organic system used just

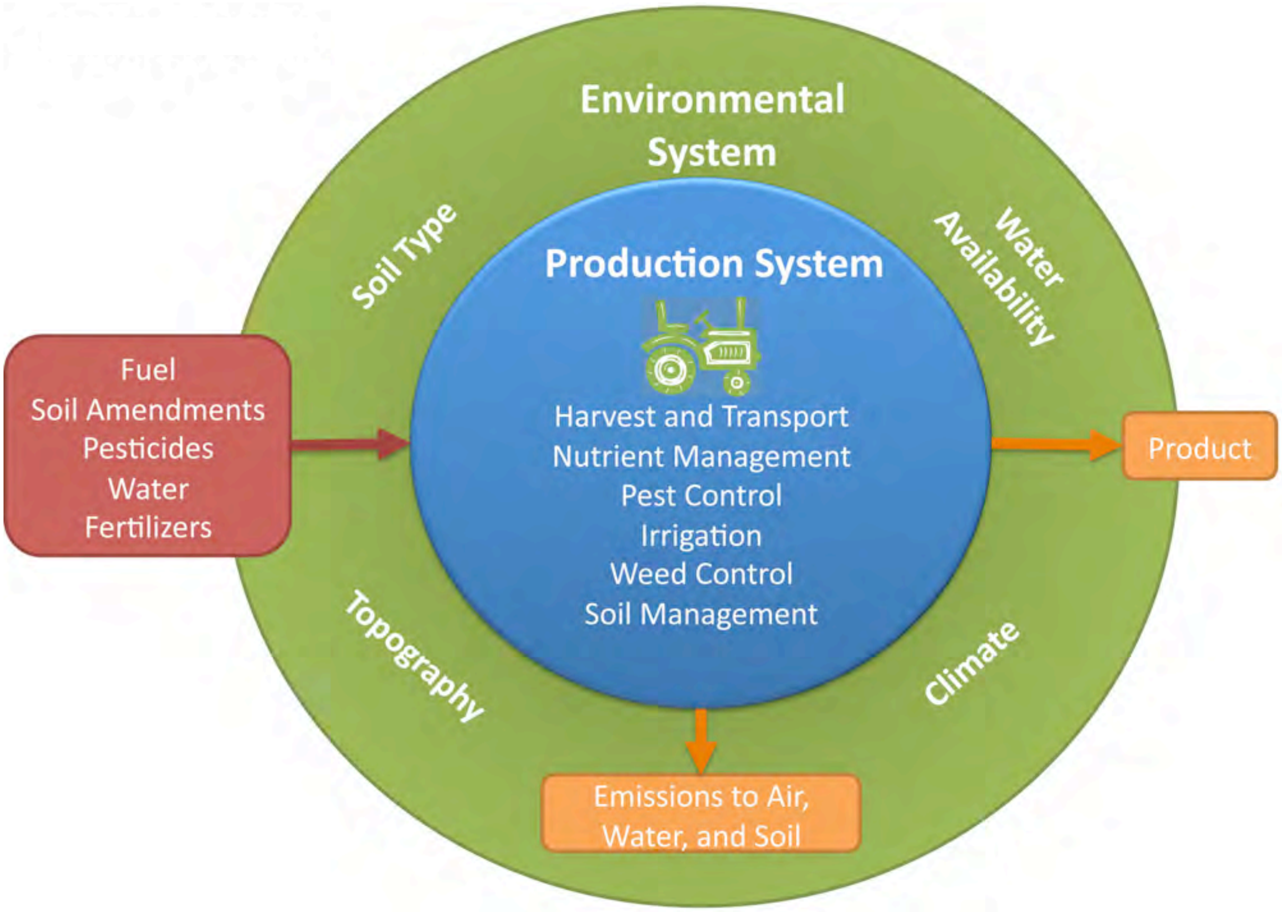


Figure 3. **On-Farm Life Cycle Components and Flow Between the Environment and the Production System**

This simplified process flow diagram shows the main components of the on-farm phase of an agricultural product's life cycle. In the diagram above, view the farm "production system" as a manufacturing plant.

At the end of the on-farm life cycle phase, the product is ready to be transported to the next phase of the life cycle (for example, to a processing plant or packaging facility).

Material inputs (such as fuel and fertilizers) and management practices used in the production system (such as nutrient and soil management) result in the release of emissions into the environmental system (for example, nitrogen loss through nitrate leaching and greenhouse gas emissions).

The production phase of an agricultural life cycle assessment (LCA) is unique because the production system is open to the environment.

In a non-agricultural LCA, environmental impacts associated with the production system generally have little effect on the production system itself. In an agricultural LCA where the production system is open to the environment, many environmental impacts can affect future production (for example, biodiversity impacts).

In addition, site-specific biological factors like soil type, water availability, topography, and climate affect how growers manage their production system (for example, soil mineralogy can affect nutrient input requirements).

By disking only alternate alleys, wine grape growers can protect the soil resource and enhance their access to the vineyard. Photo: Rex Dufour, NCAT.

11 g of pesticides per functional unit. Nearly 75% of the pesticides in the conventional system came from its high use of soybean meal. The authors of this study suggest that the conventional system should incorporate an integrative farming systems approach to reduce pesticide use.

Ecological Consequences. The global warming potential in the LCA of milk production was affected by emissions of the greenhouse gases methane, nitrous oxide, and carbon dioxide. Nitrous oxide emissions were mainly derived from fertilizer production, and carbon dioxide was generated from fuel use. However, methane was the most important contributor to global warming potential in milk production. The feeding strategy of using more roughage and fodder in organic systems led to 10-15% greater methane emissions from cows in the organic than conventional system. Another ecological consequence identified in milk production was eutrophication in natural water systems, as mentioned above.

Comments on Interpretation of Hotspots. This study demonstrates how the context in which an LCA is conducted can affect the outcome in response to the identified hotspots. The indirect effect of land use on aesthetic and cultural value is difficult to quantify, but nonetheless must be considered when proposing methods to reduce the impacts of these hotspots. While the use of greater amounts of land for organic dairy production could be viewed negatively, in this case, it is a land use that is highly valued in Sweden for its attributes related to human health. This is because in Sweden and other parts of Europe, society places strong value on the preservation of open, bucolic landscapes and cultural traditions. So organic dairies with greater pasture acreage compared to conventional dairies are viewed more positively.

IV. Sample Agricultural Life Cycle Assessments in California and the U.S.

A number of LCAs that look at agricultural systems in California are currently underway. A few are presented here to demonstrate some of the various ways of implementing LCA. The first two, wine grapes and wine, show how LCA can differ in terms of goals, spatial scales, and system boundaries. An almond LCA is described to demonstrate ways to use multiple functional units. Following these examples is a list of published agricultural LCA studies that demonstrate cropping systems in other areas of the U.S. and the world. These studies are also listed in the Appendix B.

Wine Grape and Wine Production LCAs

Two collaborative projects evaluating the life cycles of wine grape and wine production in the state of California are currently underway with the Wine Institute and with the USDA-Agricultural Research Service and the University of California, Davis. These complementary projects aim to help growers, grower groups, wine producers, and policy makers communicate and make decisions about reducing the environmental impacts associated with wine grape and wine production. Although both studies focus on the wine grape industry, they occur on different spatial scales, and possess different boundaries, goals, and scopes. Both projects are funded by California Department of Food and Agriculture (CDFA) Specialty Crop Block Grants.

The USDA-ARS/UC Davis project focuses on wine grape production from cradle-to-farm-gate in Lodi and Napa, two important yet very different wine-growing regions. Vineyard management differs across regions and within each region due to variations in climate, water availability, soil type, topography, cultivar selection, operation size, and land-use history. Through this LCA, researchers compare the range of management regimes found in each region and identify the production practices with the lowest environmental impacts.

In order to better understand differences between the two regions, environmental impacts will be expressed relative to two functional units: 1) Land Area—total yield from one acre (e.g., global warming potential per acre) and 2) Mass of Product—one ton of grapes (e.g., global warming potential per ton of grapes). For more information on functional units, see page 5. This will allow quantification and comparison of the impacts based on land area as well as product volume. This LCA's main source of data is from face-to-face interviews and vineyard management records collected across 90+ vineyard sites from 30 vineyard managers in the two regions. Results from this project will be incorporated into the wine-grape production life cycle phase of the Wine Institute's LCA.

The Wine Institute project has broader boundaries and looks at the life cycle of all California wines from cradle-to-grave. This project aims to identify the relative contributions of various phases of the life cycle (i.e., wine-grape cultivation, wine production, bottling, etc.) to the industry's overall environmental impacts and to integrate identified hotspots into existing tools to drive statewide industry improvements.

Both projects incorporate on-farm biological processes related to emissions of greenhouse gases from soils —i.e., carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4)—into their LCAs via a denitrification-decomposition model developed by Applied GeoSolutions (see Appendix A). The goal is to capture the environmental impacts from soil processes like nitrogen and carbon cycling, which vary across landscapes and land management practices.

Wine grape growers have demonstrated that alley cropping can mitigate some environmental impacts of vineyards, as well as being pleasing to the eye. Photo: Rex Dufour, NCAT.

Ultimately, the results of these two LCAs will inform growers and wine producers about the environmental impacts of the various phases of the grape-to-wine life cycle, as well as specific practices that may reduce the impacts of the wine-grape production phase. Both projects will help develop useful metrics to identify achievable targets for reducing environmental impacts.

Almond Production LCA

An LCA of California almond production began in 2010, focusing on estimating life cycle energy and greenhouse gas (GHG) emissions for "typical" conventional production across the state. The system boundary is cradle-to-processor gate over 25 years (productive lifespan of a typical almond orchard) and includes almond-production operations from tree nursery through hulling and shelling operations. While the modeling examines almond production based on area (one

This organic almond grower planted bell beans in the orchard alleys to protect the soil and provide low-cost nitrogen that has a low environmental impact. Photo: Rex Dufour, NCAT.

acre of orchard), two functional units are considered: 1 kg of almond kernels, and 1 nutritional calorie. (See page 5 for information about functional unit selection.) For a description of the research and results for the first stage of research, see Kendall, A., Marvinney, E., Brodt, S., Zhu, W. (2011) Greenhouse Gas and Energy Footprint of California Almond Production: 2010-2011 Annual Report (UC Davis Agricultural Sustainability Institute).

The impact assessment categories considered include primary energy consumption, global warming potential, and a number of other air pollution categories such as smog formation potential, acidification, and eutrophication potential. (See Glossary for more definitions of these impact categories and environmental indicators.)

Hotspots for energy and emissions include energy demand for irrigation water (calculated on a regional basis for the California Aqueduct, gravity-fed surface water, and pumped groundwater), and nitrogen fertilizer, which is energy-intensive to produce and results in nitrous oxide (N_2O) emissions from soils. N_2O is a potent greenhouse gas, with a 100-year global warming potential of 298. However, almond orchards produce a significant quantity of residual biomass, including wood removed from the orchard, hulls, and shells. Use of this biomass—particularly trees removed at the end of the orchard's productive lifespan and shells removed during processing—to generate electricity can offset a large proportion of the total system greenhouse gas emissions by displacing fossil fuels used for electricity generation in California.

This study shows the importance of examining the full life cycle and systemwide implications of agricultural systems. This research is slated to be complete in the summer of 2013 and is funded by the Almond Board of California (Project number 10-AIR8-Kendall).

Several Additional Examples of LCAs for Other Commodities

Numerous studies have looked at the environmental impacts of agriculture. For example, studies using LCAs have evaluated the energy consumption associated with various practices in apple production systems in New Zealand; the global impacts of food production (e.g., Pfister et al. 2011; Gonzalez et al 2011), and the environmental impacts of biofuel production with corn in the Midwest (e.g., Powers, 2007; Feng et al. 2010; Wang et al., 2011), or with rice husks in Thailand (Prasara-A and Grant, 2011). This small yet diverse array of examples of LCA demonstrates the technique's wide applicability. See Appendix B for full citations of these studies.

V: Relevance of Life Cycle Assessment in National and Regional Policy Programs

Agriculture in California and other regions of the United States can benefit from the use of LCA. In the context of sustainability—the "Three E's" of economics, social equity, and the environment (UN General Assembly 2005; see Figure 4)—LCA can be used to develop and support agricultural certification programs and policies in the state of

California. A few examples of national programs that utilize LCA are also described.

LCA and Certification Programs. Numerous measures of sustainability for agricultural systems have been developed and implemented by researchers and practitioners in the agricultural sector. This has been driven partly by consumer demand for "environmentally friendly" products and partly by stricter environmental regulations. Ideally, these measures of sustainability used by programs such as the Climate Action Reserve, the Stewardship Index, and California's incipient Cap and Trade System (see resources section for more information on these programs) enable producers to benchmark, compare, and communicate sustainability performances such as carbon neutrality. These emerging opportunities are designed to provide incentives including new markets and marketing strategies, and improved long-term profitability.

Incentive-based agricultural policies and certification programs frequently require adherence to a standard set of practices to qualify. Becoming certified under some programs may also lead to improved marketability, as has been demonstrated in the wine grape industry by the USDA National Organic Program, the Fish Friendly Farming label of the California Land Stewardship Institute, and the Lodi Rules accredited by Protected Harvest. The Stewardship Index for Specialty Crops takes another approach, in which desired environmental and agricultural outcomes are defined, but the practices to achieve such outcomes are not prescribed. See the Resources section for additional information on these programs.

In order for more areas of the agricultural industry to be considered for programs like these, scientists must develop reliable methods to quantify, model, and set achievable targets for reducing environmental impacts specific to agricultural sectors, cropping systems, and/or regions. These methods must be practical enough to be implemented on-farm without large investment of money or time by the farmer.

An increasing number of almond growers are encouraging winter alley crops in order to reduce runoff and improve soil quality. Photo: Rex Dufour, NCAT.

Although some agricultural research methods and certification programs take a "systems approach" to understand how all parts interact within a whole farming system, many do not consider entire life cycles of a production system. A narrow approach, which analyzes only a component of a production system, may mistakenly lead to the shift of environmental impacts from one to another area of the production chain, instead of an absolute reduction of the impacts.

LCA has the advantage of following all products and processes necessary for producing the crop ("cradle-to-farm gate"), delivering it to the consumer ("cradle-to-consumer"), and/or its final disposal ("cradle-to-grave"). It allows for evaluation of nearly all environmental impacts of the farming system and contributing systems, and identifying where in the process these environmental impacts occur. Farmers and farmer groups can utilize LCA's "whole systems" approach in order to identify their greatest opportunities for reducing environmental impacts.

Similarly, LCAs provide information to policy makers about which agricultural practices and components are most effective in reducing environmental impacts such as energy use and carbon emissions. This information can then guide funding to programs that incentivize and/or dis-incentivize particular practices in agricultural systems. It can also provide insight for prioritizing government- or farmer group-sponsored farmer-training programs focused on improving overall agricultural sustainability.

LCAs, Carbon Markets, California, and Assembly Bill 32

The agricultural sector can use LCAs to improve sustainability (see Figure 2) and respond to the tighter restrictions on resource use and greenhouse gas emissions. Agriculture and forestry in California are accountable for roughly 8% of the state's total greenhouse gas emissions (GHGs) (Carlisle et al., 2010). Although the state has not mandated emissions caps for the majority of the agricultural sector, California is proceeding in implementing its Global Warming Solutions Act, Assembly Bill 32, which requires the state to reduce its greenhouse gas emissions to 1990 levels by 2020. AB 32 will directly and indirectly affect the agricultural industry through increased costs for carbon-based fuel, energy, and fertilizer, and tighter restrictions on new development. AB 32 may also funnel research dollars to better understand agriculture's role as a source and a sink for carbon.

Through implementation of AB 32, new funds will become available to support reductions in GHG emissions and help California adapt to climate change. As this publication goes to print, the California legislature is about to begin appropriating funds from carbon credit auctions. There is on-going discussion about whether funding from these auctions ought to support 1) research on carbon sequestration in agricultural systems and 2) incentives for farmers to reduce GHG emissions in agriculture. In addition, agricultural protocols (sets of practices and rules) are in development to guide eligibility in California's carbon market. Having LCAs available for particular crops or cropping systems will inform protocol development and the provision of public funding to the practices with the most significant climate benefits. Updates on these programs are found online at California Climate and Agriculture Network (www.calclimateag.org) or the California Air Resources Board (http://www.epa.gov/otaq/fuels/renewablefuels/index.htm.).

LCA and National Programs

Life cycle assessment is currently being used on a national level to reduce the environmental impacts of transportation fuels. The Renewable Fuel Standard is a policy set in place by the U.S. EPA to decrease the life cycle-based emissions of the nation's transportation fuels that are bought and sold beginning in the year 2012. As a result of this policy, companies are required to produce fuels that, on a life cycle basis, reduce the carbon intensity relative to current gasoline and diesel. This policy provides an example of how large economic sectors similar to transportation, such as agriculture, could be regulated in the future. It also directly affects current agricultural practices in the U.S., because it mandates annual requirements for biofuel production. More information can be found online at the U.S. EPA website. www.epa.gov/otaq/fuels/renewablefuels/index.htm.

VI. Conclusions

LCAs can be useful tools for farmers, farmer groups, and policy makers. For example, LCAs can improve farmers' abilities to make decisions about their system's energy use. By pinpointing practices that have high or low environmental impacts, the farmer, or more likely the farmer group, can adjust and modify these practices to reduce environmental impacts (see table xxx). Ultimately, LCA can support green marketing strategies and will make it possible for grower groups to highlight opportunities for improved practices using self-audit tools.

Because developing an LCA requires extensive knowledge about working with large data sets and can be expensive to conduct, the purpose of this paper is not to teach farmers how to conduct their own LCA. Instead, we hope to spread understanding of

LCAs and how the results can be interpreted and applied to one's own farming system (see Appendix C: LCA Interpretation and Application). In most cases, LCA reveals the hotspots and associated trade-offs of choosing certain production methods over others. Only rarely can it point unambiguously at the "best" technological choice to reduce the overall impacts of a given production system (Ayers, 1995). Nonetheless, the LCA process helps us understand the environmental impacts associated with each alternative we examine, and where these impacts occur (locally, regionally, or globally). LCA can enable growers to select the best production practices, materials, equipment, and goods to reduce the overall environmental impacts of their farming systems.

VII. Appendix

Appendix A. Denitrification-Decomposition (DNDC) Modeling and LCA

The DNDC model performs process-based simulations of nitrogen and carbon dynamics in agroecosystems. Based on environmental drivers (inputs like soil characteristics, temperature and precipitation data, crop characteristics, and crop management) the model predicts crop growth and yield, greenhouse gas emissions (such as carbon dioxide, methane, and nitrous oxide), and other environmental effects (like nitrogen leaching and runoff). DNDC is used widely around the world and has been tested against many field datasets in the US and abroad. Incorporation of DNDC in the USDA-ARS, UC Davis Wine-Grape LCA and the Wine Institute's Wine LCA will be complete in early 2013. DNDC modeling for these projects is contracted through Applied GeoSolutions. More info can be found at www.appliedgeosolutions.com.

Appendix B. Ongoing Agricultural LCA Project List and Selected Readings

California Wine and Wine-Grape Production LCAs

USDA-ARS at UC Davis: An Environmental Comparison of Wine-Grape Production using LCA. Cradle-to-gate, assessing an annual cycle of wine-grape production, and comparing regional differences and an array of management practices. Project funded by California Department of Food and Agriculture (CDFA) Specialty Crop Block Grants, expected completion in 2013. Contact Kerri Steenwerth (kerri.steenwerth@ars.usda.gov) or Rachel Greenhut (rfgreenhut@ucdavis.edu) for further information. Research by Dr. Kerri Steenwerth & Rachel Greenhut (USDA-ARS, U.C. Davis Department of Viticulture and Enology); Dr. Alissa Kendall, & Emma Strong (U.C. Davis, Department of Civil and Environmental Engineering).

The Wine Institute: California Statewide Wine LCA. Cradle-to-grave, assessing the environmental impacts of wine production across the state of California. Project funded by California Department of Food and Agriculture (CDFA) Specialty Crop Block Grants, expected completion in 2013, more info at www.wineinstitute.org. Project led by Allison Jordan (The Wine Institute).

California Almond Production LCA

Kendall, A., Marvinney, E., Brodt, S., Zhu, W. (2011). Greenhouse gas and energy footprint of California almond production: 2010-2011 Annual Report (UC Davis Agricultural Sustainability Institute); the Almond Board of California (Project number 10-AIR8-Kendall).

New Zealand Apple Production LCA

Mila, L., Canals, I., Burnip, G.M. & Cowell, S.J. (2006). Evaluation of the environmental impacts of apple production using Life Cycle Assessment (LCA): Case study in New Zealand. Agriculture, Ecosystems and Environment, 114, 226–238.

Global Impacts of Food Production

Pfister, S., Bayer, P., Koehler, A., & Hellweg, S. (2011). Environmental impacts of water use in global crop production: hotspots and trade-offs with land use. Environ. Sci. Technol., 45, 5761–5768.

González, A.D., Frostell, B., & Carlsson-Kanyama, A. (2011). Protein efficiency per unit energy and per unit greenhouse gas emissions: Potential contribution of diet choices to climate change mitigation. Food Policy, 36, 562–570.

Environmental Impacts of Biofuel Production with Corn in the Midwestern U.S:

Powers, S.E. (2007). Nutrient loads to surface water from row crop production. Int J LCA, 12 (6), 399–407.

Feng, H., Rubin, O.D., & Babcock, B.A. (2010). Greenhouse gas impacts of ethanol from Iowa corn: Life cycle assessment versus system wide approach. Biomass and bioenergy, 34, 912-921.

Wang, M., Huo, H., & Arora, S. (2011). Methods of dealing with co-products of biofuels in life-cycle analysis and consequent results within the U.S. context, Energy Policy, 39, 5726–5736.

Environmental Impacts of Biofuel Production with Rice Husks in Thailand:

Prasara-A, T. & Grant, T. (2011). Comparative life cycle assessment of uses of rice husk for energy purposes. Int J Life Cycle Assess, 16, 493–502.

Appendix C. LCA Interpretation and Application (Comparing a Particular LCA to Your Farming System)

The following list of questions can be asked in order to interpret the findings of an LCA and determine whether using recommended alternative practices may reduce the environmental impacts of one's own system.

1. Can you relate your system to the one being evaluated?

- a. Do the system boundaries match yours?
- b. Is your production system similar to one being evaluated?
  - i. Cropping system (e.g., annual vs. perennial)
  - ii. Size of operation
  - iii. Production methods (e.g., till vs. no-till)
  - iv. Material Inputs (e.g., fertilizer, compost)
  - v. Are there regional differences to consider (e.g., transport distances, climate)

2. What hotspots are identified in the system studied?

- a. Energy use, emissions, waste, resource use
  - i. Which life cycle stages contribute the most environmental impacts?
  - ii. Acquisition of raw materials, e.g., fertilizer
  - iii. Production and maintenance of capital goods, e.g., tractor
  - iv. Energy production, e.g., fuel
  - v. Production, e.g., growing the crop
  - vi. Transportation off the farm
- b. Which of these hotspots may exist in my system as well?
- c. Is my impact similar to that of the system studied, or is my system an improvement?
  - i. Can I measure these differences?
  - ii. Can I further reduce my impact in these areas?
  - iii. How can I use these improvements as part of my marketing strategy?

3. Does the LCA offer other options or alternatives to reduce the impacts related to the significant issues?

- a. Would the alternatives work in my system?
  - i. Are they economically feasible?
  - ii. Are they technically feasible?
  - iii. Will they produce acceptable product?
- b. If I apply the alternatives to my system, would the results be measurable (e.g., reduced fuel consumption)?
  - i. Is there opportunity for improved marketability of my product by reducing my impacts?

VIII. Glossary

Acidification: Accumulation and deposition of acids (which cause widespread ecological damage) formed in the atmosphere by a reaction of sulfur dioxide and nitrogen oxide gases with water molecules. Emissions of sulfur and nitrogen gases come primarily from human sources such as electricity generation (i.e., coal power plants), factories, and motor vehicles.

Allocation: If more than one product is produced, the environmental impacts must be distributed among these products. This allocation is often performed based on weight or cost of the products.

Attributional LCA: Looks at environmental impacts of a system in its current state.

Carbon Intensity: The relative amount of carbon emitted from a particular fuel type when generating a specified amount of energy. For example, the carbon intensity to generate one megajoule of energy from coal is higher than that of solar power.

Carbon Neutral: Carbon emissions released as carbon dioxide (associated with transportation, energy production, land conversion, and industrial processes) are balanced with an equivalent amount sequestered, offset, or bought as carbon credits.

Cd (Cadmium): See Toxic Metals.

Hg (Mercury): See Toxic Metals.

Toxic Metals: Metals that form poisonous soluble compounds and have no biological role (not essential minerals). Examples include cadmium (Cd) and mercury (Hg).

CH_4 (Methane): A greenhouse gas which remains in the atmosphere for 9-15 years and is over 20 times more effective in trapping heat in the atmosphere than CO2. Human sources of CH4 include landfills, natural gas and petroleum systems, coal mining and certain industrial processes, and agricultural activities such as rice cultivation, agricultural waste burning, and livestock digestive fermentation and waste management.

CO_2 (Carbon Dioxide): A naturally present heat-trapping atmospheric gas that is a part of the Earth's carbon cycle. CO_2 is the primary greenhouse gas accumulating in the atmosphere because human activities have increased emissions (e.g., fuel combustion) and disrupted the natural processes that remove CO_2 from the atmosphere (e.g., removal of forests).

Comparative LCA: Determines the benefits and tradeoffs between two or more comparable products.

Consequential LCA: Estimates how pollution and resource flows may shift within a system in response to hypothetical changes.

Co-Products: Some production systems result in more than one product (e.g., dairy operations have co-products of both meat and milk). LCAs will typically allocate some of the environmental impacts to each of the co-products.

Cradle-to-Gate: Considers a life cycle to the point where the product leaves the manufacturer's/producer's "gate."

Cradle-to-Grave: Considers the entire life cycle of the system, including raw material extraction, production, use, transport, and final disposal.

Criteria Air Pollutants: Six pollutants regulated and monitored by the U.S. EPA because of their high level of negative impacts on human and environmental health and their high prevalence in the U.S. The six pollutants are ozone, carbon monoxide, nitrogen dioxide, particulate matter, sulfur dioxide, and lead.

Ecotoxicity: In LCA, refers to the effects of hazardous chemicals on both aquatic and terrestrial species.

Environmental Impacts: Consequences of pollution or resource use. In LCA, specific categories of environmental impacts are used, such as global warming potential (GWP), loss of diversity, resource use. See Table 2 for more examples. Environmental indicators are used to assess the magnitude of an environmental impact.

Environmental Indicator: Measures that quantify environmental impacts, e.g., CO2 emissions.

Eutrophication Potential: The potential of nutrients (e.g., nitrates, phosphates) to cause over-fertilization of water and soil, which can result in increased growth of biomass and the depletion of oxygen in the water, reducing populations of specific fish and other animals.

Functional Unit: Quantifies the goods or services delivered by the product system, providing a reference to which the environmental impacts can be related. For example, an LCA of almond production may employ a functional unit of one ton of almonds to reflect impacts like global warming potential (global warming potential per ton of almonds).

Global Warming Potential (GWP): In LCA, GWP is an environmental impact category that represents the potential of greenhouse gas emissions to change the earth's average temperature (GWP is calculated over a specific time span, commonly 25 or 100 years).

Goal and Scope: Goal defines the LCA purpose and method, including the audience, the application, and the objectives of the study. Scope defines the function of the product, the functional unit (see page 5), the system boundaries, and any data requirements, assumptions, or limitations. Time span is included and defined when applicable.

Hotspots: These are parts of the life cycle identified during impact assessment as significant contributors to the total environmental impact.

Impact Assessment: Phase of an LCA that translates the inventory assessment data into meaningful values—called environmental impact categories and environmental indicators—which inform us about the environmental impacts of a product or system.

Impact Category: A classification representing specific environmental impacts due to emissions or resource use (i.e., climate change, loss of diversity). See Table 3 for details and examples.

Inventory Assessment: The data collection phase of an LCA when all necessary inputs (e.g., energy and material use) and outputs (e.g., products, co-products, waste, and emissions to the air, water, and soil) across the product life cycle are gathered and quantified. If necessary, allocation across co-products occurs during this phase.

LCA Process Flow Diagram: A graphical representation of the linkages within and between the life cycle phases of a product.

Life Cycle Assessment (LCA) is defined by the International Organization for Standardization as a tool for the analysis of the potential environmental impacts of products at all stages in their life cycle.

Life Cycle Cost Analysis: A tool for the accounting of all costs incurred during the lifetime of a product. Costs include those associated with purchases, production, operation and maintenance (including labor), and disposal.

N_2O (Nitrous Oxide): A greenhouse gas that remains in the atmosphere for approximately 120 years and is over 310 times more powerful than CO_2. N_2O is produced and released into the atmosphere naturally from a wide variety of biological sources in soil and water, and is broken down and removed naturally from the atmosphere by sunlight (photolysis). Human sources of N_2O include agricultural soil management and combustion of fossil fuel.

NH_3 (Ammonia): The principal form of toxic ammonia. The toxicity increases as pH and temperature decrease. Animals, especially fish, are affected by the presence of toxic ammonia. Agricultural sources of ammonia include fertilizers and livestock waste.

Nitrate: Due to its mobility in water, nitrate is the primary form of leached nitrogen. Agricultural sources of nitrate include manures, fertilizers, and decaying plants and organic materials. High levels of nitrate in ground or fresh water can be toxic to newborns, young or pregnant animals, and can cause algal blooms resulting in so called aquatic "dead-zones."

NOx (NO and NO_2): Nitrogen oxides known as NOx emissions are listed by the U.S. EPA as criteria air pollutants. These are produced during combustion, especially at high temperatures (e.g., in motor vehicles and industrial facilities), and are precursors to ground level ozone and fine particle pollution. NOx gases are also harmful to human health.

Ozone: An atmospheric gas that is present in low concentrations throughout the Earth's atmosphere. Ozone blocks damaging ultraviolet light from reaching the Earth's surface, but also acts as a powerful but short-lived greenhouse gas. Ozone is a powerful oxidant with many industrial applications, but when present near ground level, it can cause respiratory damage in animals. Ozone from human sources comes primarily from fuel combustion.

Stand-alone LCA: Analyzes a single product to identify the life cycle components that contribute most to environmental impacts, known as hotspots. System boundaries can also be geographic or refer to time frame.

System Boundaries: Identifies which life cycle stages as well as which parts of associated systems are included in the LCA—where the system begins and ends.

System: In LCA this refers to the production chain(s) being evaluated

IX. Resources

California Air Resources Board
www.arb.ca.gov
The California Air Resources Board (ARB) is a part of the California Environmental Protection Agency (EPA), an organization that reports directly to the Governor's Office. The board's mission is to promote and protect public health, welfare, and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state. The board's goals are to provide safe, clean air to all Californians, protect the public from exposure to toxic air contaminants, reduce California's emission of greenhouse gases, provide leadership in implementing and enforcing air pollution control rules and regulations, and provide innovative approaches for complying with air pollution rules and regulations.

California Cap and Trade Program
www.arb.ca.gov/cc/capandtrade/capandtrade.htm
The California Cap and Trade Program is a central element of California's Global Warming Solutions Act (AB 32) and covers major sources of GHG emissions in the state, such as refineries, power plants, industrial facilities, and transportation fuels. The regulation includes an enforceable GHG cap that will decline over time. The California Air Resources Board will distribute allowances, which are tradable permits, equal to the emission allowed under the cap.

California Climate and Agriculture Network (CalCAN)
www.calclimateag.org
California Climate and Agriculture Network (CalCAN) is a coalition that advances policies to support California agriculture in the face of climate change. CalCAN follows these four guiding principles: 1) Employ a systems approach and full life cycle analysis to evaluate potential climate change solutions within agriculture, looking for co-benefits, true sustainability, and maximal impact; 2) Establish leadership within California's sustainable agriculture sector on climate change policy based on best practices; 3) Seek common ground and develop collaborative partnerships among agricultural and environmental organizations; 4) Support policies that incentivize and direct revenue to fund research and sustainable farming practices that mitigate climate change and promote agriculture's sustainable adaptation.

California Department of Food and Agriculture (CDFA) Specialty Crop Block Grants (SCBGP)
www.cdfa.ca.gov/Specialty_Crop_Competitiveness_Grants
The California Department of Food and Agriculture (CDFA) Specialty Crop Block Grant Program (SCBGP) funds projects that solely enhance the competitiveness of California specialty crops. Specialty crops are defined as fruits, vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture).

Climate Action Reserve
www.climateactionreserve.org
The Climate Action Reserve is the premier carbon offset registry for the North American carbon market. Their goal is to encourage action to reduce greenhouse gas (GHG) emissions by ensuring the environmental integrity and financial benefit of emissions reduction projects. The Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects, and tracks the transaction of credits over time in a transparent, publicly accessible system

Code of Sustainable Winegrowing Self-Assessment Workbook
www.sustainablewinegrowing.org/swpworkbook.php
The Code of Sustainable Winegrowing Practices Self-Assessment Workbook is the foundation of the Sustainable Winegrowing Program (SWP) and a tool for program participants to measure their level of sustainability and to learn about ways they can improve their practices. The workbook addresses ecological, economic and social equity criteria through an integrated set of 14 chapters and 227 criteria, which includes a built-in system with metrics to measure performance.

COMET-VR — A USDA Voluntary Reporting Carbon Management Tool
www.comet2.colostate.edu
COMET is a web-based tool that provides estimates of carbon sequestration and net greenhouse gas emissions from soils and biomass for U.S. farms and ranches. The system links a large set of databases containing information on soils, climate, and management practices to dynamically run the Century ecosystem simulation model as well as empirical models for soil N_2O emissions and CO_2 from fuel usage for field operations. The system uses farm-specific information to provide mean estimates and uncertainty for CO_2 emissions and sequestration from soils and woody biomass and soil N_2O emissions for annual crops, hay, pasture and range, perennial woody crops (orchards, vineyards), agroforestry practices, and fossil fuel usage.

Fish Friendly Farming
www.fishfriendlyfarming.org
The Fish Friendly Farming Environmental Certification Program is run by the California Land Stewardship Institute, a nonprofit organization located in Napa County. Fish Friendly Farming® provides an incentive-based method for creating and sustaining environmental quality and habitat on private land. Landowners and managers enroll in the program, learn environmentally beneficial management practices, and carry out ecological restoration projects. The focus is on the land manager as the central figure in achieving and sustaining environmental quality. This approach implements the principles of state and federal environmental regulations. Three resource agencies—the Regional Water Quality Control Board, the National Marine Fisheries Service, and the County Agricultural Commissioner—provide an objective third-party certification.

International Wine Industry Greenhouse Gas (GHG) Protocol and Accounting Tool
www.wineinstitute.org/ghgprotocol
The International Wine Industry Greenhouse Gas Accounting Protocol was developed through a partnership between the Wine Institute of California, New Zealand Winegrowers, South Africa's Integrated Production of Wine program, and the Winemakers' Federation of Australia. The protocol will soon be released for use by the global wine industry. With increased attention to climate change and GHG emissions and offsets, the goal of the project partners is to provide a free, wine-industry specific, GHG protocol and calculator that will measure the carbon footprints of winery and vineyard operations of all sizes.

Lodi Rules
www.lodiwine.com/certified-green/lodi-rules-for-sustainable-winegrowing
The Lodi Rules sustainable wine-grape farming standards were developed by a stakeholder committee of 10 Lodi California Wine Grape Commission growers, four Lodi Wine Grape Commission staff, two UC Farm Advisors, a Lodi winemaker, a wildlife biologist from the East Bay Municipal Utility District, pest control advisers, and a viticulture consultant. The group submitted the draft standards to Protected Harvest, who arranged for them to be peer-reviewed by three scientists and then reviewed by the Protected Harvest Board. Some revisions of the draft standards were suggested via the review process. These changes were made and Protected Harvest accredited the standards.

National Organic Program (NOP)
www.ams.usda.gov/AMSv1.0/nop
The National Organic Program mission is to ensure the integrity of USDA organic products in the U.S. and throughout the world. The NOP is a regulatory program housed within the USDA Agricultural Marketing Service that is responsible for developing national standards for organically produced agricultural products.

Performance Metrics Program
www.sustainablewinegrowing.org/metrics.php
The California Sustainable Winegrowing Alliance (CSWA) has integrated performance metrics into the Sustainable Winegrowing Program to further promote, measure, and communicate continuous improvement. The metrics project provides growers and vintners with tools to measure, manage, and track their use of natural resources in order to optimize operations, decrease costs, and increase sustainability. The project enhances the California wine community's global leadership position in sustainable agriculture and production by remaining on the leading edge of sustainability. It enables participating SWP winegrowers to confidentially benchmark their performance metrics to drive innovation and adoption of sustainable practices. The project expands the means for communicating continuous improvement in performance to stakeholders. The initial set of metrics include: water use (vineyards and wineries), energy use (vineyards and wineries), greenhouse gas emissions (vineyards and wineries), and nitrogen use (vineyards).

Renewable Fuel Standard
www.epa.gov/otaq/fuels/renewablefuels/index.htm
The US Environmental Protection Agency (EPA) develops and implements regulations to ensure that transportation fuel sold in the United States contains a minimum volume of renewable fuel. The Renewable Fuel Standard (RFS) program was created under the Energy Policy Act (EPAct) of 2005, and established the first renewable fuel volume mandate in the United States. As required under EPAct, the original RFS program (RFS1) required 7.5 billion gallons of renewable- fuel to be blended into gasoline by 2012.

Stewardship Index
www.stewardshipindex.org
The Stewardship Index for Specialty Crops is a multistakeholder initiative to develop a system for measuring sustainable performance throughout the specialty crop supply chain. The project seeks to offer a suite of outcome-based metrics to enable operators at any point along the supply chain to benchmark, compare, and communicate their own performance.

Wine Institute
www.wineinstitute.org
The Wine Institute advocates public policy for the responsible production, promotion and enjoyment of wine. The institute represents California wine at the state, federal, and international levels; educates public policy makers and the media on the cultural and economic value of wine; takes a leadership role in the business and political network for wine; and assists members with information and guidance on legal, policy, and compliance issues.

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Life Cycle Assessment in Agricultural Systems

By Rachel F. Greenhut (USDA-ARS), Rex Dufour (NCAT), Alissa M. Kendall (UC Davis), Emma B. Strong (UC Davis), and Kerri L. Steenwerth (USDA ARS)

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ATTRA— National Sustainable Agriculture Information Service is a project of NCAT

For more information about farm energy alternatives, see www.attra.ncat.org/attra-pub/farm_energy

1. DSC_6912 Inaugural meeting of the California Overhead Irrigation Alliance, Five Points, CA

2. Field plot layout with irrigation system main plots and tillage system subplots

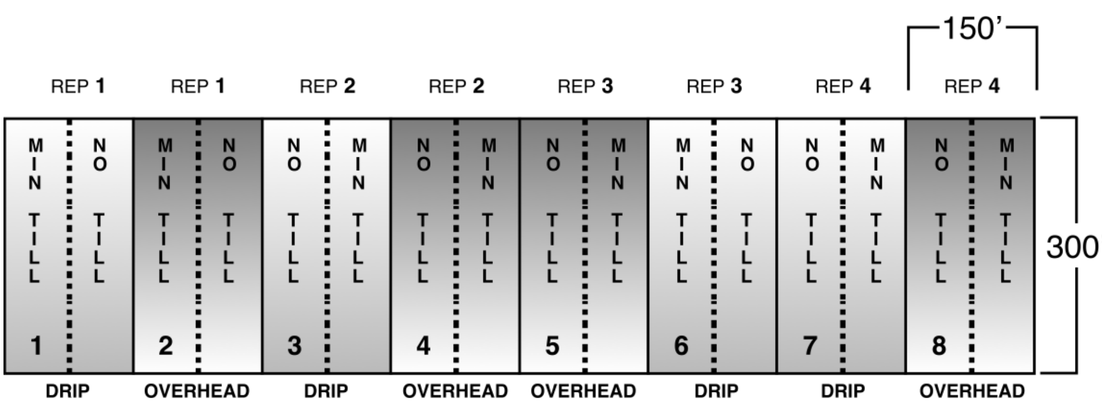
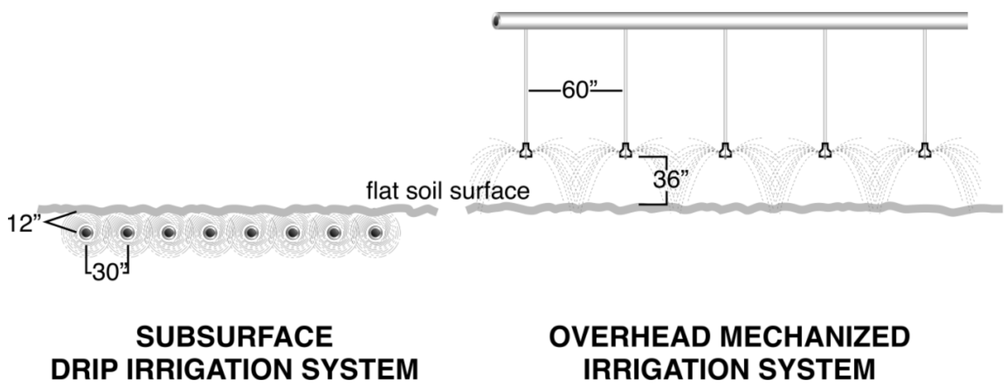


Figure 2.

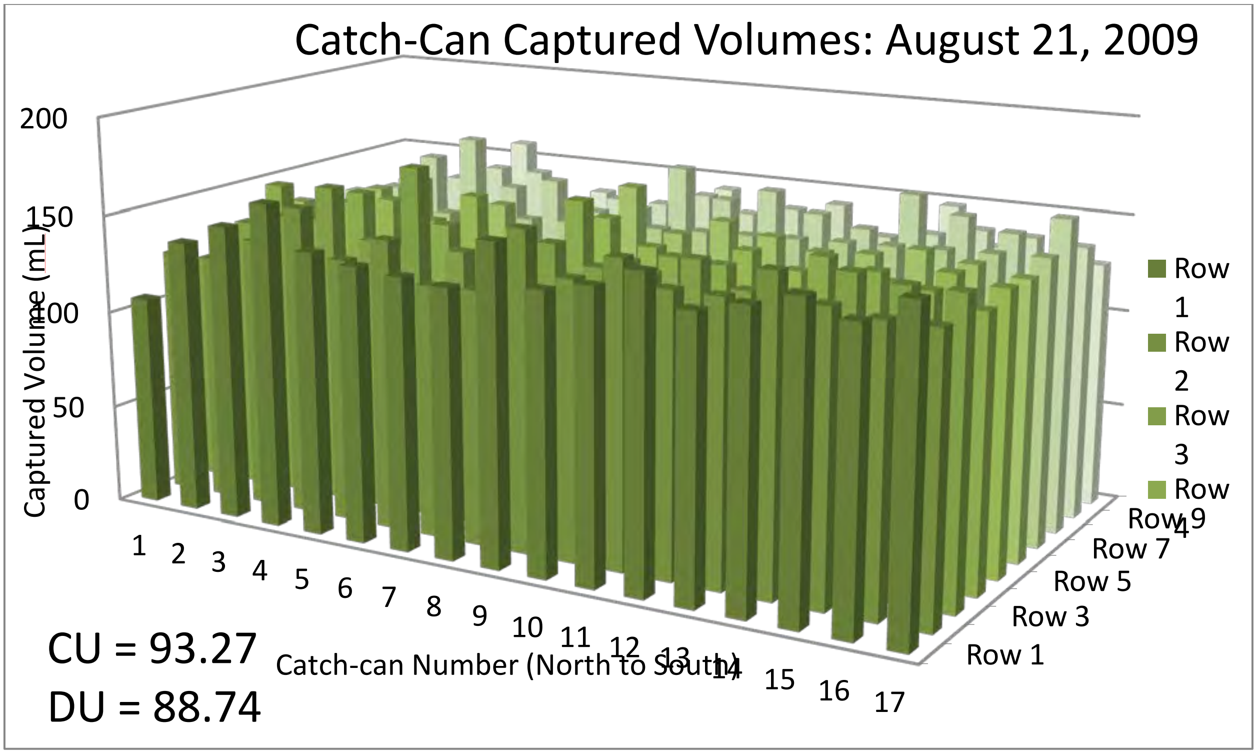
3a. Schematic description of solid-set subsurface drip and overhead mechanized irrigation systems with emitter and nozzle spacings



3b. Irrigation water application amounts for tomatoes (2010), onions (2011), broccoli (2011) and tomatoes (2012)

	Drip irrigation	**Overhead irrigation**
2010 Tomatoes	23.8”	22.7”
2011 Onions	13.63’	14.08”
2011 Broccoli	12.95”	12.24”
2012 Tomatoes		27.95”

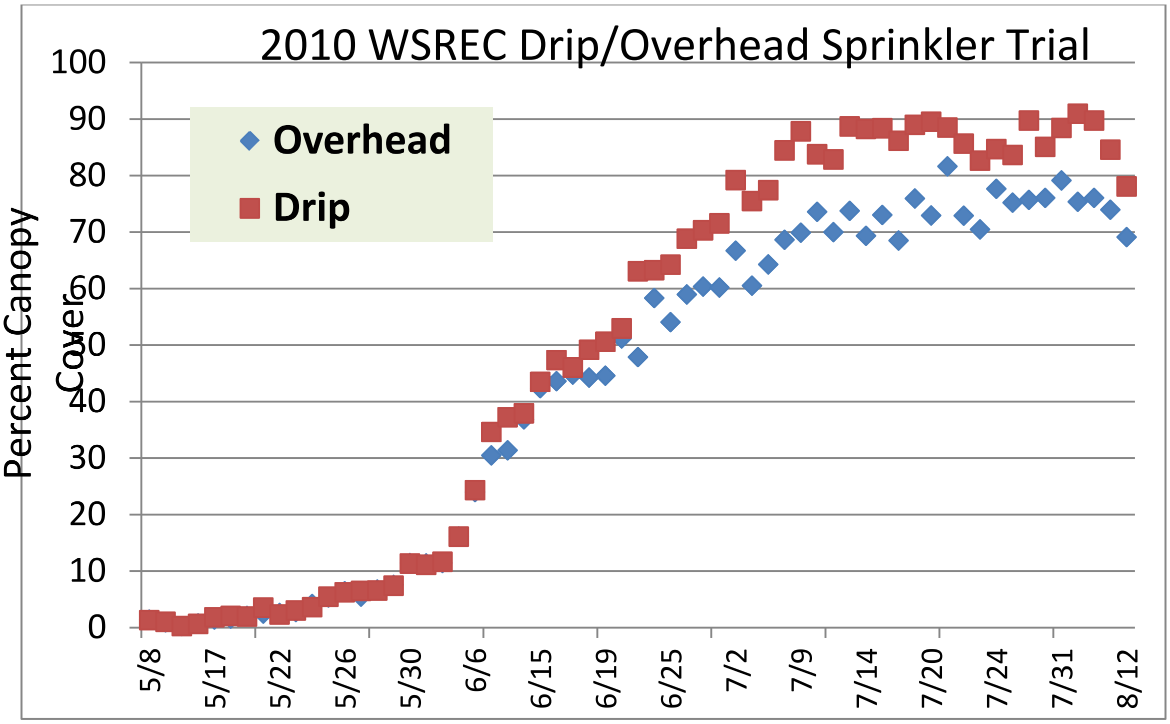
4. Coefficient of Uniformity (CU) of overhead irrigation system



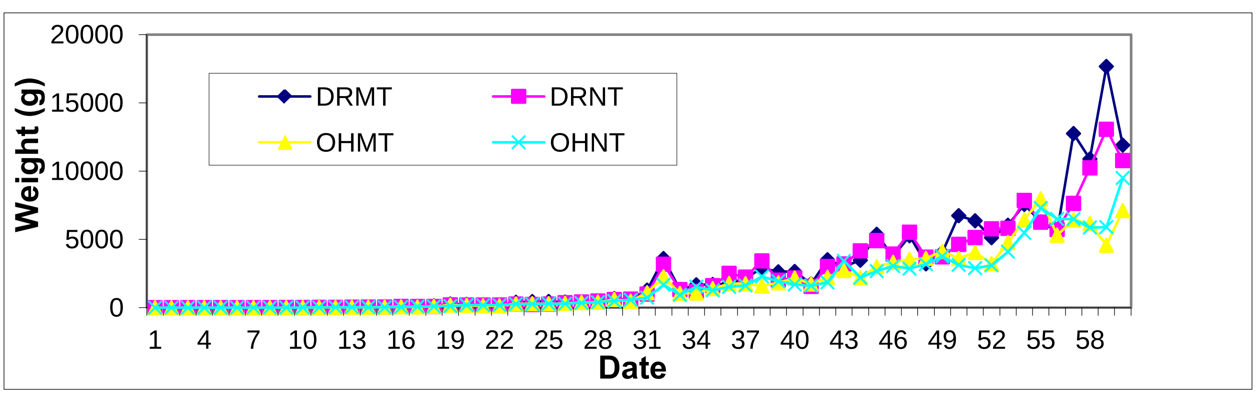
5. Yields of tomatoes (2010), onions (2011), broccoli (2011) and tomatoes (2012)

	Drip irrigation	**Overhead irrigation**
2010 Tomatoes	41.7 t/ac	24.1 t/ac
2011 Onions	29.3 t/ac	37.3 t/ac
2011 Broccoli	5945 lbs/plot	6520 lbs/plot
2012 Tomatoes	To be harvested August 28	To be harvested August 28

6. Tomato % canopy cover 2010



7. Tomato biomass 2012



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8. Soil volumetric water content (0 – 5 inches) in conventional and no-tillage plots before and following tillage in 2009 and 2010. Values are means of four replications. Means within a column followed by the same letter are not significantly different at P = 0.05 according to Fisher's Protected LSD.

Tillage system	**2009**		**2010**	
0 – 5 inches (0 – 12 cm)	**Before tillage**	**Following tillage**	**Before tillage**	**Following tillage**
	%	%	%	%
Conventional	20.7 a	12.8 b	20.0 a	11.9 b
No-tillage	19.9 a	22.5 a	20.9 a	20.2 a
0 – 8 inches (0 – 20 cm)				
Conventional			23.5 a	13.7 b
No-tillage			21.7 a	23.4 a

9. Soil volumetric water content (%) in residue and fallow treatment plots at 0 – 5 inch and 0 – 8 inch depths in 2009. Values are means.Means within a column followed by the same letter are not significantly different at P = 0.05 according to Fisher's Protected LSD.

	September 4, 2009	**September 10, 2009**	**September 18, 2009**
0 – 5 inches (0 – 12 cm)			
	%	%	%
Fallow	45 b*	23.4 b	16.7. b
Residue	48.2 a	37.2 a	34.4 a
0 – 8 inches (0 – 20 cm)			
Fallow	43.6 a	26.7 b	21.6 b
Residue	45.6 a	35.8 a	33.4 a

10. Soil volumetric water content (%) for 0 – 5 inch and 0 – 8 inch depths in second 2010 study. Values are means of four replications Means within a column followed by the same letter for a given soil depth are not significant at P = 0.05 according to Fisher's Protected LSD.

	September 9, 2010	**September 11, 2010**	**September 18, 2010**
0 – 5 inches (0 – 12 cm)			
	%	%	%
Fallow	7.7 a	42.5 a	22.0 b
Residue	8.7 a	43.2 a	30.0 a
0 – 8 inches (0 – 20 cm)			
Fallow	8.6 a	37.7 b	19.2 b
Residue	8.1 a	32.4 a	22.9 a

11. Soil volumetric water content (%) for 0 – 5 inch and 0 – 8 inch depths in first 2010 study. Values are means of four replications Means within a column followed by the same letter for a given soil depth are not significant at P = 0.05 according to Fisher's Protected LSD.

	August 3, 2010	**August 4, 2010**	**August 10, 2010**
0 – 5 inches (0 – 12 cm)	%	%	%
Fallow	7.0 a	34.4 a	15.2 b
Residue	8.3 a	35.3 a	24.4 a
0 – 8 inches (0 – 20 cm)			
Fallow	7.1 a	29.8 a	15.6 b
Residue	7.9 a	29.6 a	27.7 a

12. Preplant operations and equipment used in standard, minimum, and no-till systems

STANDARD TILLAGE

Month	Operation	Tractor	Implement	Materials	$ per Acre
Fall	Disc	225HP 4WD	Disc 18'		7.39
Fall	Subsoil 2X	325HP 4WD	Subsoil 16'		40.13
Fall	Triplane 2X	225HP 4WD	Triplane 16'		18.30
Fall	Disc 2X	225HP 4WD	Disc 18'		14.77
Fall	List/Fertilize (fertilizer not included)	225HP 4WD	Lister 15'		6.51
Fall	Shape/Mulch Beds	150HP MFWD	Mulcher 15'		6.39
Spring	Preirrigate, Sprinkler (spring)			Water 6.0 ac in	85.96
Spring	Weed Spray Beds (spring)	110HP MFWD	Boom Sprayer 45'	Roundup 1 pt	9.63
Spring	Mulch Bare Beds	150HP MFWD	Mulcher 15'		6.39
	Total Cultural Costs (prior to planting)				195.47

MINIMUM TILLAGE

Month	Operation	Tractor	Implement	Materials	$ per Acre
Fall	Rip Furrows	250HP 4WD	Rip Lister 22'		4.95
Fall	Disc 2X	225HP 4WD	Disc 18'		14.77
Fall	Level: Triplane	225HP 4WD	Triplane 16'		9.15
Fall	List/Rebed/	250HP 4WD	Lister-Bedder 30'		3.32
Spring	Preirrigate, Sprinkle			Water 6.0 ac in	85.96
Spring	Weed: Spray Beds (spring)	110HP 4WD	Boom Sprayer 45'	Roundup 1 pt	9.63
Spring	Spring Tooth	250HP 4WD	Perfecta II 15'		5.70
Spring	Power Incorporator	150HP MFWD	Cultimulcher 15'		6.39
	Total Cultural Costs (prior to planting)				139.87

NO-TILLAGE

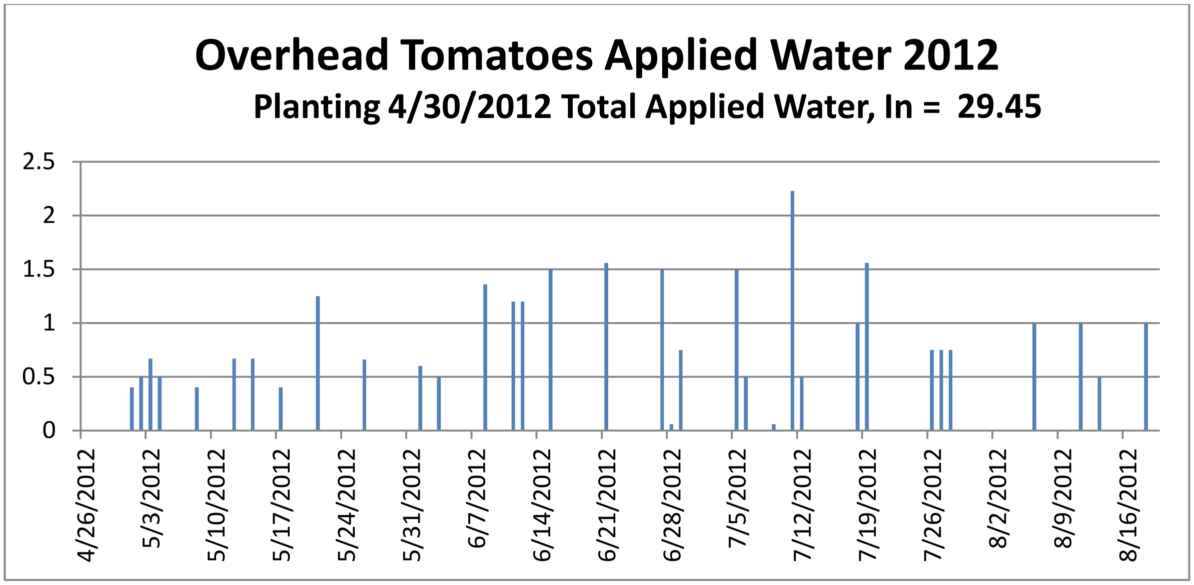
Month	Operation	Tractor	Implement	Materials	$ per Acre
Spring	Preirrigate, Sprinkler (spring)			Water 6.0 ac in	85.96
Spring	Weed Spray Beds (spring)	110HP MFWD	Boom Sprayer 45'	Roundup 1 pt	9.63
	Total Cultural Costs (prior to planting)				95.59

13. Comparative preplant tomato production costs for standard, minimum and no-till systems

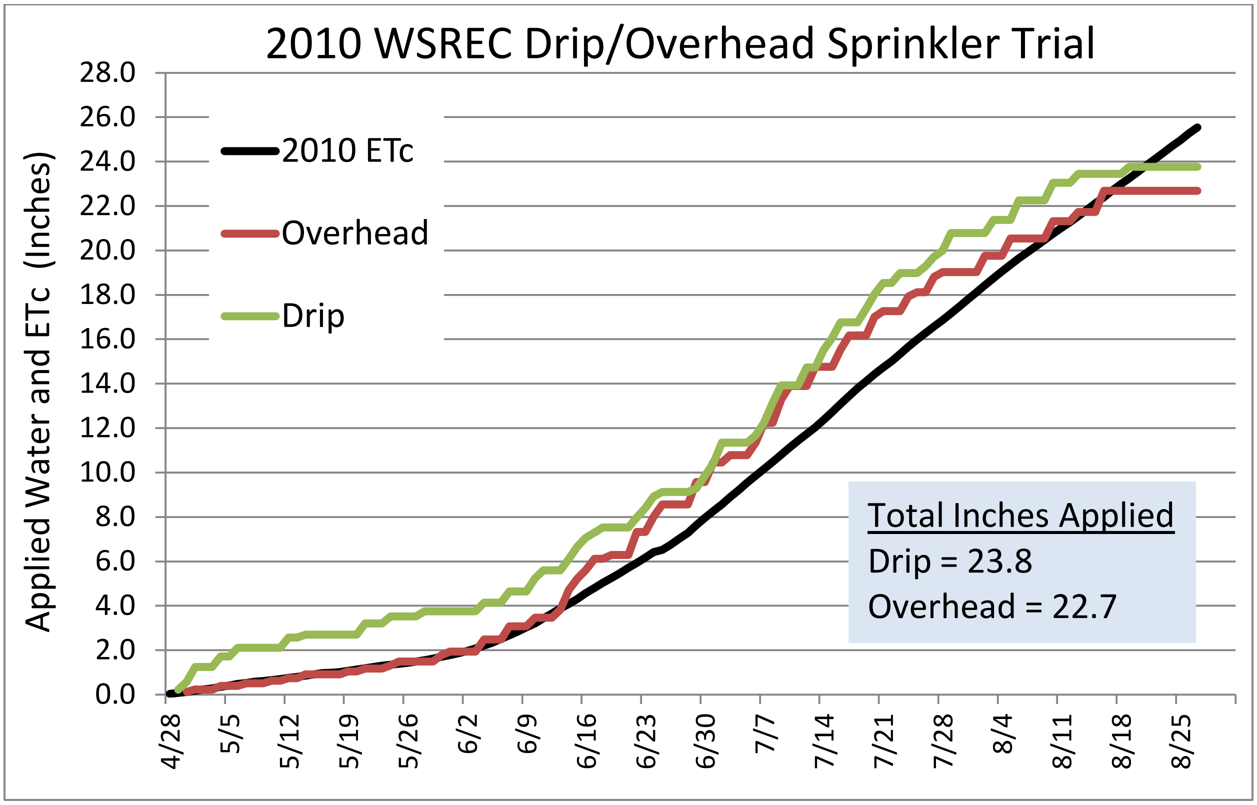
Operation	Standard	Minimum	No Till
Machine Labor Hours	1.89	0.95	0.05
Machine Labor Costs	25.93	12.95	0.71
Non-Machine Labor Hours	1.00	1.00	1.00
Non-Machine Labor Costs	10.96	10.96	10.96
Diesel Gallons	24.58	10.69	0.30
Diesel Costs	50.15	21.80	0.62
Lube	7.52	3.27	0.09
Repair	17.84	7.81	0.14
Interest	8.97	6.06	3.66
Total Operation Costs	121.37	62.85	16.18
Cash Overhead	2.75	1.09	0.07
Non Cash Overhead	29.36	11.65	0.00
Total Costs (Excluding Materials)	153.48	75.59	16.25

Add Materials	Standard	Minimum	No Till
Water	75.00	75.00	75.00
Roundup	8.07	8.07	8.07
Total Materials	83.07	83.07	83.07
Total Costs (Including Materials)	236.55	158.66	99.32

Applied overhead irrigations for 2012 tomatoes



Matching of applied water with ETcrop, 2010



2010 WSREC Drip/Overhead Sprinkler Trial
Applied Water and ETc (Inches)
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4/28
5/5
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
2010 ETc
Overhead
Drip
Total Inches Applied
Drip = 23.8
Overhead = 22.7

Appendix Table 1A. Water balance (mm) for 2010 & 2011

	Irrigation	Treatment	Water inputs	Change in soil water storage	ETc	Drainage[1]
2010	**FI**	**fallow**	301.6	-156.3	469.5	-11.7
	FI	**mixed**	511.9	-103.6	511.4	104.1
	FI	**triticale**	455.6	-96.6	481.7	70.5
	SDI	**fallow**	580.0	-36.0	743.1	-127.1
	SDI	**mixed**	384.9	-125.4	514.0	-3.6
	SDI	**triticale**	383.2	-116.2	505.3	-5.9
2011						
	FI	**fallow**	895.7	-145.8	606.4	435.1
	FI	**mixed**	1124.7	-116.9	589.6	652.0
	FI	**triticale**	943.9	-135.0	599.8	479.1
	SDI	**fallow**	644.2	-68.9	592.8	120.4
	SDI	**mixed**	602.2	-53.9	580.2	75.9
	SDI	**triticale**	602.0	-47.3	583.2	66.1

[1]positive drainage values represent losses below rootzone

Figure 1. Growing Season Water Balance

Calculated percolation below root zone

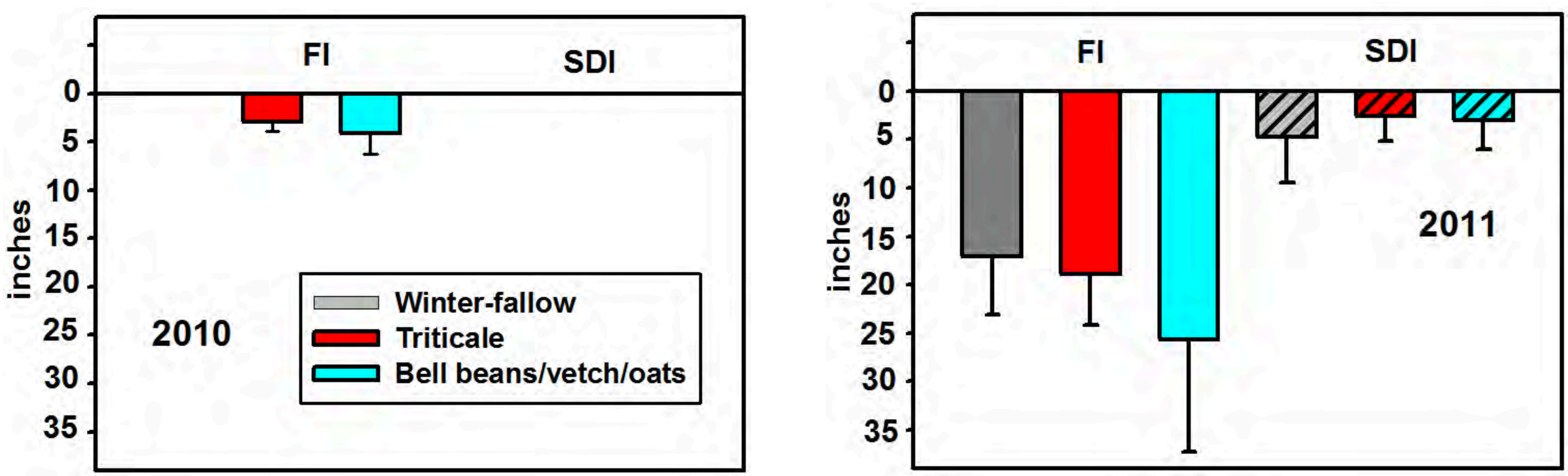


Figure 2. Soil water tension at three depths during tomato crop growth in 2010

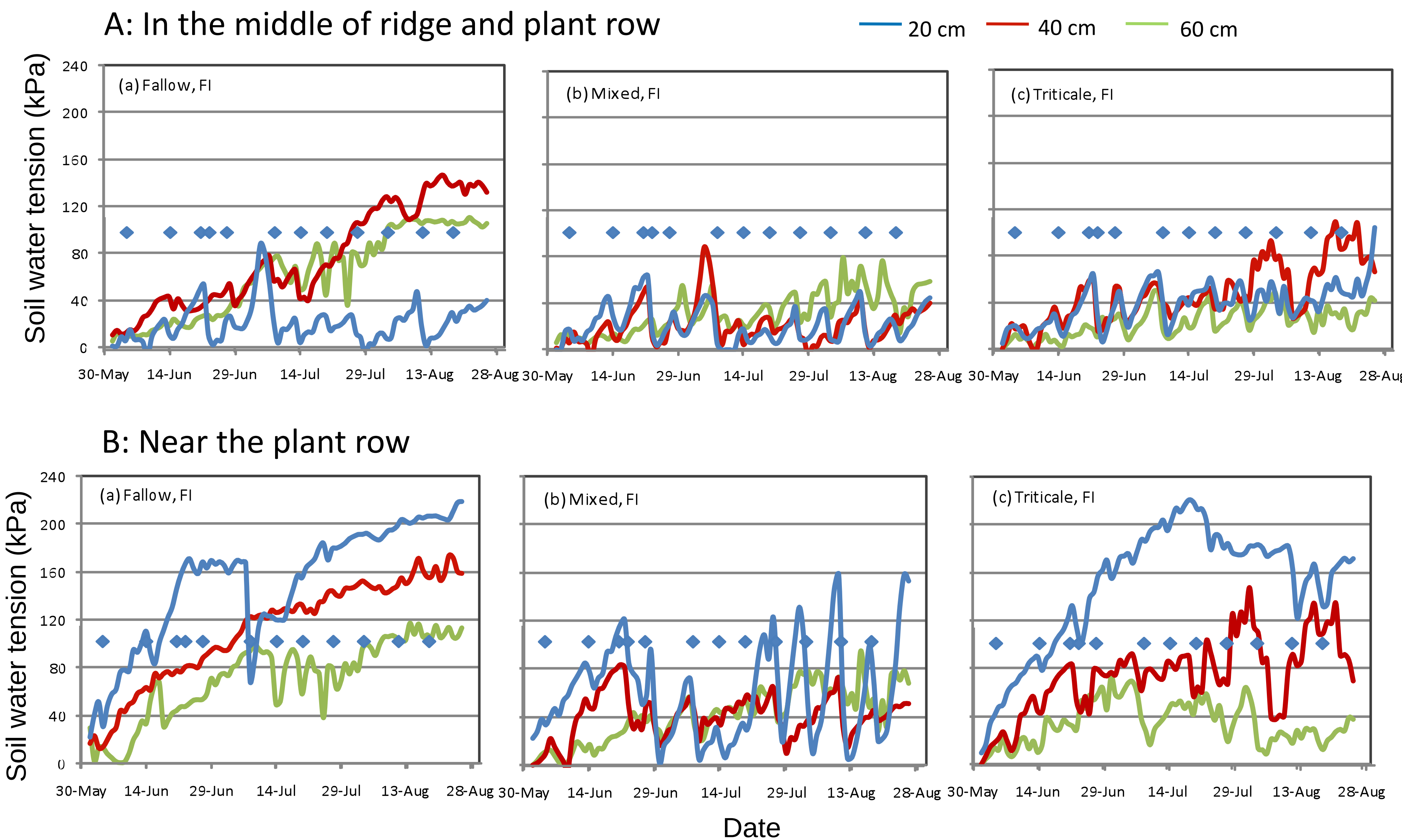


Figure 3. Soil water tension at three depths during tomato crop growth in 2011

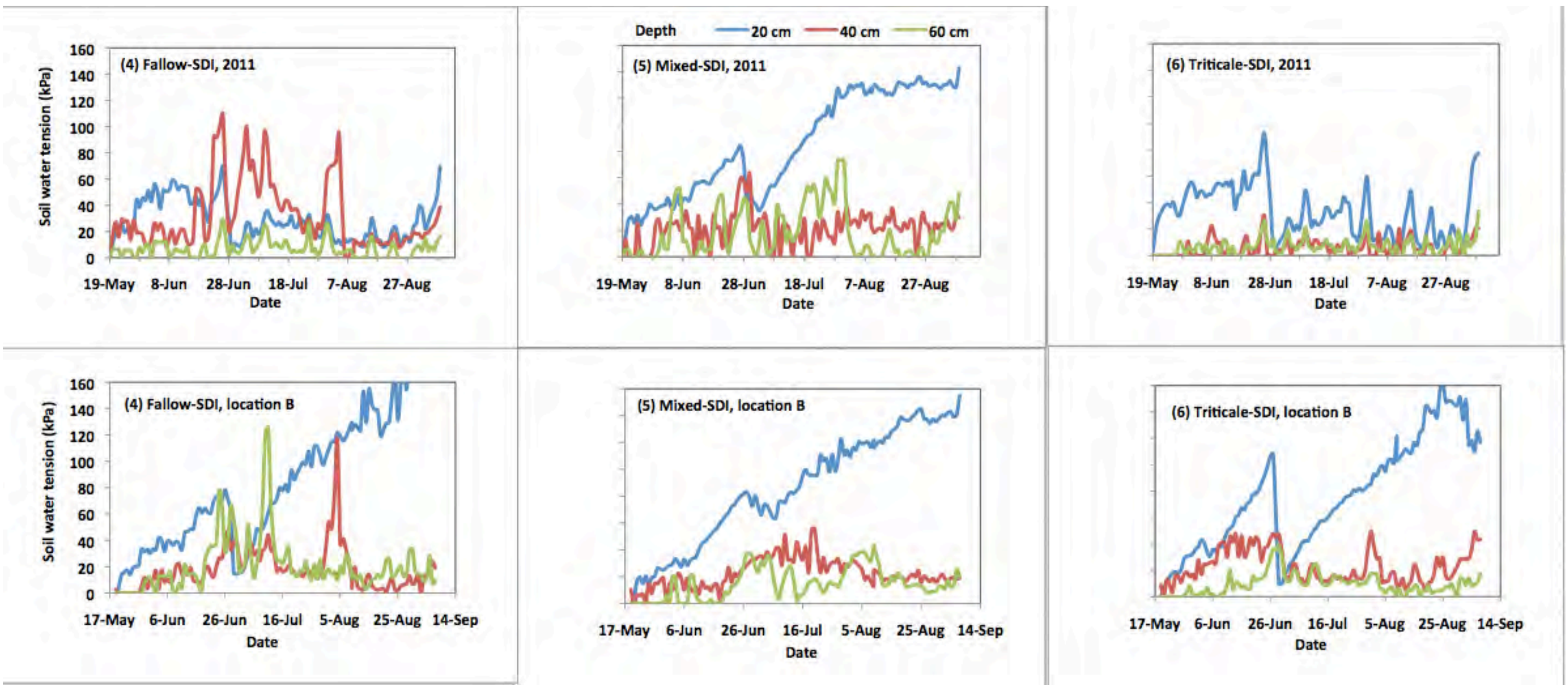


Figure 4. Water stress assessed through stomatal conductance & ^{13}C carbon isotope analysis

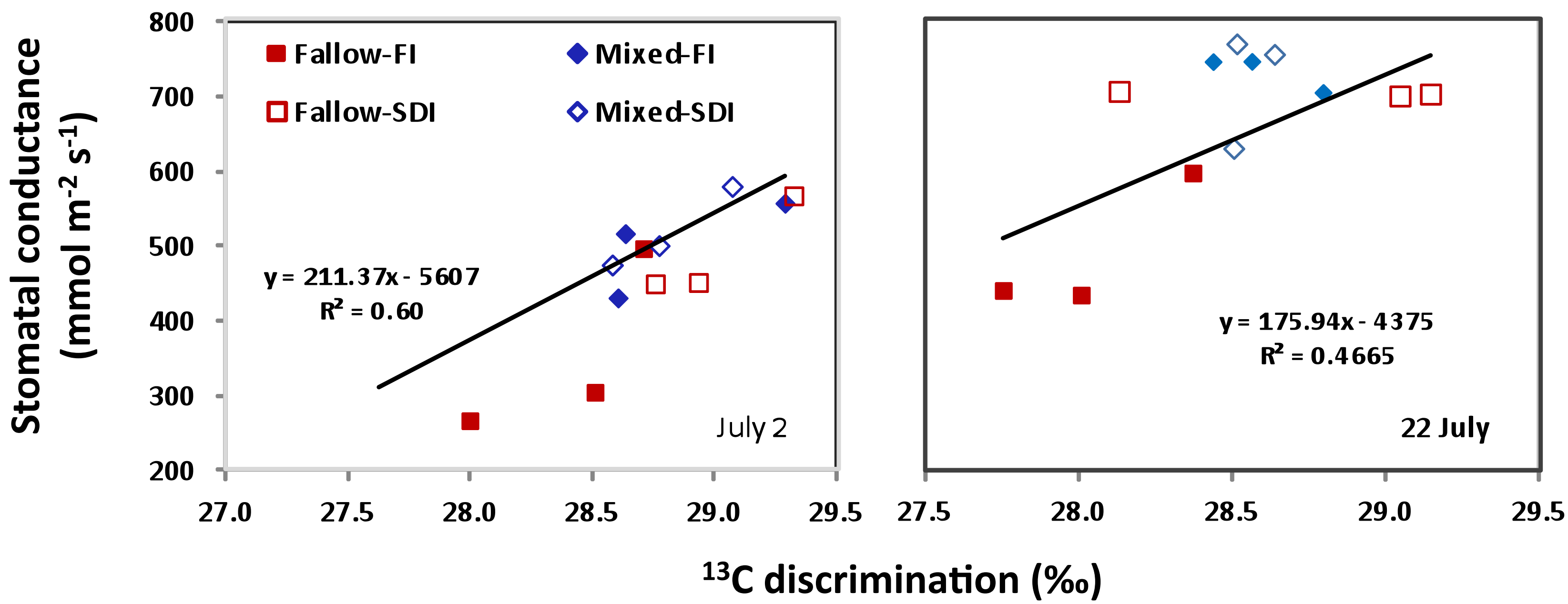


Figure 5a: Tomato yields:

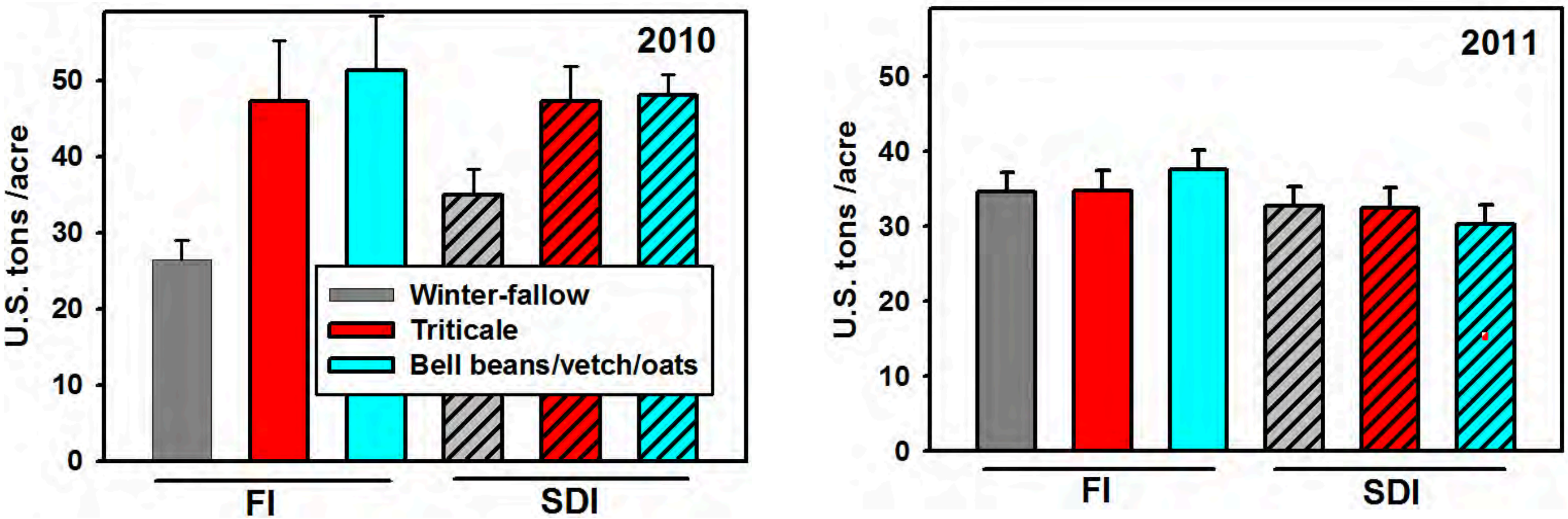


Figure 5b. Yields / unit applied water:

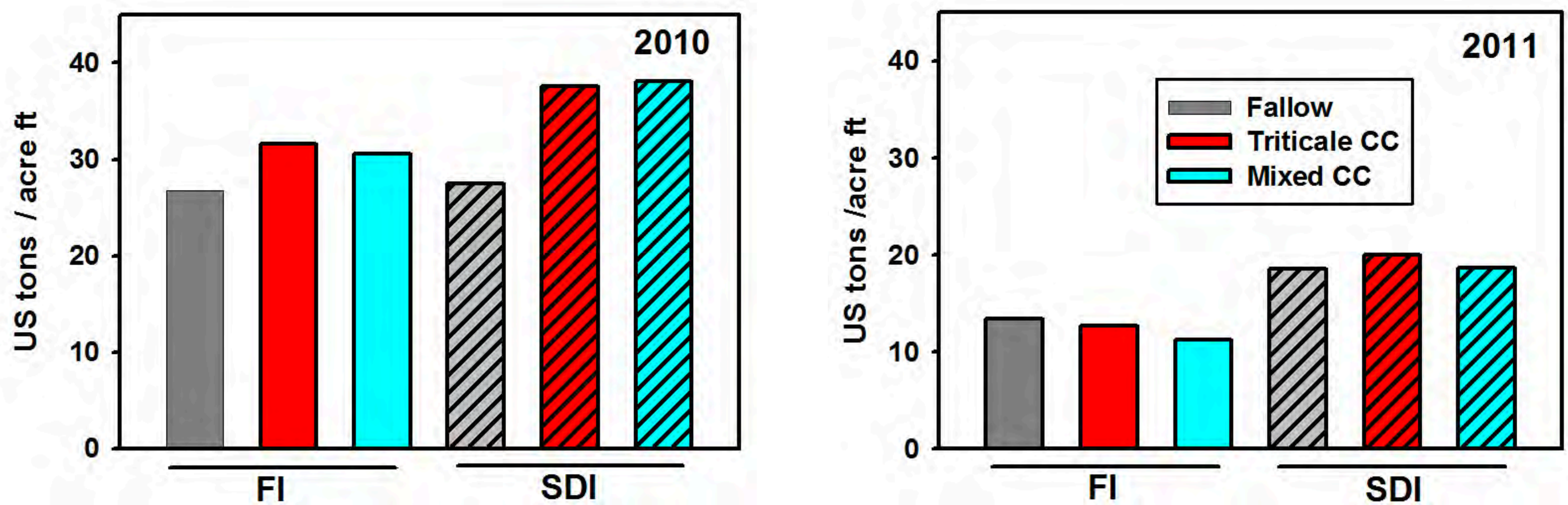


Figure 6. Irrigation & Cover Crop Effects on N_2O Emissions

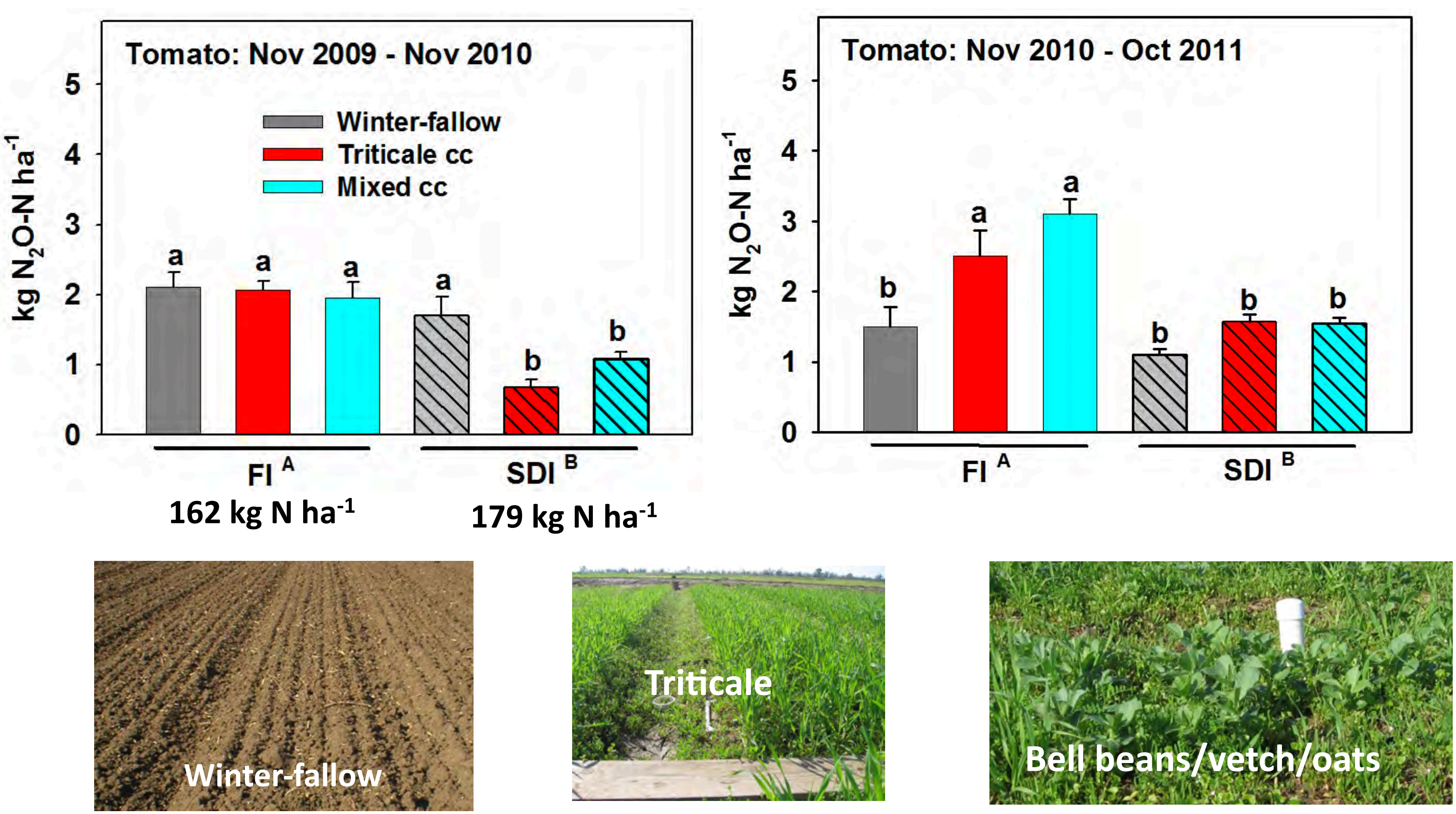


Figure 7a. Total greenhouse gas emissions of tomato rotation in 2010

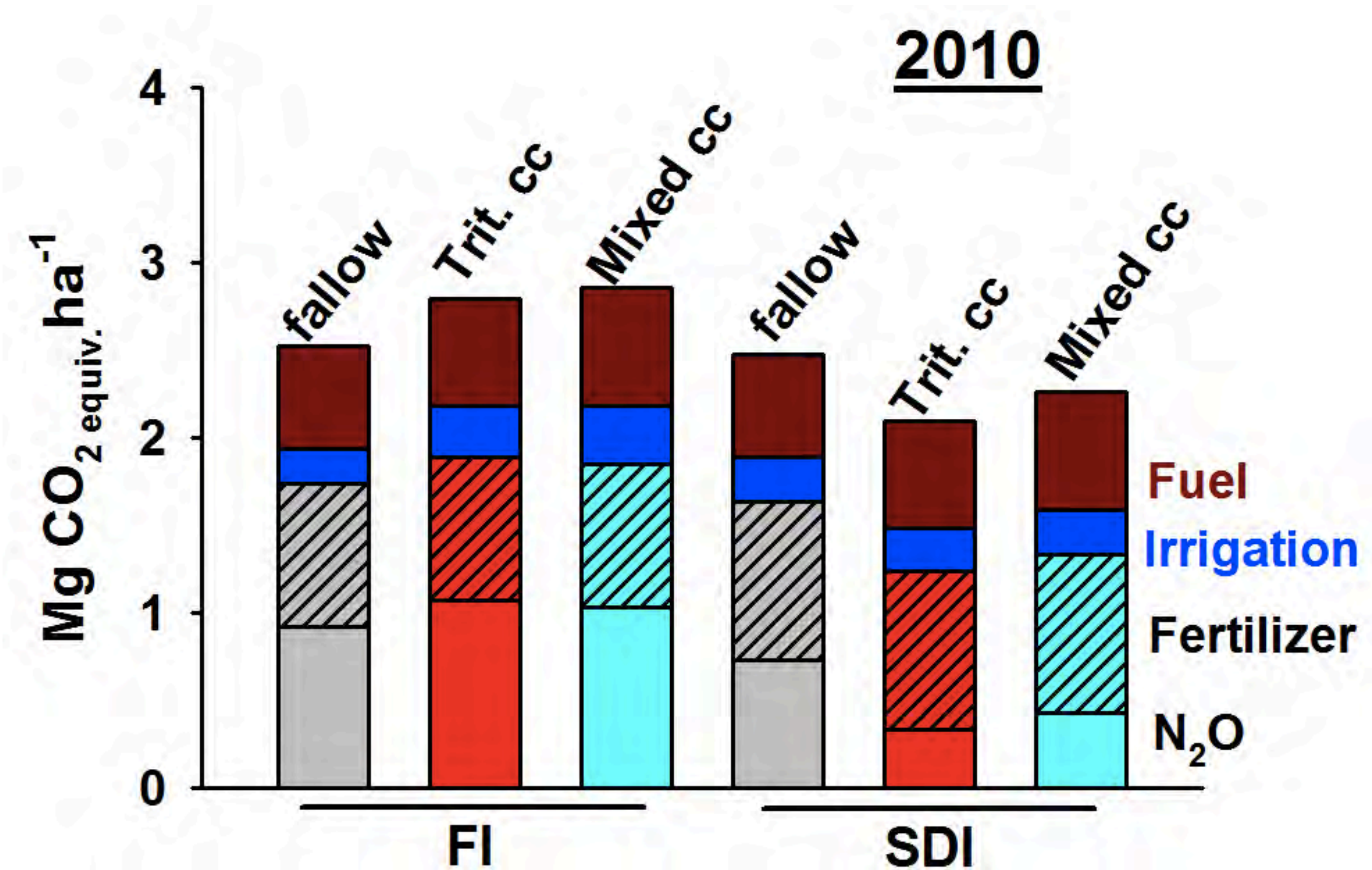
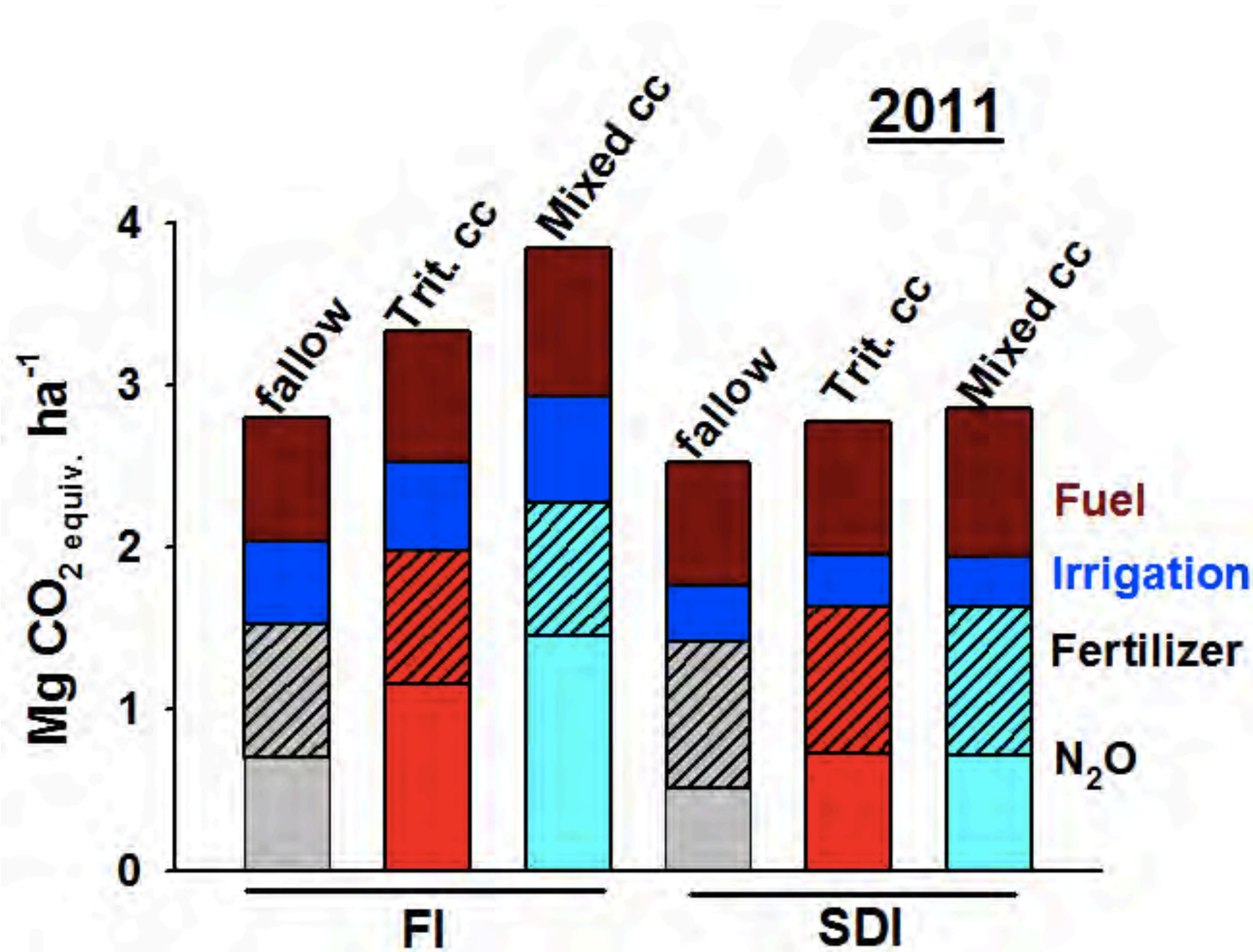
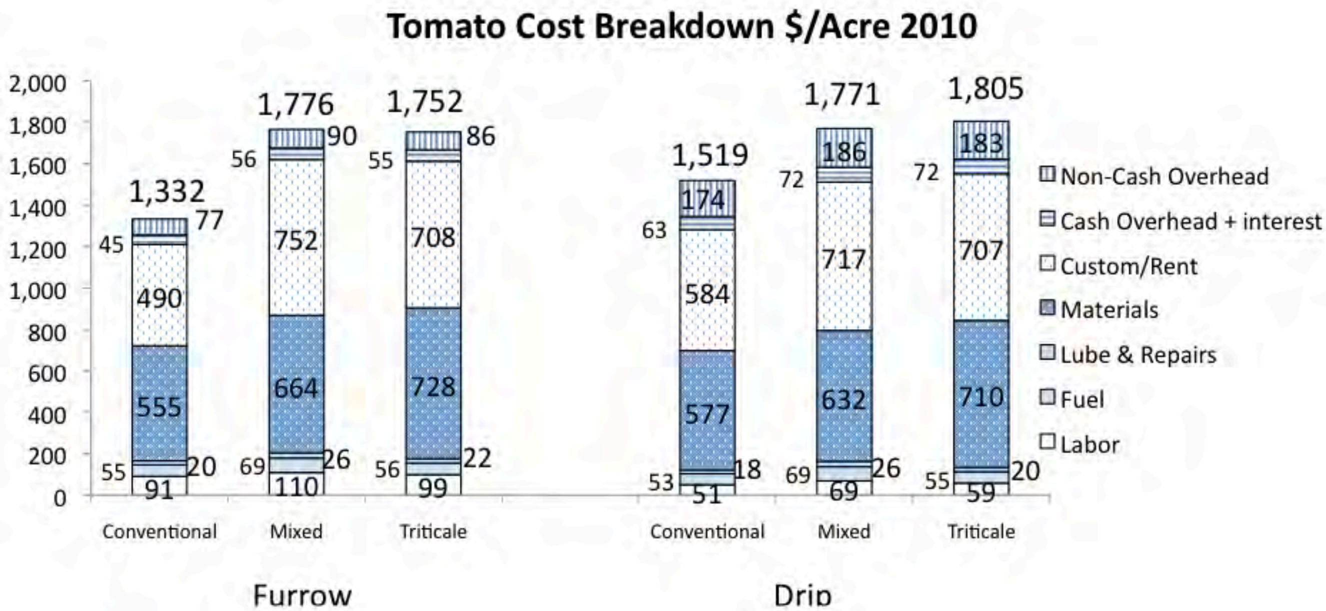
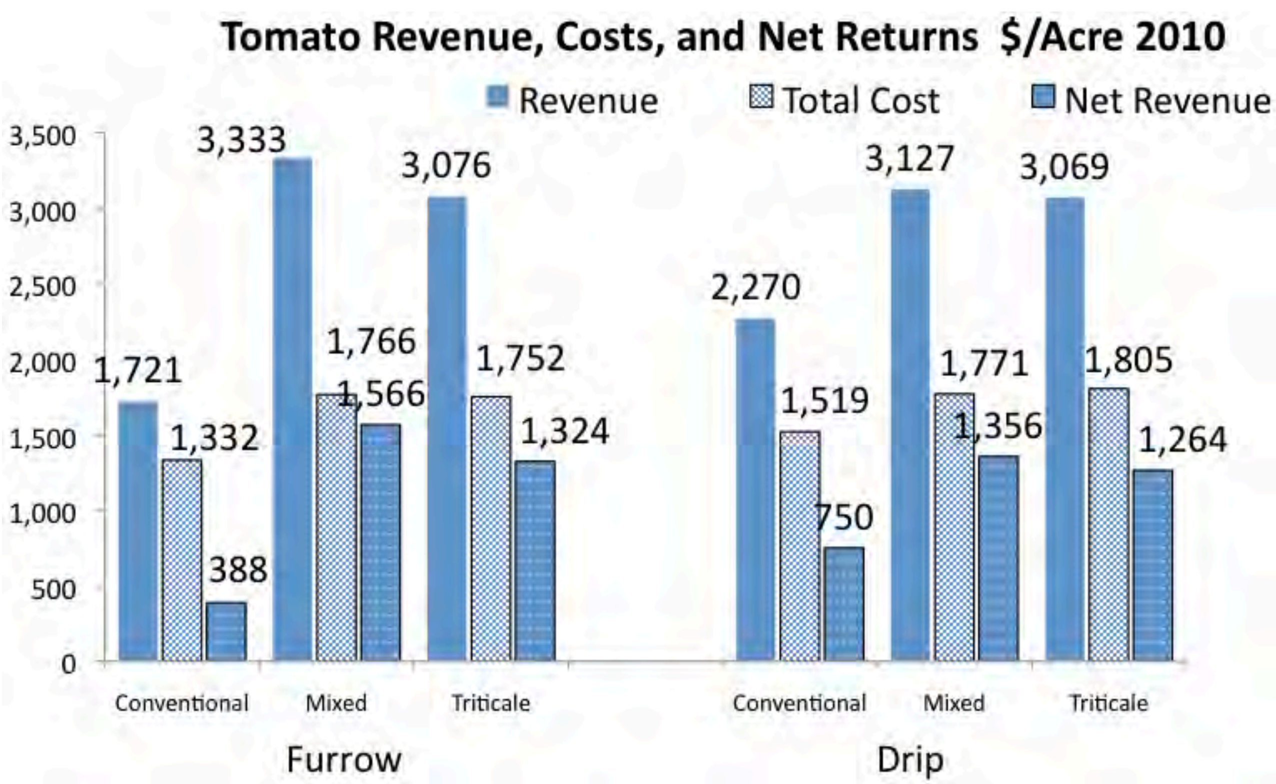
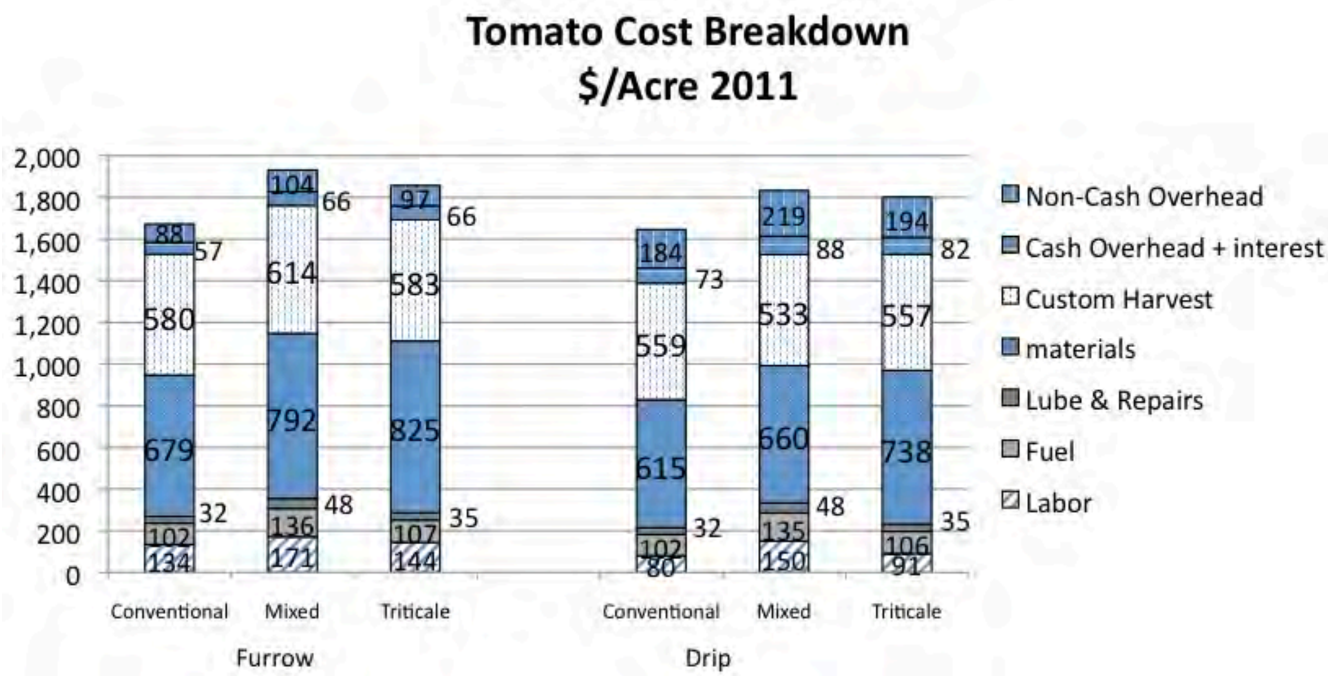


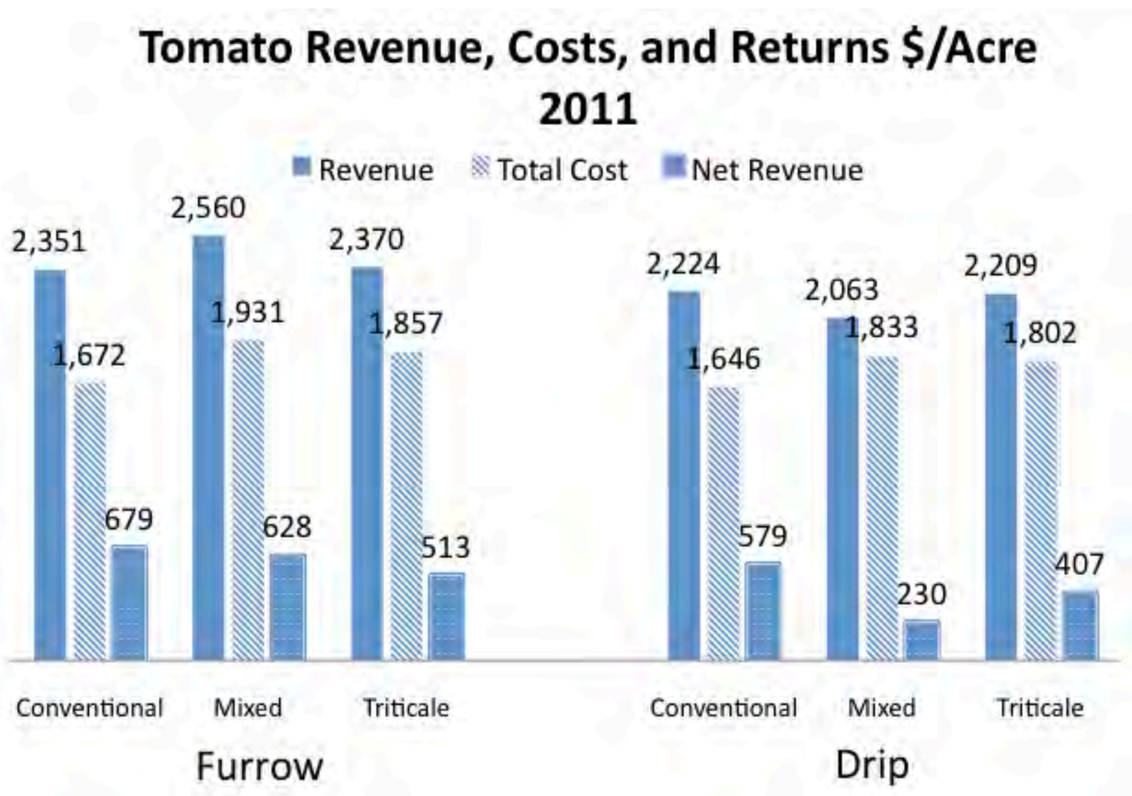
Figure 7b. Total greenhouse gas emissions of tomato rotation in 2011




Tomato Cost Breakdown $/Acre 2010
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1,332
1,776
1,752
1,519
1,771
1,805
77
45
490
555
55
20
91
56
90
752
664
69
26
110
55
86
708
728
56
22
99
63
174
584
577
53
18
51
72
186
717
632
69
26
69
72
183
707
710
55
20
59
Non-Cash Overhead
Cash Overhead + interest
Custom/Rent
Materials
Lube & Repairs
Fuel
Labor
Conventional
Mixed
Triticale
Conventional
Mixed
Triticale
Furrow
Drip


Tomato Revenue, Costs, and Net Returns $/Acre 2010
Revenue
Total Cost
Net Revenue
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1,721
1,332
388
3,333
1,766
1,566
3,076
1,752
1,324
2,270
1,519
750
3,127
1,771
1,356
3,069
1,805
1,264
Conventional
Mixed
Triticale
Conventional
Mixed
Triticale
Furrow
Drip


Tomato Cost Breakdown
$/Acre 2011
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Non-Cash Overhead
Cash Overhead + interest
Custom Harvest
materials
Lube & Repairs
Fuel
Labor
88
57
580
679
32
102
134
104
66
614
792
48
136
171
97
66
583
825
35
107
144
184
73
559
615
32
102
80
219
88
533
660
48
135
150
194
82
557
738
35
106
91
Conventional
Mixed
Triticale
Conventional
Mixed
Triticale
Furrow
Drip


Tomato Revenue, Costs, and Returns $/Acre
2011
Revenue
Total Cost
Net Revenue
2,351
1,672
679
2,560
1,931
628
2,370
1,857
513
2,224
1,646
579
2,063
1,833
230
2,209
1,802
407
Conventional
Mixed
Triticale
Conventional
Mixed
Triticale
Furrow
Drip

SureHarvest

SUSTAINABILITY FROM THE GROUND UP

What is a Sustainability Plan – the 5 P's:

1. ***Principles*** – your sustainability vision for the farm; your goals
2. ***Processes*** – e.g. irrigation management, nutrition management, pest management, etc.
3. ***Practices*** – e.g. cover cropping, pest monitoring, irrigation system maintenance
4. ***Performance*** – e.g. crop quality, yield, water use, energy use
5. ***Progress*** – self-assessment, benchmarking, action plans, improvements, re-assessment

The Multi-Commodity Project for Specialty Crops

Brief Project History

Over the last 10 years the field of sustainable agriculture has become more and more important in the eyes of the retailers, buyers and consumers of food. As is often the case when new concerns arise in relation to food and food production, the spot light shines on the grower. Sustainable agriculture is challenging to define and once defined it can be challenging for a grower to figure out how to implement it on the farm in an economically viable way. To meet these challenges a group of specialty crop trade associations, NGO’s, and other specialty crop stakeholders met to discuss the topic of sustainable agriculture. One outcome of these discussions was an application to the a California Department of Food and Agriculture Specialty Crop Block grant program for funds to hire sustainable agriculture professionals to help develop a plan to meet the challenges presented by sustainable agriculture. The Great Valley Centered coordinated the grant application and engaged SureHarvest to help with the application. SureHarvest is a company with extensive experience in sustainable agriculture strategic planning, program design, and program implementation. The grant application was successful and began in September of 2009.

The grant had two primary goals. The first was, through a stakeholder process, to develop a sustainable agriculture strategic plan that each of the participating groups could use internally to help lay the foundation for a sustainable agriculture program for their particular specialty crop. The second was to develop a tool or tools that could be used by their member growers to put the strategic plan into action on the farm.

The following pages contain the sustainable agriculture strategic plan developed by the project participants.

The tool that was agreed upon and developed by a stakeholder process is contained in a separate document and is titled ‘Development of a Multi-Commodity Self-Assessment Template’.

Sustainability Strategic Plan for the Multi-Commodity Project
June 2011

The sustainability strategic plan for the Multi-Commodity Project is based on the 5 P's model for developing a sustainable farming program. The 5 P's are: Principles, Processes, Practices, Performance, and Progress. They are defined as follows:

1. Principles – This is the sustainable vision for the project. It consists of the goals that the participants want to achieve from the design and implementation of the project.
2. Processes – These are the resource areas on the farm that need to be addressed in order to meet the principles or goals of the project. For example, this could be water, energy, human resources, etc.
3. Practices – These are the practices that are implemented on the farm that impact the processes or resource areas. They are the on-the-ground actions that are carried out to assure that the principles or goals of the project are met.
4. Performance – The outcomes resulting from the practices implemented on the farm. There are many and some examples are crop quality, water use, energy use, worker satisfaction, etc. Performance is a measure of the level of success in meeting the principles or goals of the project.
5. Progress – Improvement of performance over time. In other words tracking the degree one is making towards achieving the goals of the project. Measuring progress will require some kind of system for assessing the farms performance over time, creating action plans to improve particular areas of performance, and reassessment over time to track progress.

Figure 1 presents a schematic of the 5 P's using vineyards as an example specialty crop.

The goal of the Multi-Commodity Project is to create tools which would simplify and reduce costs for an individual commodity group in establishing a sustainability program for their growers, which in turn would equip the growers to work through these 5 Ps in their farming operations. The scope of the CDFA Block Grant that is funding the Multi-Commodity Project is to establish the principles of the project, identify the processes or resource areas, and establish practice areas that are relevant to most specialty crops.

Table 1 contains the names of the groups participating in the project and people representing those groups.

Principles:

The principles for the Multi-Commodity Project were established at the Project Leadership Team meeting on March 15. They are:

1. Create a resource area/practice template that:
    a. Will focus on increasing the economic performance for the participant.
    b. Is scalable and can be used by participating groups to accomplish the goals of their own sustainability programs.

c. Provides the participant the ability to gauge the state of the industry and their farm.
d. Encourages continual improvement on the farm.
e. As a whole encourages ecological harmony.
f. Better defines the 3 E's (economic viability, environmental soundness and social equity/responsibility) in a way we can all agree upon.
g. Is open to and usable by any individual or group in the future that was not a part of the original participants.
h. Benefit the participants and not result in unintended negative consequences.

2. The program should provide the information/data needed for groups to tell their sustainability story better to all their audiences, e.g. buyers, regulators, consumers, NGO's.
3. The outcomes from the project cause no harm to producers.

Figure 1. Example Sustainability Strategic Plan

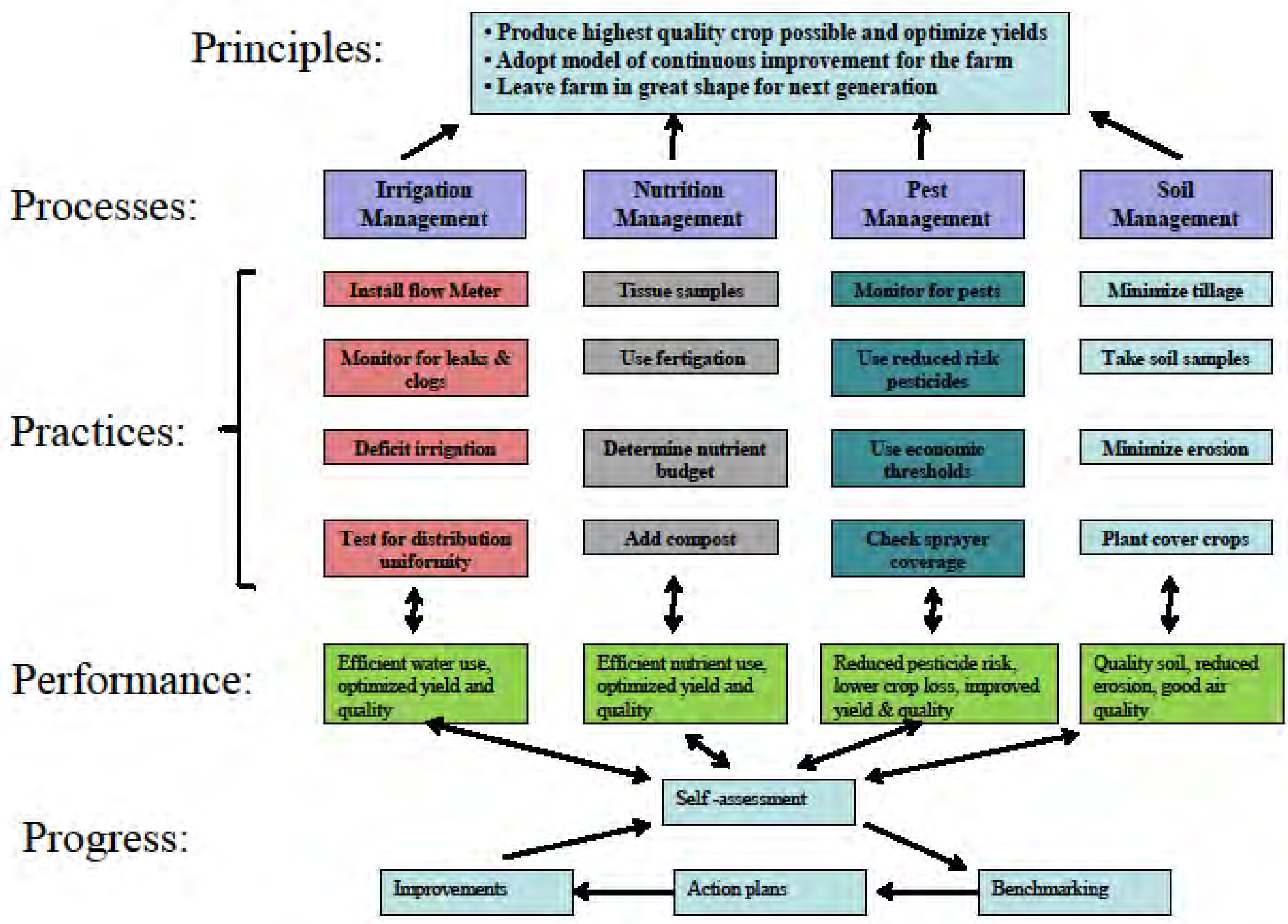


Table 1. Multi-Commodity Project Participants

Organization	Representative
Almond Board of California	Gabriele Ludwig*, Robert Curtis*
Bolthouse Farms	Troy Elliott*, Justin Groves*
California Dried Plum Board	Gary Obenauf
California Grape & Tree Fruit League	Chris Valadez*, Barry Bedwell
California Specialty Crop Council	Lori Berger*
California Garlic & Onion Research Advisory Board	Robert Ehn
California Olive Council	Patty Darragh
California Pear Advisory Board	Bob McClain
California Pepper Commission	Glen Fischer*
California Pistachio Board	Robert Klein*
California Raisin Marketing Board	Gary Schultz
California Tomato Farmers	Ed Beckman*
California Tree Fruit Agreement	Gary VanSickle*, Lauren Friedman
California Walnut Board	David Ramos
DelMonte Foods	Pat McCaa
SunMaid Growers	Rick Stark*

*Leadership Team Member

Processes:

The processes or resource areas for the Multi-Commodity Project were identified at the May 27, 2010 meeting of the Leadership Team. They are:

1. Water
2. Crop
3. Pest Management
4. Air
5. Land
6. Continuity
7. Energy
8. Social Responsibility
9. Waste

Practices Areas:

The practice areas within the resource areas for the Multi-Commodity Project were identified at the May 27, 2010 meeting of the Leadership Team. They are:

1. Water:
    a. Amount
        i. Irrigation scheduling

        ii. System distribution and maintenance
        iii. Infiltration
    b. Quality – both of water going on the crop, but also quality of surface and ground water.
        i. Source – what is in the water coming in; does it need to be treated and what are the effects of the remediation.
        ii. Water offsite movement, surface and ground water.

Issues to Consider for Water Resource Area:

- Cause/effect
- Interplay of resources
- Unintended consequences
- Varying qualities of water required for various crops

2. Crop:
    a. Quality (e.g. marketable yield, Return on Investment). Issues to consider:
        i. Quality goes up yet yield suffers – how do you maximize marketable yield taking in to account ROI related to economies of scale, costs, boost yields, bottom line
        ii. Cost analysis/economic trade-offs
    b. Food Safety
        i. How is this done on a scalable basis? How do you make this work for small and large growers
        ii. Use harmonized standards from recognized buyers/regulators?
        iii. Ability to comply with harmonized standards?
    c. Nutrient management was moved to the Soil Resource Area.

3. Pest Management:
    a. Risk assessment – e.g. location, climate, variety/crop selection, economics, crop quality, market (Maximum Residue Levels - MRLs)
    b. Monitoring/scouting - e.g. thresholds
    c. Resistance management
    d. Pesticide management – e.g. calibration, mixing, spraying, safety, storage, drift
    e. Prevention and cultural practices (pest specific mostly)
    f. Resistance management (pest and product specific – mostly)
    g. Non-target issues – e.g. pollinators
    h. Issues to consider:
        i. Where does deciding what pesticide to apply fit in, if a decision is made that an application is necessary?
        ii. Each pest has its own IPM program
        iii. Where do Biocontrols fit in?

    iv. Pest management framework is applied to the following pest categories: insects, disease agents, weeds, vertebrates.

4. Air:
    a. Ground level ozone – VOC and NOx
    b. Particulate matter – visible dust, PM10, PM2.5
    c. Greenhouse gases – CO2, methane, NOx
    d. Stratospheric ozone layer - Methyl Bromide phase-out
5. Land:
    a. Soil management
        i. Knowing your soils
        ii. Nutrient management
        iii. Organic matter and soil quality management
        iv. Erosion, both wind and water.
    b. Ecosystem management
        i. Habitat
        ii. Biodiversity; there can be a food safety issue when it comes to animals and habitat to encourage them.
        iii. Agro-ecosystem/landscape knowledge
6. Continuity:
    a. Business plan
        i. Financial planning
        ii. Estate planning,
        iii. Succession planning
        iv. Diversification.
    b. Fair price – The group struggled with coming up with practice areas for this resource area.
        i. Markets
        ii. Pricing and strategy
        iii. Value added efforts
    c. Issue to consider – surcharges for energy and food safety to compensate growers for dealing with these issues.
7. Energy:
    a. Planning and analyses
    b. Fuel
        i. Tracking
        ii. Alternatives
    c. Electricity
    d. Embedded energy in inputs – e.g. in pesticides, fertilizers, etc.
    e. Asset utilization (e.g. time of use, hp for right equipment, 4 wheeler vs tractor for a job)
8. Social Responsibility
    a. Human Resources – someone suggested looking at CIW (Coalition for Immokalee Workers) and what are they requirements to see what the hot button issues are for groups that represent labor interests.
    b. Community – the group adopted a broad definition of community, including community where one lives, community of buyers, community of consumers, etc.

One participant said they define community as all those who do they touch with their practices and products.

9. Waste:
    a. Un-harvested product
    b. Crop residue
    c. Waste to landfill
    d. Hazardous waste.

Development of the Multi-Commodity Self-Assessment Template

The Leadership Team of the Multi-Commodity Project decided the best tool for implementing their sustainability strategic plan was to develop a self-assessment of practices template that stakeholders from specific specialty crops could then fine tune for their own use. The team chose to use the model developed by the California Sustainable Almond Program. The Leadership Team formed a stakeholder committee to draft the self-assessment template that covered the practice areas listed in the Multi-Commodity Project Strategic Plan. The Stakeholder Committee members are listed in Table 1.

Individual Contact	Title	Expertise
Billy Heller	Grower, Pacific Triple E Farms	Crop management
Bob Giampaoli	Grower, Live Oak Farms	Crop management
Cliff Sadoian	Grower	Crop management
Pat McCaa	Manager Pest Management, Del Monte Foods	Crop management
Mechel S. Paggi (Mickey)	Director, Center for Agricultural Business, California State University Fresno	Ag Business & economics
Glen Fischer	Ag Representative, Saticoy Foods Inc.	Crop management
John Trumble	Professor of Entomology, University of California Riverside	Pest management
Jeff Mitchell	Extension Specialist, University of California Davis	Soils & plant nutrition
Pete Goodell	UC IPM Area Advisor, University of California Davis	Pest management
Terry Prichard	Extension Specialist, University of California DAvis	Irrigation & crop water relations
Bill Peacock	Representing raisin growers and Tree Fruit Growers - Raisin Marketing Board is the associated group	Crop management
Troy Elliott	Director of Agronomy, Bolthouse Farms	Crop management

Table 1. Multi-Commodity Project Stakeholder Committee

Over a period of six months through a series of 6 webinars, the Stakeholder Committee drafted the self-assessment template presented here. The template was approved by the Leadership Team and Stakeholder Committee at a meeting in April 2011.

Air Quality Management

We all appreciate good air quality. Unfortunately, the San Joaquin Valley is out of attainment of the Federal Clean Air Act. Because of this the region is under threat of losing federal highway dollars if attainment cannot be achieved. Therefore a lot of pressure is being brought to bear on urban and rural industries, including agriculture, to reduce air pollutants in the Valley in any way that is possible. This section of the self-assessment will help you identify practices that influence air quality, see where you are doing well, and determining areas that need improvement.

Air Quality Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
In Field and Adjacent Land					
1.1 To minimize airborne dust and PM10[1] particles a reduced tillage program is in place					
1.2 To minimize airborne dust and PM10 particles a no-till program is in place					
1.2 If tillage is done, moisture content of the soil is taken into consideration to minimize dust					
1.3 Mulch, either plastic or natural material, is used in the field to minimize dust (and conserve soil moisture)					
1.4 To minimize airborne dust and PM10 particles in perennial crops, a permanent cover crop is maintained at least every other row					
1.5 An every row permanent cover crop is maintained in perennial crops					
1.7 Vegetation is maintained on non-cropped areas such as headlands, roadsides, and field edges to reduce wind erosion causing airborne dust					
1.8 Crop residues or prunings are either chipped and/or incorporated into the soil or composted rather than burned					
1.9 Burning is restricted and only done when necessary, such as when taking out an old orchard or vineyard and is done in strict accordance with the law					
Roads					
2.1 Vehicle speed is restricted on dirt roads around fields to minimize airborne dust					
2.2 Dirt roads are treated with an anti-dust agent that meet the 50% PM10 control for a Fugitive PM10 Management Plan[2]					

[1] PM 10 are particles 10 microns in diameter or smaller and pose a health risk because they pass through the throat and nose and penetrate the lungs.

2.3 Dirt roads are graveled, chipped, mulched (crop residues), sanded or seeded					
2.4 Heavy used roads are paved (e.g. main thoroughfares on farm)					
Engines and Fuel Consumption					
3.1 Engines are maintained on a regular schedule to ensure they are running at optimum performance and efficiency and emissions are minimized					
3.2 At least some vehicles are equipped with engines able to use alternative fuels with lower emissions (e.g., compressed natural gas, flex fuel, biodiesel, propane)					
3.3 Some off-road farm vehicles are battery powered (e.g. golf carts)					
3.4 Vehicle miles are tracked on an annual basis					
3.5 Stationary diesel engines have been replaced (or retrofitted) to Tier III or better					
3.6 Stationary diesel engines have been replaced (or retrofitted) with technology relying on cleaner burning fuel (e.g. propane, natural gas, biodiesel) or replaced with electric pumps					
3.7 Selection of vehicle power plants and stationary engines is in part determined by lower emissions ratings					
3.8 Some of the farm's energy requirements are obtained through renewable sources such as wind or solar					
Pesticide Management and Air Quality					
4.1 Soil fumigants are used only when necessary and in a targeted fashion (e.g. pre-planting where soil sampling has identified a significant pest problem)					
4.2 When choosing a pesticide to apply its VOC 'footprint' is considered either in consultation with a PCA or by using a VOC calculator[3]					
4.3 Practices are implemented that reduce pesticide drift such as use of air induction nozzles, turning sprayers off at turn-arounds, , not spraying when a temperature inversion exists in the field, and when wind exceeds 10 mph					
Greenhouse Gas Emissions					
5.1 I am aware of the role of CO_2, NOx, and methane as greenhouse gases and where they are produced in my farming operations					
5.2 CO_2 and NOx production are calculated and tracked					

[2] For details see http://www.airquality.nrcs.usda.gov/Documents/Dust_Control_Products.htm
[3] A VOC calculator is found at: http://apps.cdpr.ca.gov/voc-calculator/

What are VOC's?

VOC stands for volatile organic compound. These are carbon based compounds contained in products used on the farm, such certain pesticides, that volatilize (evaporate) when exposed to the air. Ground-based ozone is produced by chemical reactions involving VOC's, nitrogen oxides (NOx) and sunlight. While not direct air pollutants themselves, VOC's are important ozone precursors and considered key targets for reduction in the Central Valley of California in regions where air quality is an issues.

Energy Management

Energy is essential for crop production and it comes in several forms; as sunlight to power photosynthesis, as fuel to power our internal combustion motorized vehicles and pumps, and as electricity to power our shop and office lights and electronic equipment. Tracking energy is very important because it is getting more and more expensive all the time, increasing our cost of production. Burning of fuel produces GHG's affecting air quality and contributing to climate change. So minimizing energy consumption saves money and reduces GHG production. Completing this section should help improve your understanding of energy use in your operation and encourage you to consider some forms of energy conservation.

Energy Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
1.1 The total amount (gallons) of fuel used annually on the farm in all operations is recorded and year to year comparisons are made. Gasoline is recorded separately from diesel.					
1.2 The total amount of fuel used annually per unit of crop production is determined and year to year comparisons are made[4]					
1.3 The total amount of fuel used annually is calculated for each field and year to year comparisons are made. Gasoline is recorded separately from diesel.					
1.4 Annual fuel consumption and/or electrical use for irrigation pumps is recorded and comparisons made from year to year.					
1.5 Electrical use for office(s), shop(s), and outdoor security lighting is tracked using energy bills and year to year comparisons are made					
1.6 Fuel and electricity used are converted to a common metric such as British Thermal Units (BTU's) so they can be combined to calculate the total amount of energy used annually for crop production and year to year comparisons are made[5]					
1.7 The amount of energy used annually per unit of crop production is calculated and year to year comparisons are made					
1.8 The amount of energy used annually in each field is calculated and					

[4] This can be a simple calculation of dividing the total gallons of fuel used for the year divided by the total amount of crops produced for the year

[5] Energy conversion calculators for kilowatt hours to BTU's and gas or diesel to BTU's are readily and freely available on the Internet. For example using Google type 'convert gas to BTU's and you will be directed to a website where a calculator is available to make your conversion. Simply type in the number of gallons of gas and the calculator will produce the number of BTU's it represents.

year to year comparisons are made					
1.9 An energy management plan is being implemented on the farm that includes yearly goals for overall energy use as well as energy used per unit of crop production.[6]					
1.10 A process is in place to ensure that the most appropriate piece of equipment is used for a given job (e.g. the most appropriate horse power engine for the job)					
1.11 One or more solar energy systems are installed on the property to generate electricity					
1.12 One or more wind generators are installed on the property to generate electricity					
1.13 Residue from crop production is used in a cogeneration plant					
1.14 Engines (stationary and mobile) and motors are maintained on a regular schedule to ensure they are running at an optimum fuel efficiency or optimum efficiency.					
1.12 Pumping plant efficiency (energy per acre foot pumped)is is checked every 1 to 3 years (based on use) and adjustments made if necessary (FSU website recommends every 1-3 years based on use)					
1.13 At least some light switches are fitted with motion detectors or photo cells to reduce time of use					
1.14 At least some office and shop lights have been fitted with low energy consumption compact florescent bulbs or LED lights.					

Indirect Energy Use/Consumption:

Energy is directly expended when driving a vehicle, operating a pump, photocopying, or turning on a light bulb. Energy is also expended to manufacture inputs that are used on the farm, such as fertilizers, compost and pesticides. This type of energy consumption is called imbedded energy. If you want to figure out the total amount of energy consumed to produce a crop then calculations should also be made to determine the amount of embedded energy that was consumed to produce the fertilizers, compost, and pesticides that were used to produce the crop.

[6] Ideally one would convert all energy consumption to BTU's but initial energy management plans could start with using gallons of gasoline and diesel and kilowatt hours for electricity.

Financial Management

The economic E of sustainable farming is literally where the buck stops. If a farm is not profitable it is not sustainable. People farm not because they want to be accountants. They farm because they want to grow things. However, while financial management may be a burdensome part of farming, doing it well is one of the keys to a successful and sustainable farm. This chapter will help you recognize where your strengths are in financial management as well as point out areas where improvements are needed.

Financial Management **(The most appropriate person to fill out this section/chapter is the CEO/owner of the farm)**	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Planning and Risk Management					
1.1 A production and marketing plan has been developed for my farm and seasonal outcomes are compared to these plans					
1.2 A succession[7] plan is in place for the farm					
1.3 I have a written will and estate plan for the farm[8]					
1.4 A business continuation plan (disaster[9] management plan) has been developed for the farm					
1.4 A risk management plan has been developed for the farm					
1.5 Key personnel in the company have health insurance					
1.6 Key personnel in the company have disability insurance					
1.7 Key personnel have life or accidental death insurance					
Accounting and Financial Analyses					
2.1 I use a financial accounting system to track and report farm finances and use it to make decisions about my farming operation					
2.2 I understand how to interpret both cash and accrual financial statements including a balance sheet, income statement, cash flow, and financial ratios					
2.3 I meet with a financial advisor on an annual basis					
2.4 Financial profitability analyses for investments are done if investments are made					

[7] A succession plan is one where the change in leadership in the company has been determined, whether it is expected such as the CEO voluntarily stepping down/retiring, or unexpected such as due to illness or accident.
[8] An estate plan is a plan for the financial assets to pass from one generation to the next. It does not deal with the human and intellectual capital and passing that transition to the next generation. That is succession planning.
[9] Disaster in this case is not just weather but also unexpected death of one or more key company personnel.

2.5 The revenue and returns are tracked for each field/management unit in my financial management reports					
2.6 Costs and returns are tracked for all important farming practices					
2.7 Costs and returns are tracked for implementing new sustainability practices and compared to costs and returns of practices they replaced					
2.8 Sensitivity analysis, i.e. change in crop prices over time, is used to analyze financial risk over time					
Purchasing and Borrowing					
3.1 More than one quote is obtained for major input purchases such as pesticides and fertilizers					
3.2 Interest rates and services from more than one lending institution are compared before borrowing a significant amount of money					

Food Safety Management

What is safe food? This is a question that is being debated by everyone all along the supply chain. New food safety compliance is costing some growers a lot of money. When you think about it, proving a food to be safe is a very difficult thing to do because in reality one has to prove that it is not safe.

Food Safety Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Food Safety Risk Assessment of Field					
1.1 An assessment has been made of the production field focusing on the likelihood of intrusions by animals that pose significant food safety risks (e.g. deer, pigs, livestock) and, if necessary, actions are taken to reduce the likelihood of intrusion					
1.2 An evaluation has been made on land and waterways adjacent to the field for possible sources of human pathogens of concern (e.g. manure storage, CAFO's, grazing/open range areas, surface water, sanitary facilities and composting operations)					
1.3 An assessment of historical land use has been made to determine any potential issues from these uses that might impact food safety (e.g. hazardous waste sites, landfills, etc.)					
1.4 My company participates in a third party food safety certification program (e.g. Agriculture Marketing Service GAP Certified, Scientific Certification Systems, Primus)					
Water					
2.1 The water system description for the field/ranch has been created that indicates, either with drawings or maps, the location of permanent fixtures, such as pumps, wells, underground lines, gates & valves reservoirs, and returns					
2.2 Irrigation water and water used in harvest operations is tested for microbial quality, and if microbial levels are above specific action levels, corrective actions are taken					
2.4 Records of all water tests are retained, along with Certificates of Analysis, for at least 2 years					
2.5 Irrigation pipe and drip tape are stored in a manner that reduces or eliminates the potential for pest infestation					
2.6 Water applied to edible portions of the crop, either as overhead irrigation or pesticide applications, is tested for microbial quality					

Organic Soil Amendments					
3.1 Raw manure or a soil amendment that contains un-composted or incompletely composted or non-thermally treated animal manure is not applied to field					
3.2 If compost is applied, it is sourced from a supplier that provided their written Standard Operating Procedures that prevents cross-contamination of finished compost with raw materials through equipment, runoff or wind.					
3.3 If organic soil amendments are used microbial testing is performed by the supplier prior to application					
Sanitation					
4.1 Toilet facilities are readily available to all field employees and are located according to Cal OSHA reguations					
4.2 Toilet facilities are clean and maintained on a regular basis					
4.3 Field employees are trained on the importance of sanitation in the field					
4.4 Field sanitation units are accessible to all employees					
4.5 A response plan is in place in the event of a spill from toilet or sanitation facilities and employees are trained to implement it					
4.6 Workers are educated on sanitation issues such as not working on the job while sick or injured (e.g. infected cuts)					
Harvesting and Transportation					
5.1 A traceability system is in place and appropriate for my crop					
5.2 A mock recall has been done to check the effectiveness of the traceability system					
5.3 All harvesting containers and bulk hauling vehicles that come into direct contact with the harvest crop are cleaned and/or sanitized on a scheduled basis using a written record system					
5.4 Packaging materials used in field operations are properly stored and protected from contamination					
5.5 Harvesting equipment that comes into contact with the crop is kept in good repair					

Soil Management

Soil is the most complex ecosystem on earth. Gaining a greater understanding of the soil resource in your fields is critical for making informed soil management decisions. Knowing your soil resource gives you greater control over yield and crop quality and is especially important in determining the long-term sustainability of your farm.

Soil provides the crop with three vital things: water, nutrients and air. These three things are best provided by a soil with good depth and structure i.e. a soil in which the particles are bound together into small clumps (aggregates) of varying size. Soil aggregation is a measure of soil structure. Soil organic matter is important in maintaining soil structure by gluing soil minerals together into aggregates. Spaces between large aggregates (measured as millimeters) permit rapid drainage and easy root growth, and spaces between small aggregates (measured as less 1 millimeter down to 0.001 millimeter) trap water for use between irrigation and rain events. One of the more important aspects controlling aggregate stability is the amount of microbial activity and soil organic matter. Stable aggregates occur in varying sizes and are created by the cementing action of microbes and their byproduct and soil organic matter. The assemblage of soil aggregates creates habitat to promote faunal and microbial diversity, an important index of soil quality. Management of soil structure is done primarily through additions of organic amendments such as compost, cover crops and crop residues[10].

Due to the warm to hot California climate soil organic matter is low in many soils due to rapid breakdown of soil organic matter. However, it is still important to add organic matter to the soil if possible because it is the breakdown of the organic matter that contributes to soil aggregation not simply the presence of the organic matter.

The following self-assessment template will help document the practices producers are using to managing their soil sustainably as well as suggest areas where improvements might be possible.

Soil Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Knowledge of soil properties					
1.1 The soil types in the field has/have been identified using NRCS soils maps					
1.2 The soil types in the field has/have been identified using soil samples taken pre-planting (for permanent crops soil pits were dug to establish soil series)					
1.3 Soil properties for each soil type in the field is recorded, including					

[10] Horwarth, W., C. P. Ohmart, and C. P. Storm. 2008. Chapter 4. Soil Management *in* Ohmart, C. P., C. P. Storm and S. K. Matthiasson. Lodi Winegrower's Workbook 2nd Edition. Lodi Winegrape Commission. pp. 111 – 141.

soil moisture holding capacity, texture, and rooting depth					
1.4 A soil sample has been taken in the field more than 6 years ago and analyzed for macro and micro nutrients					
1.5 A soil sample has been taken in the field within the last 6 years and analyzed for macro and micro nutrients as well as soil chemistry (e.g. pH, CEC, salts)					
1.6 A soil sample has been taken in the field within the last 4 years and analyzed for macro and micro nutrients as well as soil chemistry (e.g. pH, CEC, salts)					
1.7 A soil sample has been taken in the field within the last 2 years and analyzed for macro and micro nutrients as well as soil chemistry (e.g. pH, CEC, salts)					
1.8 If soil pH is less than 5.5 it is amended with lime and if it is above 8.0 it is amended with an acidifying agent					
Soil properties management					
2.1 If water infiltration is poor (water puddles and runs off when soil is dry underneath) the soil is amended either chemically (e.g. with gypsum or organic matter such as compost or manure) or physically (e.g. chiseling or shallow ripping)					
2.2 Cover crops are planted to add organic matter and nutrients to the soil and to improve water infiltration					
2.3 For permanent crops, resident vegetation is allowed to grow as a cover crop to add organic matter to the soil and improve water infiltration					
2.4 If soil organic matter is low for the soil series in my field I have an ongoing program to build soil organic matter either through additions of compost, manure and growing cover crops or a combination of them					
2.5 Equipment is chosen or is modified to minimize soil compaction (e.g. lightest equipment possible, track-layers, wider or bigger diameter tires, tire pressures as low as possible)					
2.6 For permanent crops the soil is never tilled unless a problem develops that requires one pass to alleviate the problem (e.g. soil is too uneven for safe operation of equipment)					
2.6a For permanent crops tillage is done every 5 years or less (this does not include aerating the soil with equipment like an Aerway)					
2.7 For permanent crops tillage is done every 3 to 5 years					
2.8 For permanent crops tillage is done every year					
2.9 For annual crops conservation tillage is practiced					
2.10 For annual crops, tillage passes are fewer than most neighboring farms producing the same commodity					
2.11 For annual crops, tillage passes are about the same as most neighboring farms producing the same commodity.					
2.10 Surface tillage is practiced on a regular basis					

2.11 Deep tillage is practiced on a regular basis					
Crop nutrition management					
3.1 I have a written crop nutrient management plan that uses a 'budgeting approach'[11] in determining the nutrient needs of the crop and takes into consideration factors like crop tissue analyses, soil type, time of year, soil moisture, crop load, etc.					
3.2 The crop's nutrient management plan is based solely on the recommendations as given by my field consultant and/or from the soil testing lab					
3.3 With the help of my field consultant I am able to interpret the lab results from the field soil samples and we use them in the crop nutrient management plan					
3.4 I am able to interpret the lab results from the soil samples and I use them in my crop nutrient management plan					
3.5 Plant tissue are taken and analyzed at least once a season and used to help assess crop nutrient needs					
3.6 I record from year to year the amount of nitrogen applied per acre and calculate the amount of N applied per unit crop production					
3.7 I record from year to year the amount of phosphorus applied per acre and calculate the amount of P applied per unit crop production					
3.8 I record from year to year the amount of potassium applied per acre and calculate the amount of K applied per unit crop production					
3.9 Fertilizers are applied using Fertigation					
3.10 The total amount of nitrogen needed for the season is applied in one application					
3.11 The total amount of nitrogen needed for the season is applied in a split application					
3.12 Fertilizers are applied using a 'spoon feeding' approach where only the amount of nutrients required by the crop at the time are applied and multiple applications are made throughout the growing season based on crop growth stage and nutrient demand					
3.13 Micro nutrients are applied on a regular basis without reference to crop needs or crop history					
3.14 Micro nutrients are applied based on past crop history					
3.15 Micro nutrients are applied based on soil sample test results					
3.16 Micro nutrients are applied based on crop tissue sample test results					
Soil erosion					
4.1 Vegetation is maintained along farm roads, on field edges, and along irrigation canals not controlled by the irrigation district					

[11] A budgeting approach means that the amount of nutrients leaving the field in the crop is estimated and the amount of nutrients added back to the field is based on this estimate. A one -to-one replacement is not implied or required since factors such as soil type affect nutrient availability to the crop and these factors must also be taken into account.

4.2 I know the infiltration/run-off rates of the field's soil and the rate of irrigation water is applied and is adjusted according					
4.3 No tillage is done on field borders or along irrigation canals					
4.4 Ditches have been grassed or hardened to prevent downcutting					
4.5 Culverts are properly sized to accommodate high flows, and inlets and outlets have been hardened to prevent scour or energy dissipaters have been installed					

Ecosystem Management

An ecosystem is the complex community of living organisms and their physical environment functioning as an ecological unit. Components of an ecosystem are inseparable and interrelated. An ecosystem management approach to growing specialty crops acknowledges that people are a part of and have a significant impact on ecosystem structures and processes, and that people depend on and must assume responsibility for the ecological, economic, and social systems where they live. Ecosystem management is currently being encouraged and implemented by communities, government agencies, businesses, academics and various conservation organizations throughout the world[12].

Ecosystem Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Habitat maintenance and enhancement					
1.1 Field borders, roadsides, and ditch-banks are kept free of vegetation					
1.2 Hedgerows of trees and/or shrubs are maintained on at least some field edges					
1.3 Vegetation such as grasses, trees or shrubs are maintained along roadsides, ditch-banks and headlands					
1.4 Vernal pools or swales are preserved and managed with setbacks to reduce probability of soil disturbance					
1.5 Trees have been planted to provide habitat for wildlife					
1.6 Trees are maintained to provide habitat for wildlife					
1.7 Nesting boxes for owls have been placed around the farm and they are cleaned annually					
1.8 Perches for raptors have been placed around the farm					

[12] Reeves, K. 2008. Chapter 1. Ecosystem Management *in* Ohmart, C. P., C. P. Storm and S. K. Matthiasson. Lodi Winegrower's Workbook 2nd Edition. Lodi Winegrape Commission. pp. 15- 63.

1.9 If water courses exist on my property crops are planted up to the edge of water courses					
1.10 If water courses exist on my property setbacks are in place to minimize disturbance					
1.11 If water courses exist on my property resident vegetation is maintained on the banks					
1.12 If water courses exist on my property banks are vegetated with a mix of grasses, trees and shrubs					
Whole farm issues					
2.1 I am an active member in the local watershed coalition					
2.2 I participate in a watershed stewardship planning group if one exists in my region					
2.3 Invasive pests (e.g. puncture vine, arundo) are monitored for and when found removed from the farm					
2.4 A formal or informal environmental survey of the farm has been done noting the presence of sensitive areas, such as vernal pools, swales, oak trees, habitat for endangered species, and other environmental features which affect farming and actual farmable acres such as an NRCS conservation survey[13]					
2.5 I manage my property to protect and/or enhance habitat for threatened and endangered species					
2.7 Some or all of the natural areas of my property are protected by a conservation easement (see education box below)					
2.8 Some or all of my property are protected by an agricultural easement program					
2.9 The farm is managed to optimize ecosystem services such as wildlife, pollinators, and/or arthropod natural enemies and increased biodiversity (see box below for definition of an ecosystem service)					
2.10 Indicators of biodiversity on the farm are monitored and recorded, such as animal and plant populations , pollinators, or arthropod natural enemies					
2.11 Unfarmed areas are maintained to increase biodiversity on the farm including wildlife, pollinators and/or arthropod natural enemies					

Education box: What is an ecosystem service?

The biological communities in an agricultural ecosystem provide benefits over and above the commercial crops they produce. These benefits are known as **ecosystem services**. They include removing carbon dioxide from the atmosphere, reducing greenhouse gases, the recycling of nutrients, regulation of microclimate and local hydrological processes, in some cases they result in the suppression of pest plants and animals through the production of pest natural enemies, and detoxification of noxious chemicals that enter the environment.

[13] NRCS has a lot of resources available for helping with environmental planning on the farm. Contact your local NRCS office and see if they can help you.

Education Box: What are Conservation and Agricultural Easements?

Conservation and Agricultural Easements

Conservation easements for protection of natural resources are legal agreements that allow landowners to donate or sell some "rights" on portions of their land to a public agency, land trust, or conservation organization. In exchange, the owner agrees to restrict development and farming in natural habitat, and assures the easement land remains protected in perpetuity. A 1996 study conducted by the National Wetlands Conservation Alliance indicated that the leading reasons landowners restored wetlands were to provide habitat for wildlife; to leave something to future generations; and to preserve natural beauty. Only 10% of landowners surveyed in the study restored wetlands solely for financial profit. This would also apply to other habitats besides wetlands. A conservation easement can provide you with financial benefits for the protection, enhancement, and restoration efforts for the natural environments on your property. The belief that natural resources such as wildlife, especially sensitive species, will reduce your land value is not true. Many easement programs include some sort of cash payment for a portion of the costs associated with habitat restoration and enhancement.

Agricultural conservation easements are for the explicit purpose of keeping farmland in production. They are similar to natural resource conservation easements, but, specifically protect farmland and maintain the practice of farming. In 1996, the state established the California Farmland Conservancy Program to protect farmland by buying easements. Based on a study conducted by UC Cooperative Extension and published in 2002, there were 34 local conservation organizations, land trusts, and open space districts that protect farmland through conservation easements (see – *Agricultural Easements: New Tool for Farmland Protection California Agriculture*, January-February 2002, Volume 56:No. 1). Local opportunities may exist for one or both kinds of conservation easements on your property.

Pest Management

Integrated pest management (IPM) is a fundamental part of any sustainable farming program. It is cost-effective, flexible, and resilient. IPM was developed to respond to some significant pest management challenges that developed in the 1950's and 1960's. Events such as the development pesticide resistance by many pests, secondary pest outbreaks, and environmental contamination due to the use of certain problematic pesticides led a forward-looking group of entomologists at the University of California to conclude that agriculture was heading toward a pest management crisis. They realized we had forgotten the fact that pest problems are complex and connected to ecosystem processes. They concluded that the solutions to complex ecological problems must be broad-based and take the farm ecosystem into account. These researchers developed the IPM concept to meet the pest management crisis. Since its inception in 1959, IPM has evolved into the best way to manage pest problems on the farm.

University of California Statewide IPM Program crafted the following as the definition of IPM[14]:
Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

Farming is carried out within the ecosystem and is a long-term endeavor so we want to use management practices that are ecosystem-based and long-term in nature. By using a combination of control techniques to manage a pest problem, we develop a broad-based management strategy that will still be successful even if one particular technique does not work. Also, based on our experience with chemical controls, we know that pest control decisions must take into account not only economic risks, but effects on the environment and people's health, as well[15].

Pest Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Pest Management Framework for Farm					
1.1 I have a integrated pest management framework/plan for my farm that takes into account the landscape within which I farm, an					

[14] http://www.ipm.ucdavis.edu/IPMPROJECT/about.html
[15] Ohmart, C. P. and C. P. Storm. 2008. Chapter 6. Pest Management. *in* Ohmart, C. P., C. P. Storm and S. K. Matthiasson. Lodi Winegrower's Workbook 2nd Edition. Lodi Winegrape Commission. pp. 187- 267.

understanding of the cropping system and how it affects the population levels of key pests, includes monitoring protocols and economic thresholds for key pests, monitoring protocols and important pest natural enemies, and the key biological, cultural and chemical control options available for key pests					
1.2 Each year I review the pest management framework with all those involved in pest management on my farm and make adjustments according to my goals and pest management results from the past year					
Risk Assessment					
2.1 Key pests for my farm have been identified in the following groups: diseases, insects, mites, weeds, mammals and birds; and targeted for management					
2.2 Monitoring protocols have been established and are followed for key pests					
2.3 I and/or my PCA have established and use economic thresholds for key pests					
2.4 I and/or my PCA keep written spray records containing the information required by California Department of Pesticide regulation as well as weather conditions and effectiveness					
2.5 I am aware of the environmentally sensitive areas in and near my field such as distance to ground water, surface water, wetlands, vernal pools, swales, houses, schools, public and private roads					
2.6 I have mapped the environmentally sensitive areas in and near my field such as distance to ground water, surface water, wetlands,vernal pools, swales, houses, schools, public and private roads					
Monitoring					
3.1 I and/or my PCA follow the UC IPM year round program for my crop if available for my crop					
3.2 I and/or my PCA use the UC IPM pest management guidelines if available for my crop					
3.3 I and/or my PCA use the UC IPM pest management manual if available for my crop					
3.4 I monitor pest populations in my fields					
3.5 A licensed Pest Control Advisor monitors pest populations in my fields					
3.6 I and/or my PCA monitor for pest natural enemies if they are important in controlling key pests and take their numbers in consideration when making pest management decisions					
3.7 Cultural factors, such as time to harvest, preexisting plant damage, plant moisture stress, plant health, and crop load, are considered in pest management decision-making if they have significant effects on the risk of damage due to key pests					
3.8 I or my PCA keeps qualitative (descriptive) written pest monitoring records and they get shared during the decision making process					

3.9 I or my PCA keeps quantitative (numeric) written pest monitoring records and they get shared during the decision making process					
3.10 If I rely on pest management recommendations from a PCA I and/or my farm manager review with them the pest situation before making a decision to take a management action					
3.11 I encourage my crew supervisors and farm managers to report any pest problem that is out of the ordinary (e.g. pests they have never seen before) and report it to the appropriate person					
3.12 Pictures of important invasive pests are posted in convenient places so employees can monitor for their presence					
Pesticide Management					
4.1 'Smart'[16] sprayers are used when applying pesticides to some or all of my fields					
4.2 Pesticide drift is minimized by using technologies such as air induction nozzles, or some pesticides are applied using chemigation					
4.3 I rotate the use of pesticides according to 'mode of action' to minimize development of resistance					
4.4 I keep a written record of pesticide use by 'mode of action' as a part of my pesticide resistance strategy					
4.5 A written spray drift management plan has been drawn up for each field that includes a map of the field and location of sensitive areas and sprayer operators follow the plan					
4.6 Calibration and spray coverage tests are done at least once a season on my sprayer and are based on manufacturers' recommendations as well as site characteristics such as crop canopy present					
4.7 Buffer zones have been established for each field based on pesticide label specifications as well as adjacent crops and other sensitive sites					
4.8 Sprays are timed such that there is minimal or no human activity in adjacent areas					
4.9 Dormant season pesticide applications are made when wind speeds exceed 10mph[17]					
4.10 Dormant sprays are not done in dead calm when a temperature inversion exists to avoid long distance pesticide drift					
4.11 Sprayer nozzles are shutoff at row ends near environmentally sensitive areas					
4.12 There is a berm around the wellhead that prevents surface water running from the perimeter to the wellhead					
4.13 Pesticide mixing and loading area is more than 100 feet from the wellhead unless it is protected by a berm or other physical characteristics that prevent surface water running from the perimeter to the wellhead					

[16] A smart sprayer is one equipped with sensors that detect present or absence of target and shuts off when target is not present.
[17] CDPR Rule for Dormant Season Insecticides Fact Sheet

4.14 A separate water supply tank is used for pesticide mixing or chemicals are added to the tank at least 100 feet away from the well.					
4.15 Either a double-check valve, reduced pressure principle backflow prevention device or an air gap is in place and maintained between the well pump and sprayer tank[18]					
4.16 Pesticide mixing and loading is done using a closed system or with water soluble pesticide packets when available for the pesticide being applied					
4.17 Spray mixing, loading and calibration is planned so that the tank is empty at the end of the spray job					
4.18 I use the following safe pesticide storage practices: dry pesticides stored above liquids, pesticides are stored more than 300 feet from nearest well, storage area has impermeable floor and sump to contain leaks, an only undamaged containers are stored					
4.19 I have an emergency response plan for pesticide and fertilizer spills and exposure posted in the appropriate places					
4.20 Workers are trained to follow the emergency response plan for pesticide spills or exposure					
4.21 A pesticide risk model such as PRiME[19], WIN PST or UC IPM's Water Tox[20] is used when considering which pesticides to apply					
4.22 The VOC 'footprint' of a pesticide is considered when deciding which pesticides to apply[21]					
Prevention and Cultural Practices					
5.1 I use resistance varieties/rootstocks to manage some of my key pests					
5.2 I use crop rotation to manage some of my key pests					
5.3Timing of planting of crops to avoid key pests					
Biological control					
6.1 I monitor for pest natural enemies if they are important in controlling my key pests					
6.2 If a pest natural enemy is important for a key pest I implement practices that augment their populations like planting cover crops, nectar sources and avoid using pesticides that may be harmful to natural enemies					
6.3 I release pest natural enemies that have been proven to be effect controls for a key pest					
6.4 Conservation of pest natural enemies is considered when choosing a pesticide to use in the field					

[18] This is a legal requirement
[19] PRiME is the Pesticide Risk Mitigation Engine and can be accessed at http://ipmprime.org/cigipm/
[20] The model output is accessible at http://www.ipm.ucdavis.edu by viewing the webpage for the pest in question and clicking on the link labeled 'Water Quality Compare Treatments)
[21] http://apps.cdpr.ca.gov/voc-calculator/

6.5 Conservation of natural enemies is considered when deciding on spray timing					
6.6 I establish areas adjacent to the field to augment natural enemies by growing plants that provide shelter, nectar, and pollen for them					
Effects of Pest Management on Non-Target Sites & Organisms					
7.1 Effects of a pesticide on pollinators are considered when selecting the material to apply					
7.2 I am a member of the local Irrigated Lands Water Quality Coalition					
7.3 Effects of a pesticide on non-target organisms existing on my farm, such as birds and small mammals, are considered when selecting the material to apply					

Social Responsibility

Social Equity is one of the 3 E's of sustainable farming. What is social equity? There are several contexts in which it can be defined. In terms of conservation Wikipedia states "Social Equity implies fair access to livelihood, education, and resources; full participation in the political and cultural life of the Community; and self-determination in meeting Fundamental Needs". Social equity is about people having fair access to the things mentioned above and people are the resource that is the foundation of any company. Human Resources (HR) is the label that has been given to the people that make up a company, including the owners. Managing HR effectively is how social equity is achieved.

Human Resources Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Staffing and Recruiting Strategy					
1.1 A long term (2-5 years) staffing and recruiting strategy is in place					
1.2 A variety of recruiting methods is used depending on job opening, e.g. word of mouth, newspaper, web recruiting, job fair, temporary or contract services					
1.3 A standard interviewing process is used in recruitment which includes a specific set of review questions					
1.4 A job description exists for each type of job and it is given to the employee and their supervisor					
1.5 Job descriptions are reviewed and updated at least once every two years					
1.6 For non-seasonal employees, an exit interview is conducted to determine why employees left the company					
Employee Orientation, Training, and Career Development					
2.1 An orientation program is provided for new non-seasonal employees					
2.2 Safety training is done according to Cal OSHA regulations, i.e. when employee begins a new job assignment, or any new process, procedure or use of a substance or equipment that creates a new hazard					
2.3 All new employees undergo safety training					
2.4 If labor is contracted, a check is made to ensure contract labor company adheres to all relevant Cal OSHA safety regulations					
2.5 Safety statistics such as time lost due to accidents are tracked and retained for at least 2 years					
2.6 Employees are instructed as necessary to attend training seminars or					

other educational programs at least once a year that enhance their skills in the workplace					
2.7 Employees are encouraged to attend training seminars or other educational programs at least once a year that enhance their skills in the workplace					
2.8 My company pays for training when required and/or provides tuition reimbursement for work-related college classes					
2.9 A formal career planning process is in place for non-seasonal employees					
2.10 Every non-seasonal employee is provided an employee handbook that includes at a minimum the company's work standards and policies and an overview of benefits					
2.11 The employee handbook is written in an appropriate language(s)					
2.12 An employee meeting is held at least once a year to discuss company goals and to exchange ideas					
2.13 A meeting of top management is held annually to discuss company goals and exchange ideas					
Staying Informed					
3.1Trade journals/appropriate trade literature (include literature on worker issues, safety issues, Farm Bureau, Trade Association literature, etc.) are made available for the farm management team (FMT) to read					
3.2 The FMT has current membership in local grower association(s)					
3.3 The FMT regularly attend regional and/or statewide industry meetings (e.g. irrigation district, Farm Bureau, Water Coalition, etc), trade shows (e.g. World Ag Expo), and seminars (e.g. UC, CDFA, CSU seminars, Research meetings from Commodity Boards)					
3.4 The FMT takes a leadership role in local, regional or state industry associations (e.g. ??)					
Performance, discipline, grievance process, and employee recognition					
4.1 A job performance process is in place and is linked to pay and promotions					
4.2 A form and process is in place for employees to comment on job satisfaction					
4.3 My company has a grievance process in place and it is documented in the employee handbook					
4.4 Filed grievances are recorded and processed in a timely manner					
4.5 A formal process is in place by which employees are recognized for good job performance and/or years of service					
4.6 A suggestion box is provided in a convenient location so that employees can provide ideas for improvements in company practices, working environment, and other areas.					
Health benefits, paid time off, and other benefits					

5.1 Basic health benefits are provided to non-seasonal employees					
5.2 Non-seasonal employees have paid holidays and vacation time					
5.3 Employees are provided sick leave and/or personal days					
5.4 Non-seasonal employees are provided (or employees are encouraged to) a formal pension plan or a company 401k					

Community Support	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
1.1 My company is involved in regional land use planning					
1.2 My company is involved in initiatives, through time commitment and/or donations, that enhance the community such as the Chamber of Commerce, schools/education programs, churches, public health, affordable housing					
1.3 My company is involved in regional water issues such as the regional water quality coalition, irrigation districts, ground water use planning, and/or the irrigated lands waiver program planning					
1.4 My company participates in the Spray Safe Program[22]					

[22] http://www.foodandfarming.info/spraysafe.asp

Waste Management

Sustainable agriculture provides a strategy for managing all aspects of your farming enterprise, including the management of the crop, soil, water, pests and human resources. It also relates to your farms infrastructure as well such as your offices and shop. While the most interesting part of sustainable farming addresses what happens in the field it is important not to forget important issues like waste management. In a lot of situations, waste management is one of the most straightforward processes to address on the farm.

Waste Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
In field, shop and office					
1.1 Crop residue or crop byproduct is recycled by either selling to another user (e.g. for cattle feed, co-generator/digester), composted, or returned to the field for incorporation into the soil					
1.2 The farm has an established recycling program for metal, cardboard, plastics, paper and glass					
1.3 The value of recycling is part of the orientation and training of employees					
1.4 The amount of metals, cardboard, plastics, paper and glass recycled annually vs. the amounts thrown away is determined and year to year comparisons are made					
1.5 The number of tires, batteries used per year and the amount of lubricants purchased vs the amount sent back or recycled per year is recorded and year to year comparisons are made					
1.6 All unused or worn out items such as appliances, tractors, ATVs, electrical equipment, are taken to the proper recycling centers for disposal					
1.7 The total amount of hazardous materials, other than pesticides and fertilizers, present on the farm is known and their use is tracked on an annual basis (e.g. solvents, cleaning materials, explosives, compressed gases, fuel, acids, and lubricants)					
1.8 Employees are trained on the proper handling and disposal of hazardous materials (e.g. solvents, cleaning materials, explosives, compressed gases, fuel, acids, and lubricants)					
1.8a Employees are trained on legal requirements related to cleaning of farm equipment with water or steam cleaners and the resulting runoff					
1.9 Hazardous materials no longer used, as well as their containers, are disposed of according to legal requirements					

1.10 The farm participates in the pesticide container recycling program[23]					
1.11 Dumpsters and/or recycling containers are on cement pads to contain spills					
1.12 Dumpsters and/or recycling containers are covered to keep out rain					
1.13 Dumpsters and/or recycling containers are periodically inspected for leaks, spills, and litter. Problems noticed are corrected					
1.14 Bi-lingual signs are posted near the dumpster and/or recycling containers indicating what can or cannot be put in the container					
1.15 The farm has a written waste management plan that includes waste reduction goals, recycling goals, hazardous material use reduction goals					

[23] Use the following link to find out how to participate in an Ag Container recycling program: http://www.acrecycle.org/contact_us.html

Water Management and Water Quality

California is the leading agriculture state in the US by a significant amount. This is due in large part to the high value of the many specialty crops grown in the state. It is also due to the excellent growing conditions such as fertile soils, a Mediterranean climate and the availability of affordable high quality surface and ground water for irrigation. California is also the most populace state in the US and therefore affordable high quality water is needed to support this population. It is clear that because of the demands for high quality, affordable water, this critical resource needs to be used efficiently and effectively by specialty crop producers. The following template will help document practices producers are using to achieve optimum water quality and use efficiency as well as bring to their attention areas where improvements can possibly be made.

Irrigation Management	**Not Familiar**	**Familiar, not tried**	**Have tried it**	**Currently Use**	**Not applicable**
Pre-plant Planning					
1.1 Pre-plant analyses of the site was done to identify factors that affect quantity of irrigation water delivery and percolation rate such as existence of soil compaction, a root restricting layer, soil type, soil texture, soil chemistry (pH, salinity, etc.) and soil organic matter					
1.2 Ripping, plowing, chiseling, or other practices were implemented if pre-plant soil tests indicated water percolation and/or drainage problems					
1.3 Soil amendments were applied to correct soil chemical or physical issues if sampling identified factors that would affect water percolation					
1.4 Water source was sampled and evaluated for water quality, including biological problems such as presence of E. coli					
1.5 The irrigation system was designed to deliver the quantity of water required for the crop and accommodate for variation in topography as well as in soil texture that affects water percolation and water holding capacity					
Irrigation Scheduling & Rates					
2.1 I measure and record the total amount of water used in each field every season and calculate water use per unit of crop production.					
2.2 I have a written water management plan for my field(s) that includes goals for the growing season and takes into consideration annual rainfall, crop variety, crop maturity, water-related pest management issues, soil type, soil preparation, slope, water quality, irrigation efficiency, irrigation uniformity, energy efficiency					
2.3 Irrigation is initiated at the start of the season based on visual cues					

from the crop					
2.4 Irrigation is initiated at the start of the season based on measured soil moisture depletion					
2.5 Irrigation is initiated at the start of the season based on directly measuring plant moisture stress (e.g. with pressure bomb)					
2.6 Irrigation scheduling is influenced by peak energy pricing					
2.7 Water percolation rate and infiltration depth is monitored during the irrigation season					
2.8 Soil moisture depletion is estimated by visual inspection of the crop (e.g. growth or development) that indicates plant water stress					
2.9 Soil moisture depletion is tracked through soil coring					
2.10 Soil moisture depletion is tracked using soil-installed moisture monitoring devices					
2.11 Soil moisture depletion is tracked by directly measuring plant moisture stress (e.g. with a pressure bomb)					
2.12 Amount of irrigation and timing are dictated by the amount and timing of water available through my Water District					
2.13 Amount of irrigation and timing are based on visual cues of the crop					
2.14 Amount of irrigation is and timing are based on irrigation history from past growing seasons					
2.15 Amount of irrigation and timing are based on historical crop evapotranspiration (ET)					
2.16 Water demand of the crop is estimated by determining ETo[24] either through using data from the nearest CIMIS weather station and used in irrigation rate and scheduling					
2.17 Water demand from the crop is estimated by converting ETo to Etc by using the appropriate crop coefficient factor (Kc) which takes into account crop canopy and used in irritation rate and scheduling					
2.18 When appropriate less than full water demand is applied to the crop (deficit irrigation)					
Irrigation Performance and System Maintenance – Pumps & Filters					
3.1 Pumping plant efficiency has been measured within at least the last 3 years (for areas where water table fluctuates considerably pumping plant efficiency should be checked at least once very 2 years)					
3.2 Pumping plant efficiency has been measured within at least the last 5 years					
3.3 Energy use for irrigation is tracked on an annual basis an related to unit of production					
3.4 Electrical irrigation pumps are on time of use metering					
3.5 If pumping efficiency is significantly reduced I have improved it					

[24] ETo is the reference evapotranspiration and is calculated using measurements of climatic variables including solar radiation, humidity, temperature and wind speed and is expressed in inches or millimeters of water. It is based on water use for a short mowed full coverage grass crop.

3.6 Diesel irrigation pumps are Tier 2 or higher					
3.7 A flow meter is installed on wells and/or pumps and I monitor and record the flows					
3.8 Pressure check points are installed on key lines from pumps					
3.9 Filters status (and flushing system) is manually checked at least twice a season and corrected if necessary					
3.10 Pressure gauges are installed for measuring pressure drops through filters					
Irrigation Performance & System Maintenance – Drip & Micro-sprinklers					
4.1 Distribution uniformity of the irrigation system is tested at least every 2 years					
4.2 The system has pressure compensating emitters to help maintain system distribution uniformity					
4.3 The irrigation system is monitored for leaks, breaks, and clogging every irrigation					
4.4 The irrigation system is monitored for leaks, breaks, and clogging at least once a season					
4.5 Fertigation is used to apply most of the fertilizers for the field					
4.6 An interlock system is installed so injection pump shuts down if irrigation pump shuts down to prevent water source contamination					
4.7 Irrigation lines are flushed at the start of the season and then again at mid season, or more often as needed					
Irrigation Performance & System Maintenance – Sprinklers					
6.1 The irrigation system is monitored for leaks, breaks, and clogging every irrigation					
6.2 The irrigation system is monitored for leaks, breaks, and clogging at least once a season					
6.3 Sprinkler head rotation and nozzle clogging have been checked within the last 12 months and repaired if necessary					
6.4 Sprinkler head rotation and nozzle clogging are checked at least every other irrigation and repaired if necessary					
6.5 Sprinkler heads have been checked for wear in the past 5 years and replaced with the correct nozzle size if necessary to maintain distribution uniformity					
6.6 Fertigation is used to apply most of the fertilizers for the field					
6.7 An interlock system is installed so injection pump shuts down if irrigation pump shuts down to prevent water source contamination					
Irrigation Performance & System Maintenance – Flood & Furrow					
7.1 The field was laser leveled before planting the crop					
7.2 Levee locations in the field are based on observed infiltration rates (i.e. each check is appropriately sized for maximum water application uniformity)					
7.3 Irrigation produces no tail-water					

7.4 Irrigation produces tail-water and a tail-water recovery system is in place					
7.5 Flower meters are installed and flow volumes recorded on lines from pumps or in supply pipelines or ditches (e.g. Weir notch or Parshall flume) or a record of flow volumes is provided by the water district					
Water quality – Source and resource					
8.1 Irrigation water is tested at least every 3 years for quality, including pH, total salt, nitrates, and biological problems. The quality of water in distribution reservoirs is tested if they are present on the farm.					
8.2 If a water quality problem exists it is addressed					
8.3 I have accessed resource maps to determine if my field(s) are in Ground Water Protection Areas (GWPA)[25]					
8.4 If a field is in a GWPA I have accessed and read the legal requirements for handling restricted use pesticides in GWPA areas and they are on file in the office					
8.5 I have identified and mapped areas on the farm that are potential sites for pesticides and fertilizers to enter the ground water					
8.6 The wellhead is situated so no surface water can reach it or a berm has been placed around the wellhead that prevents surface water from reaching it					
8.7 Return water wells, older wells and abandoned wells are sealed to prevent ground water contamination					
8.8 Irrigation practices create no off-site movement of chemical residues and sediments					
8.9 If storm water run-off occurs one or more of the following mitigation practices are implemented: filter fabric fencing, filter strip, straw bale check dam, straw bale water bars, sediment basin, or other containment system					
8.10 Cover crops/vegetation is maintained on drain ditches and non-paved minor roadways to minimize rainfall run-off from field					
8.11 Soil percolation problems in the field have been addressed to minimize off site movement of irrigation or storm water					

[25] http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpamaps.htm

SUSTAINABILITY FROM THE GROUND UP

The What and the Why of the Sustainability Plan

Multi-Commodity Sustainability Practices Program
Great Valley Center
January 28, 2010

Clifford P. Ohmart, PhD
VP of Professional Services
SureHarvest

SureHarvest

SUSTAINABILITY FROM THE GROUND UP

Presentation Outline

- My background
- Revisiting Concept of Sustainable Farming
- What a Sustainability Plan Is and Is Not
- What is the Stewardship Index for Specialty Crops
- Potential Benefits of Program Participation
- Project work plan and timeline

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SUSTAINABILITY FROM THE GROUND UP

Three Challenges to Implementing Sustainable Farming

1) Defining it:
   - How can I do it if I can't define it?
   - What are the boundaries of the definition?
   - There are no universally accepted standards

2) Implementing it:
   - How do I practice it on my farm?
   - How do we extend this to an entire sector/region?

3) Measuring it:
   - Tracking practices & performance – where am I at?
   - How is it impacting my farming operation/bottom line?

The Sustainability Plan will help you meet these challenges

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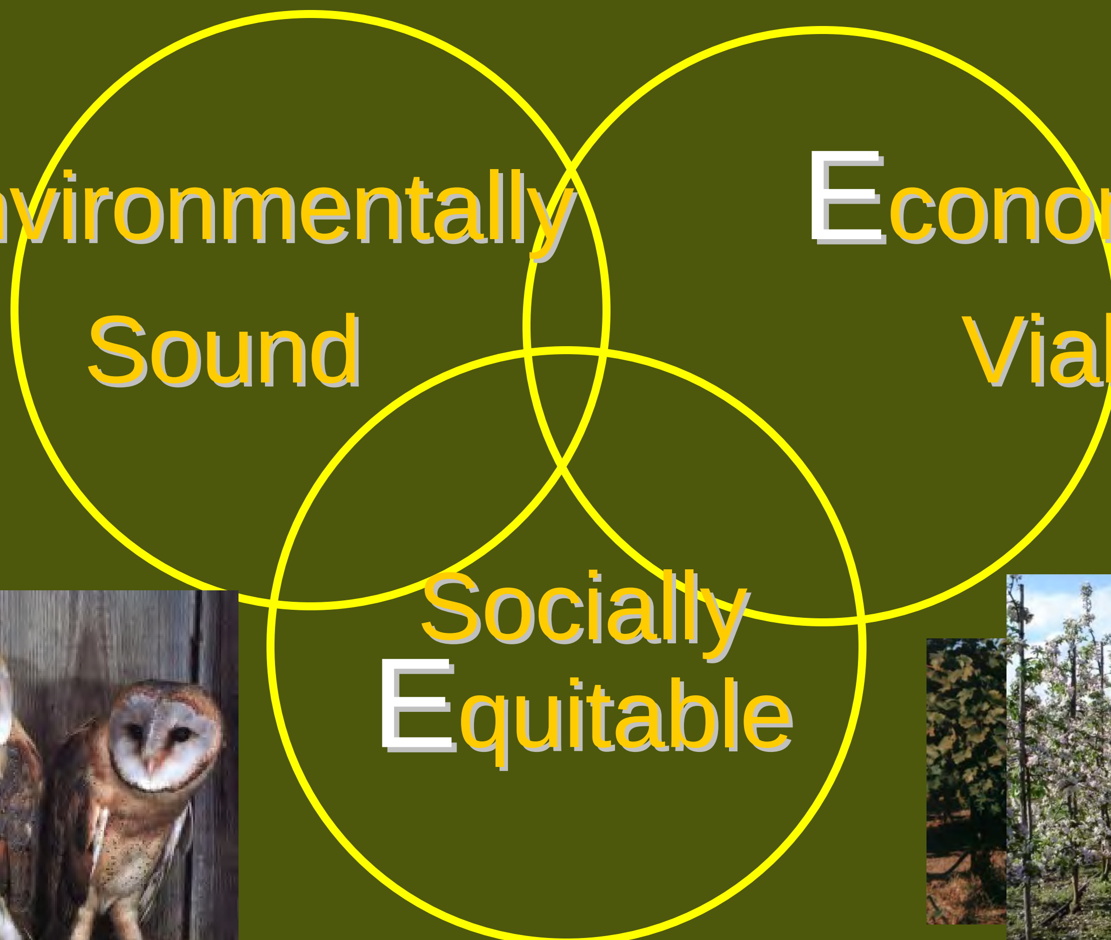
SUSTAINABILITY FROM THE GROUND UP

Defining Sustainable Farming

Leaving the farm in as good or better shape for the next generation than when one started farming it.

...development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

- 1987 United Nation's Brundtland Commission



The three “E’s” of Sustainability

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SUSTAINABILITY FROM THE GROUND UP

The Role of Economics in Sustainable Farming

- I sometimes hear “I cannot afford to do sustainable farming”
- A farm is not sustainable if it goes out of business
- Sustainable farming uses the 3 E’s in management decision-making
- Sustainable farming is all about compromises because often a practice is good for one E but not another
- Price of the crop will dictate what sustainable practices can be implemented e.g. $400/ton grape crop vs $4000/ton grape crop

SUSTAINABILITY FROM THE GROUND UP

How Does Organic Relate to Sustainable?

- Organic and Biodynamic were codified a long time ago, focused on pesticides & fertilizers, Sustainable Ag is not & focuses on whole farm
- Growers implementing sustainable farming are <u>not</u> in transition to organic or Biodynamic

Why? What are the current issues?

- Water use
- Energy use
- Air quality
- GHG & climate change
- Human resource issues

Organic & Biodynamic do not have rules for these issues

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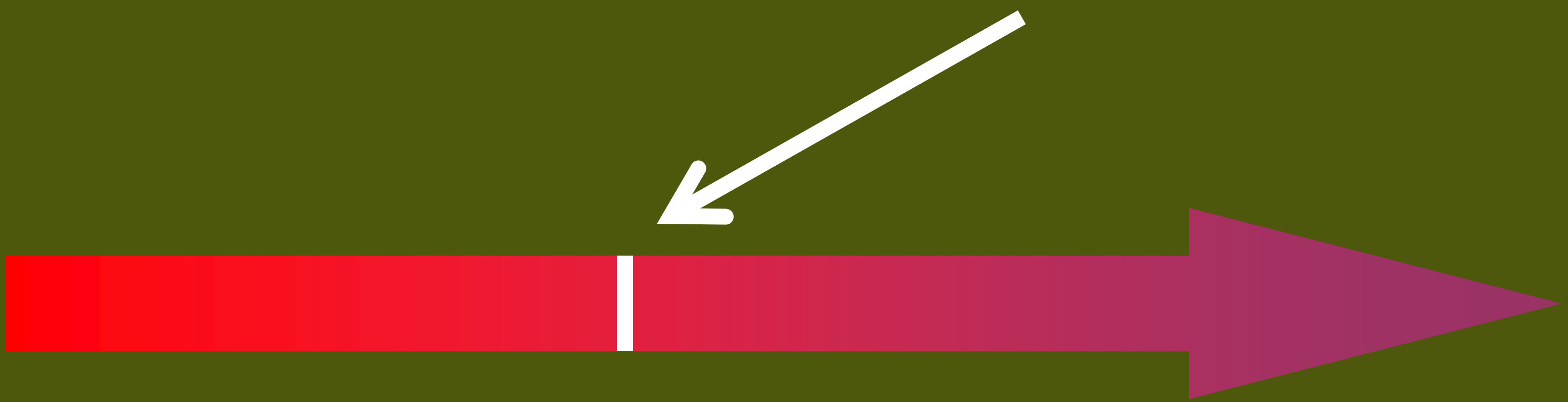
SUSTAINABILITY FROM THE GROUND UP

Sustainable Farming is a Continuum

Where does one draw a line?



Less Sustainable

More Sustainable

Thoughts to Consider About Sustainable Farming

It is a business model to apply to one’s farm

Sustainable farming is a journey, it is not a destination

The world of sustainable farming is one where the horizon is always seems to be receding!

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What is a Sustainability Plan – the 5 P's:

1. ***Principles*** – your sustainability vision for the farm; your goals
2. ***Processes*** – e.g. irrigation management, nutrition management, pest management, etc.
3. ***Practices*** – e.g. cover cropping, pest monitoring, irrigation system maintenance
4. ***Performance*** – e.g. crop quality, yield, water use, energy use
5. ***Progress*** – self-assessment, benchmarking, action plans, improvements, re-assessment

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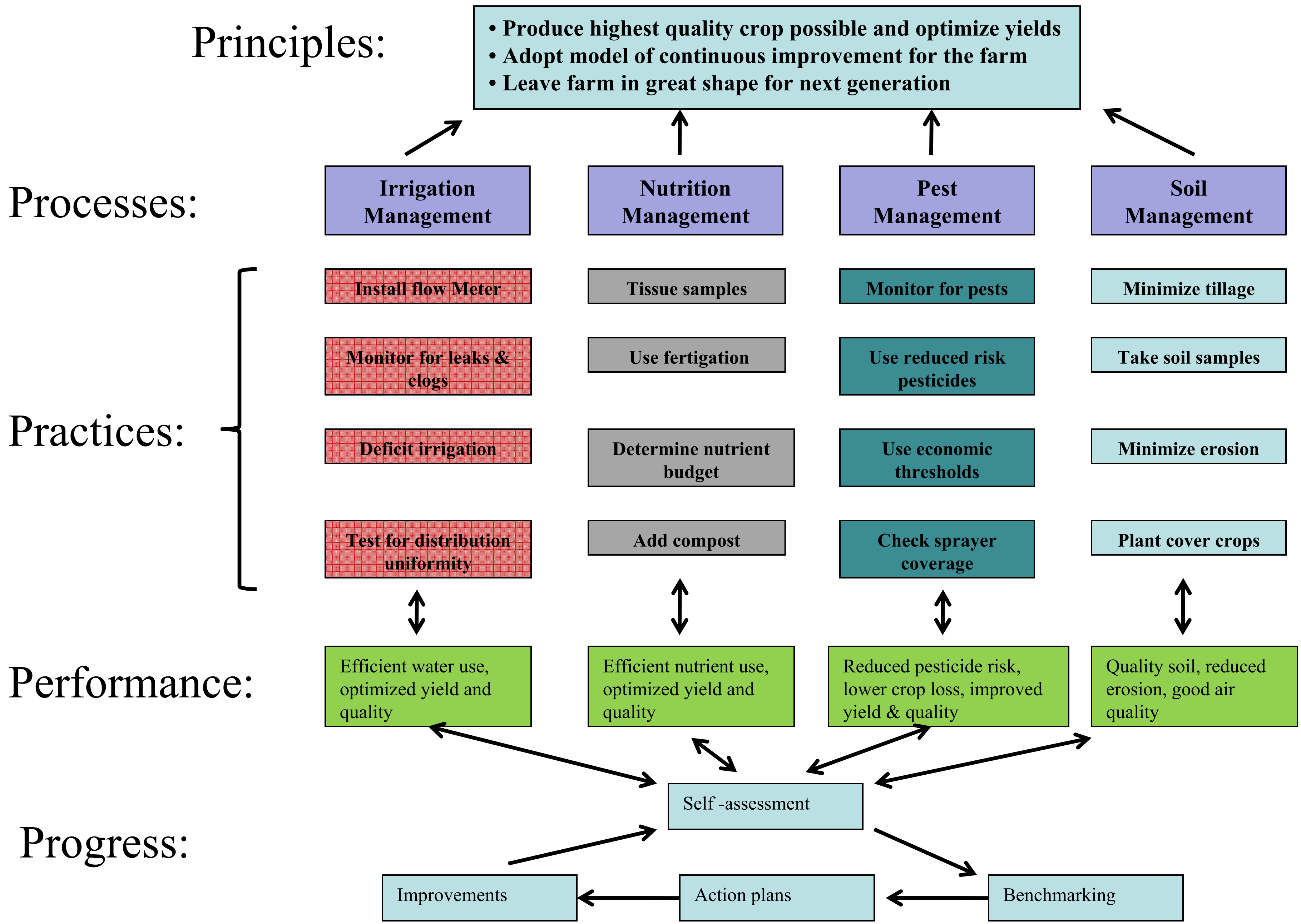
Importance of a Sustainable Plan/Vision for the Farm

If you don’t know where you are going;

You may end up someplace else

- Yogi Berra

Example Sustainability Plan



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SUSTAINABILITY FROM THE GROUND UP

What a Sustainability Plan Is Not

- It is not a recipe
- It is not a certification
- It is not a set of regulations

It Needs to be Your Plan!!

How Does Your Multi-Commodity Project differ from the Stewardship Index for Specialty Crops?

- Multi-Commodity Project is practice based as are virtually all existing sustainable farming programs e.g.:
  - pest monitoring
  - deficit irrigation
  - tissue sampling
  - irrigation system maintenance
- Assumption is that BMP's result in desirable outcomes e.g. good quality & yields, cleaner air, cleaner water, reduced pesticide risk, but some are not necessarily measured

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SUSTAINABILITY FROM THE GROUND UP

How Does Your Multi-Commodity Project differ from the Stewardship Index for Specialty Crops?

- Stewardship Index is a performance or outcome-focused project – an attempt to agree on metrics to measure performance e.g.:
  - water use
  - energy use
  - GHG production
  - air quality
  - soil quality
- The outcome of practices is performance so the two approaches are related & connected but are different parts of the same equation

Stewardship Index for Specialty Crops

www.stewardshipindex.org

Stewardship Index Coordinating Council

Growers

California Association of Winegrape Growers ● DelCabo ● Fresh Sense ● Lodi Woodbridge Winegrape Growers ● National Potato Council ● The Wine Institute ● United Fresh Produce Association ● Western Growers

Buyers

Bon Appétit Management Company Foundation ● Compass Group ● Del Monte ● Food Marketing Institute ● Heinz ● Markon Cooperative ● Produce Marketing Association ● Sam's Club ● Sodexo ● SYSCO ● Unilever ● Wal-Mart ● Wegmans

NGOs & Experts

American Farmland Trust ● California Institute for Rural Studies ● California Rural Legal Assistance Foundation ● Community Alliance with Family Farmers ● Defenders of Wildlife ● Environmental Defense ● NRDC ● Organic Center ● SureHarvest ● Sustainable Food Lab ● University of Arkansas ● World Wildlife Fund

Stewardship Index Overview

Purpose

Develop or adopt specific, measurable and verifiable, outcomes-based metrics for benchmarking, comparing and improving sustainable performance in the specialty crop sector.

Scope

Farm → Distribution → Processing → Retail/Food service

People, Planet, Profit

Specialty crops!

Proposed Initial Phase

Develop open source metrics through a transparent, multi-stakeholder process

Envisioned Benefits

- Tool for finding cost reduction opportunities
- Reduce duplicative sustainable reporting systems
- Data for backing marketing claims
- Frees users to innovate the best practices
- Recognizes high performers or improvement over time – all can participate
- Can be applied across many commodities
- Tool for solving problems and preventing need for future regulations

Metrics Review Committee

Agriculture and Life Sciences Inst.
American Farmland Trust
Apple Leaf LLC
ARAMARK
ARES - Institute for Responsible Agribusiness
B & B Ag Consulting
BAL Associates
Bayer CropScience
Bon Appetit Management Co Fdtn
Business for Social Responsibility
C & R Orchards
CA Dept. Food and Agriculture
Cal/EPA Dept. of Pesticide Regulation
California Agricultural Water Stewardship Initiative
California Association of Winegrape Growers
California Farm Bureau Federation
California Grape & Tree Fruit League
California Institute for Rural Studies
California Institute for Rural Studies
California League of Food Processors
California Rural Legal Assistance
California Specialty Crops Council
California Strawberry Commission
California Sustainble Winegrowing Alliance
California Tomato Farmers
Calvert Group, Ltd.
CCOF
Center for Agricultural Partnerships
Center for Agroecology & Sustainable Food
Center for Reflection, Education and Action
Central Coast Vineyard Team
Cirrus Partners, LLC
Colorado Potato Administrative Committee
Community Alliance with Family Farmers
Constellation Wines
Cooper Land Corp.
Cornell University
Cranberry Institute
Cultivo Consulting
Cultural Technology
Curry & Company
Davenport Orchards, Vineyards and Winery
David Katz & Associates

Defenders of Wildlife
Del Monte Foods
Delta Institute
Dept. of Revenue and Smith Farms
Dixon Ridge Farms
Driscolls Strawberry Associates
E. & J. Gallo Winery
Earthbound Farm
Environment Canada
Environmental Defense Fund
Environmental Strategy Innovations
FAO
Farm Fresh Direct LLC
Fetzer Vineyards
Food & Agriculture Organization
Food Alliance
Food Fundamentals
FreshSense LLC/Tastco Cooperative
Full Circle Connect
Glades Crop Care, Inc.
Global Environmental Ethics Counsel
Great Valley Center
Green Mountain Coffee Roasters
Green Mountain College
Green Seal
Grow My Profits LLC
Growers Alliance Corporation
H. Brooks and Company
HJ Heinz
IFCO Systems, N.A.
International Crane Foundation
International Labor Rights Forum
International Labor Rights Forum (ILRF)
INTI
Investor Environmental Health Network
IPM Institute of North America Inc.
Jacobs Farm / Del Cabo
Just Harvest
Karp Resources
Kennedy/Jenks Consultants
Leonardo Academy
Leopold Center for Sustainable Agriculture
Liberty Fruit Co., Inc.

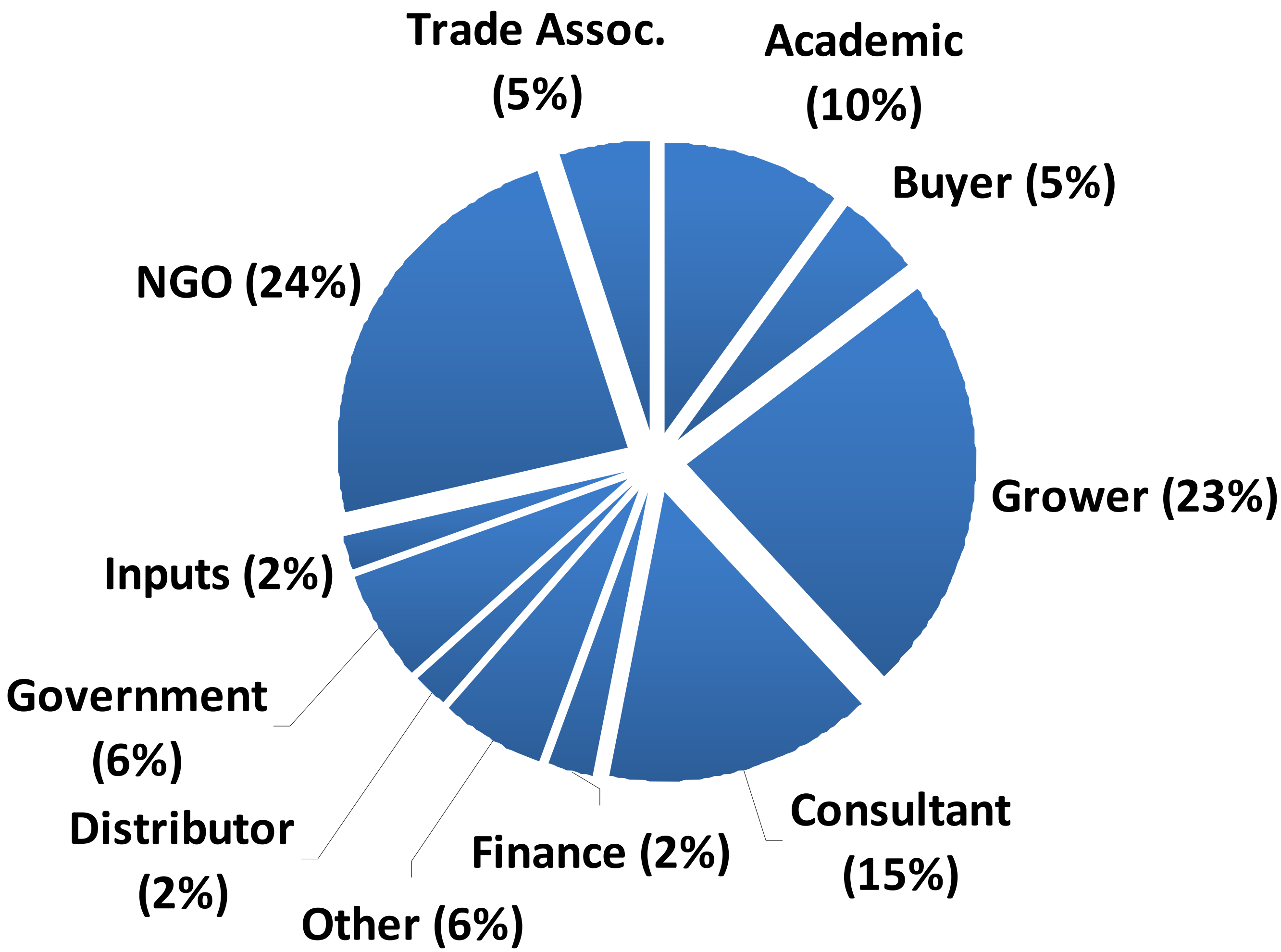
Lodi Winegrape Commission
Magnanimus Wine Group
Manomet Center for Conservation
Musco Family Olive Co.
National Grape Cooperative
National Potato Council
Natural Logic, Inc.
Natural Resources Defense Council (NRDC)
NFREC-Quincy, Univ. of FL
Oregon Wine Board
Organization
Ovis and Vitus Vineyard
Pacific Southwest Container
Pactiv
PepsiCo
Pesticide Action Network
Pesticide Research Institute
Potandon Produce, L.L.C./Green Giant Fresh
Prairie Ventures
Prairie View A&M University
Procacci Brothers Sales Corporation/Santa
Produce Marketing Association
Pulse Canada
PureSense
Purfresh
Raemelton Farm
Responsible Source
Rio Farms
Sambrailo Packaging
Sam's Organic Acres
Scientific Certification Systems
SGS North America Inc.
Sodexo
Stemilt Growers
Sterman Masser Inc.
Sun-Maid Growers of California
SureHarvest
Sustainable Food Lab
Sustainable Harvest
Sustainable Supply Consulting
Sustainamatics
SustainBIz/Global Health & Safety Initiative
Sylvatica, UQAM, CIRAIG

Synergy Integrators
Syngenta
Teamsters
Terrien Consulting (to the wine industry)
the nature conservancy
The Organic Center
The Packard Foundation
Top 10 Produce
Trillium Asset Management Corp
Tufts University
two tons per acre
UC Berkeley
UC Davis SAREP
United Fresh Produce Association
University of California - Davis
University of California Santa Barbara
University of Illinois, Urbana-Champaign
University of Maine Cooperative Extension
University of Nebraska Lincoln
US EPA
US EPA Region 9
US EPA Region 9 Pesticide Program
USDA NRCS
USDA/CSREES
UW- Madison
Wake Forest University School of Medicine
Wallace Center at Winrock International
Wallendal Supply Inc
Wal-Mart Stores, Inc.
Walter P Rawl & Sons, INC
Washington State Horticulutral Assoc.
Water Stewardship, Inc.
Wegmans Food Markets
Western Growers Assn.
Wild Farm Alliance
Willard Bishop, LLC
William Blackburn Consulting, Ltd.
Woodland Produce
World Bank
World of Good Development Organization
World Resources Institute
World Wildlife Fund

Metrics

PEOPLE	
	Community
	Human Resources
PLANET	
	Air quality
	GHG emissions
	Biodiversity/Ecosystems
	Packaging
	Energy
	Nutrient management
	Pesticides
	Soils
	Waste
	Water use and quality
PROFIT	
	Green procurement
	Fair price

Metrics Review Committee



Next Steps

- Complete draft metrics
- Pilot metrics in working supply chains (Expected partners: California Sustainable Winegrowing Alliance, Del Cabo, Del Monte Foods, Driscoll Strawberry Associates, FreshSense, Lodi Winegrape Commission, Markon Cooperative, National Potato Council, Sodexo, Stemilt, Stoneyfield Farms, Unilever, Wada Farms, Wal-Mart, Western Growers)
- Develop protocols for using metrics
- Develop tools for scoring and sharing data

SureHarvest

SUSTAINABILITY FROM THE GROUND UP

Potential Benefits to Participating in the Multi-Commodity Sustainable Practices Program

- Fine tuning farming operations; increasing efficiencies

  “If you can’t measure it, you can’t manage it”

- Imbed cycle of continuous improvement into your farming operations

Potential Benefits to Participating in the Multi-Commodity Sustainable Practices Program

Public Relations:

Demonstrates being proactive

Speaking about sustainability using a common language to:

- Buyers
- Consumers
- Regulators

SureHarvest

SUSTAINABILITY FROM THE GROUND UP

Potential Benefits to Participating in the Multi-Commodity Sustainable Practices Program

Financial Benefits:

- Farming efficiencies = cost savings
- Lower insurance premiums or bank loans?
- Better ranking for NRCS programs like EQIP, CSP, WHIP ?
- New contracts?
- Opportunities for branding/value add?

SureHarvest

SUSTAINABILITY FROM THE GROUND UP

Benefits of Having Multiple Commodities Involved

- Shared approach to sustainability
- Benefiting from others experiences – shared wisdom
- Commonality of certain issues like air quality, water use, energy use, pest management
- Better use of financial resources

Looking into the Future – CDFA Block Grant II

- Create self-assessment workbook/tool with option of commodity individualization
- Convene grower self-assessment workshops
- Collect self-assessments into confidential database
- Benchmark agreed upon practices – set targets for improvement?
- Measure performance against benchmarks

SureHarvest

SUSTAINABILITY FROM THE GROUND UP

Project Workplan and Timeline

<u>Completion</u>

- Form leadership team and: (Jul - 2010)
  - Identify education/outreach model
  - finalize strategic plan (program goals & ‘flow chart’)

- Form stakeholder group and: (Mar – 2011)
  - indentify common practices areas
  - identify common practices

- Complete sustainable program template from strategic plan & practice area and practices content (Jun – 2011)

SUSTAINABILITY FROM THE GROUND UP

Defining the Role of the Leadership Team

- Identify the sustainability goals for the project
- Define practice areas/processes that are common to most commodities
- Identify practices within practice areas that are common to most commodities
- Determine education and outreach components to best achieve progress for growers
- Determine if sustainability metrics are warranted
- Create strategic plan for multi-commodities

<table>
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13</td><td colspan="2">Project Title: Minimizing Water Use and Fertilizer Loss in California Container Nurseries by Precision Control</td></tr>
<tr><td>Grant Recipient:
University of California, Davis</td><td>Grant Agreement No.:
SCB09012</td><td>Date Submitted:
December 2012</td></tr>
<tr><td>Recipient Contact:
Leslie Lipman</td><td>Telephone:
530-752-1814</td><td>Email:
lalipman@ucdavis.edu</td></tr>
</table>

Figure 1. Wireless nodes installed in nursery 1.

Figure 2. Wireless nodes installed in nursery 2.

Table 1. Irrigation treatments for automated variable-rate irrigation control and manual control by the grower in 2 container nurseries.

Nursery	Treatment	Type	Duration	Frequency
1	A	Automated	4 minutes	up to every 3 hours
	B	Automated	2 minutes	up to every 3 hours
	C	Grower	about 6 minutes	as needed
2	A	Automated	2 minutes	up to every 3 hours
	B	Automated	1 minute	up to every 3 hours
	C	Grower	about 2 minutes	as needed

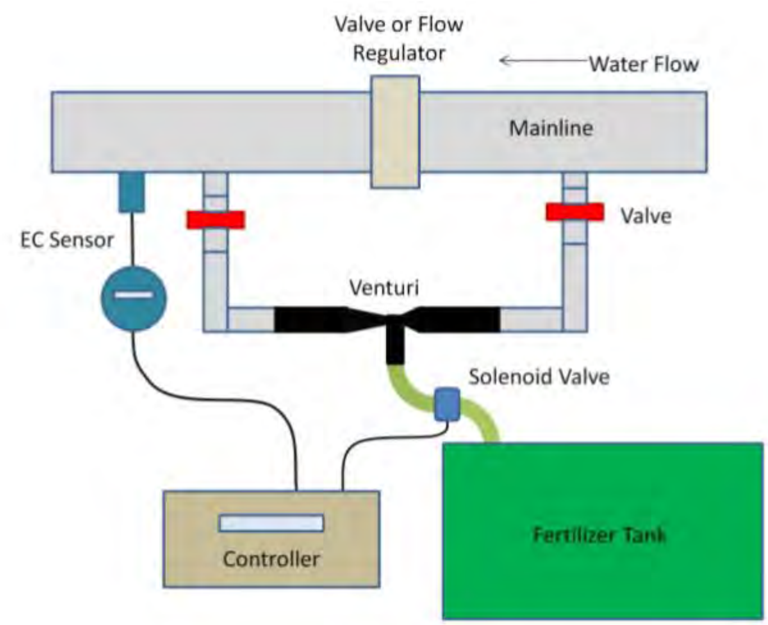

Figure 3. Diagram of the variable-rate injector using venturi, valve, and electrical conductivity sensor.

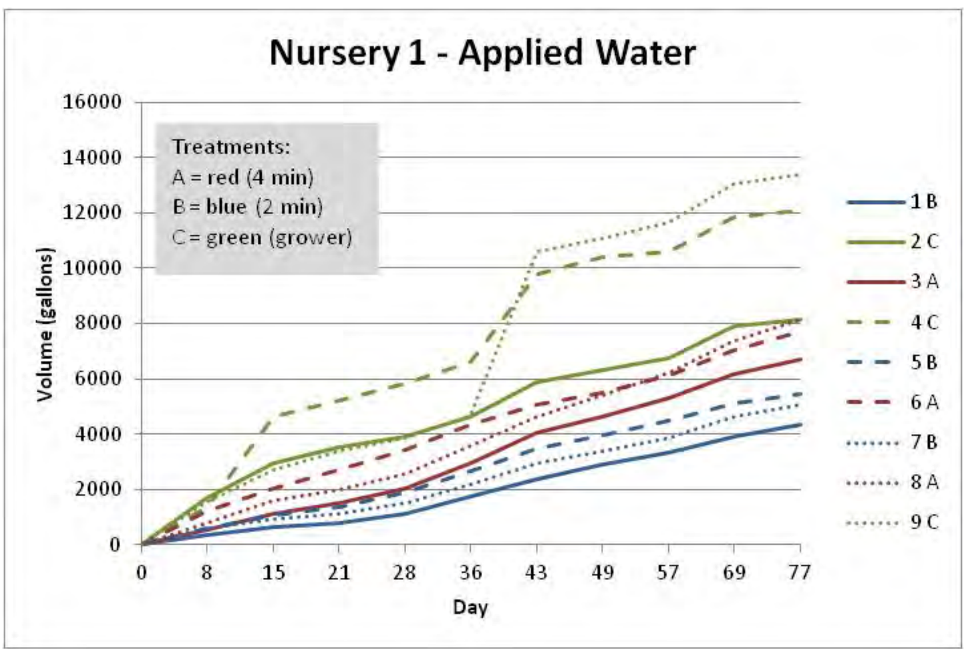

Figure 4. Total water applied to 9 beds in nursery 1.

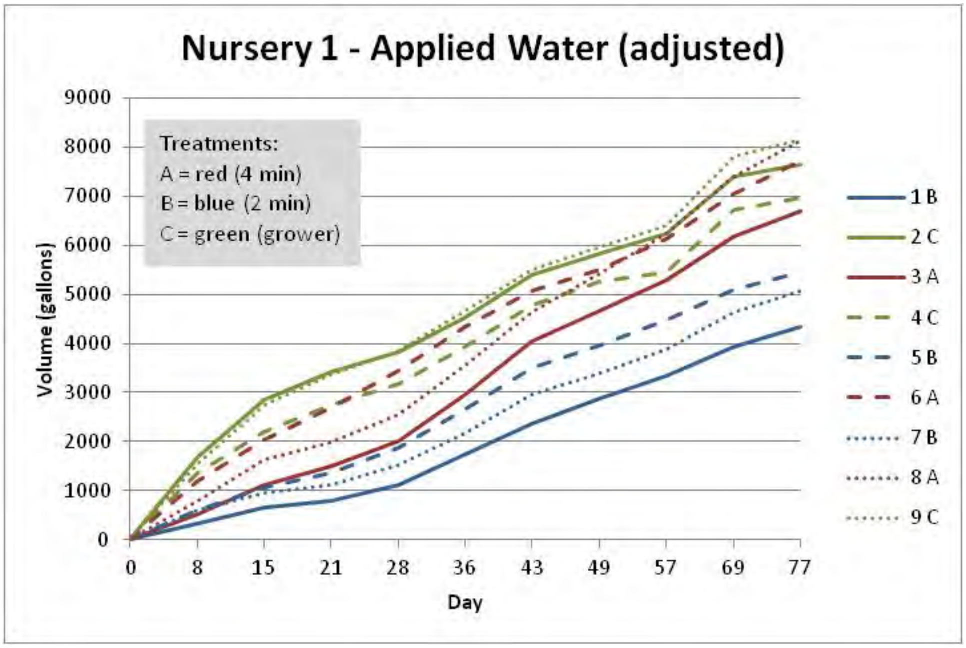

Figure 5. Total water applied to 9 beds in nursery 1 with over-irrigation due to leaks removed.

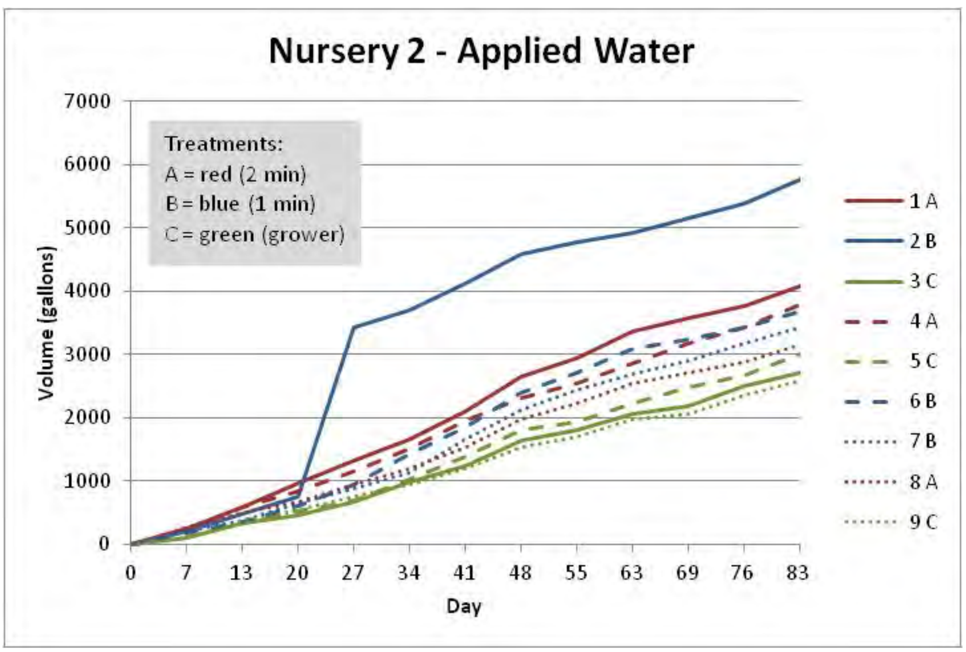

Figure 6. Total water applied to 9 beds in nursery 2.

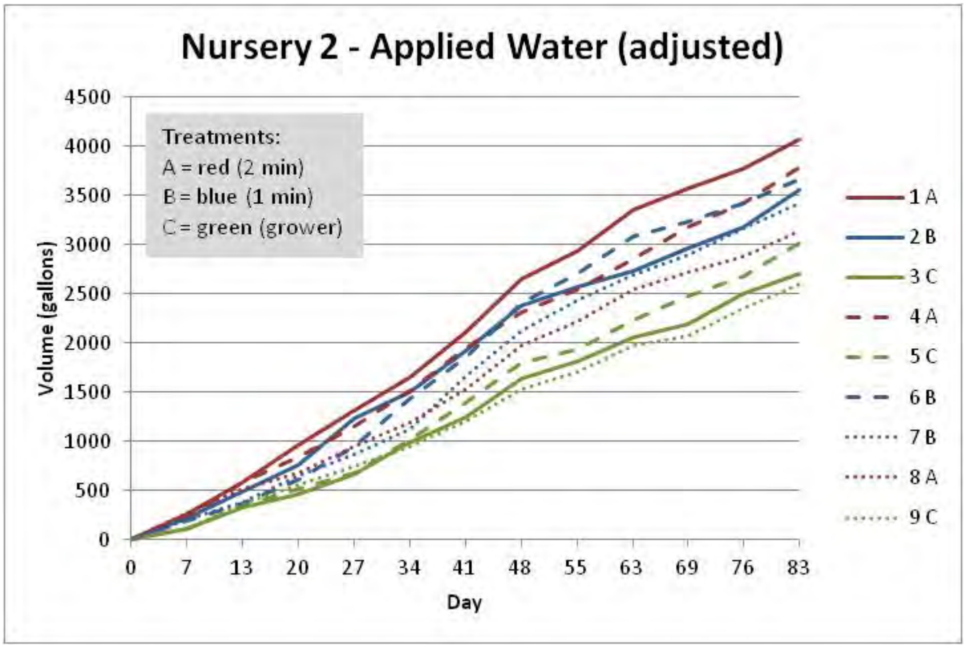

Figure 7. Total water applied to 9 beds in nursery 2 with over-irrigation due to leaks removed.

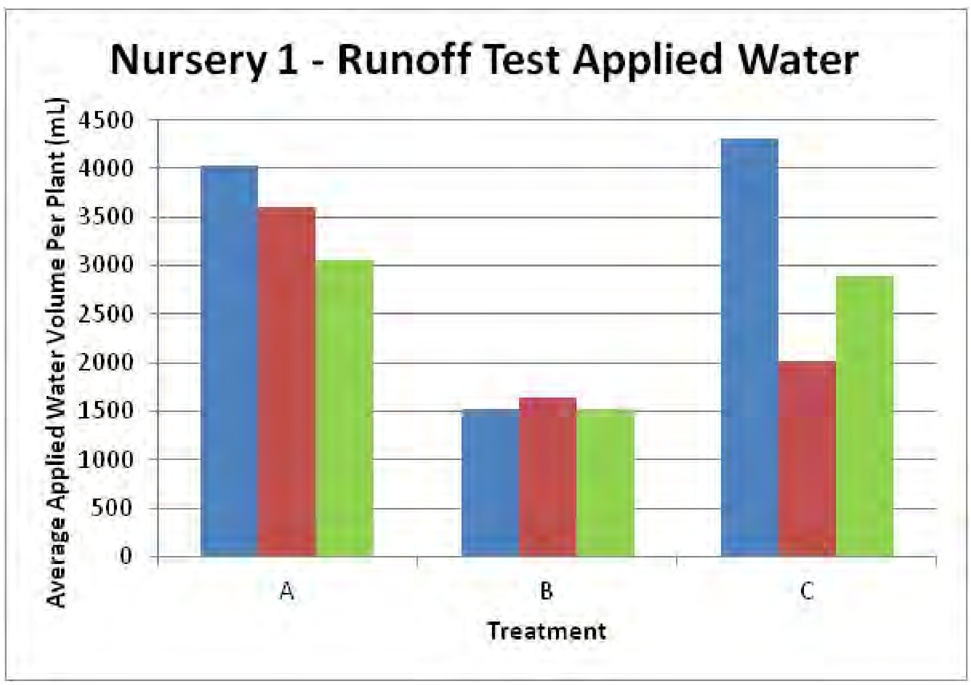

Figure 8. Average volume of water applied to 5 plants for each of 3 irrigation treatments in 3 separate runoff tests in nursery 1.

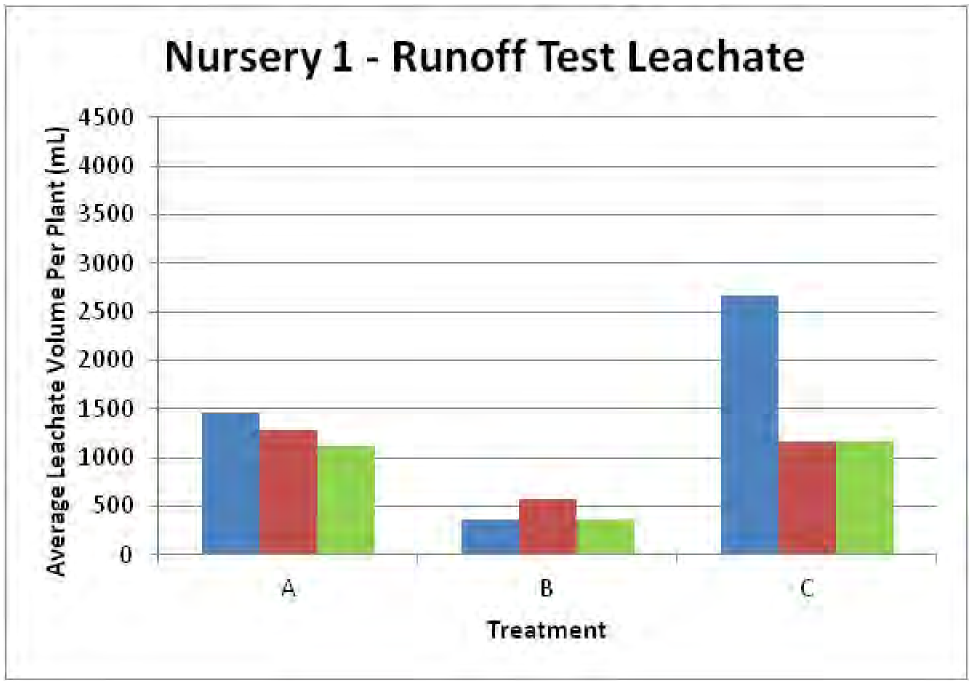

Figure 9. Average volume of leachate collected from 5 plants for each of 3 irrigation treatments in 3 separate runoff tests in nursery 1.

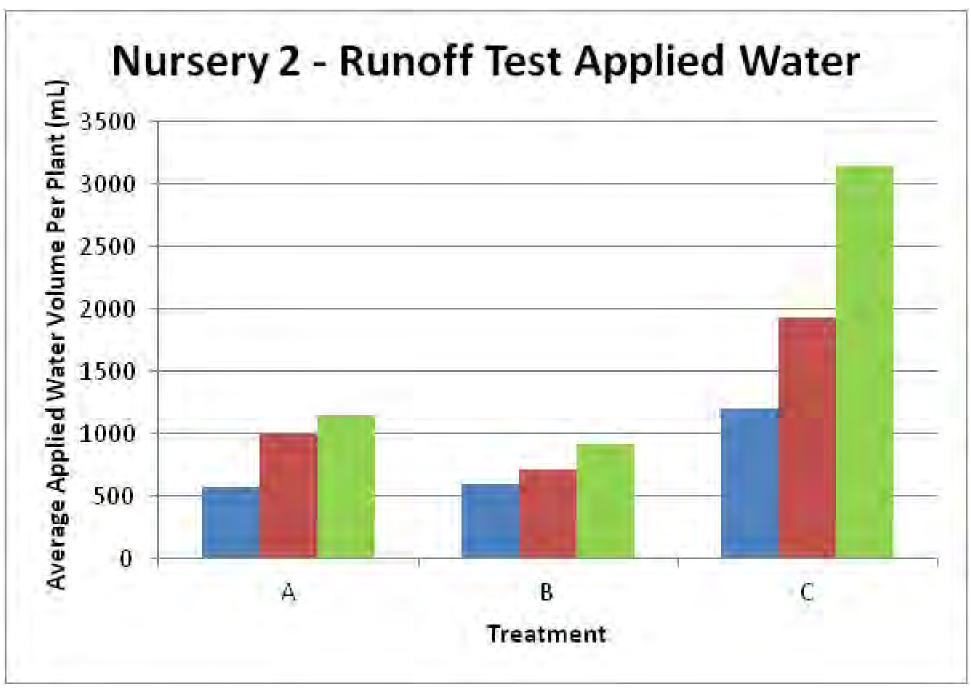

Figure 10. Average volume of water applied to 5 plants for each of 3 irrigation treatments in 3 separate runoff tests in nursery 2.

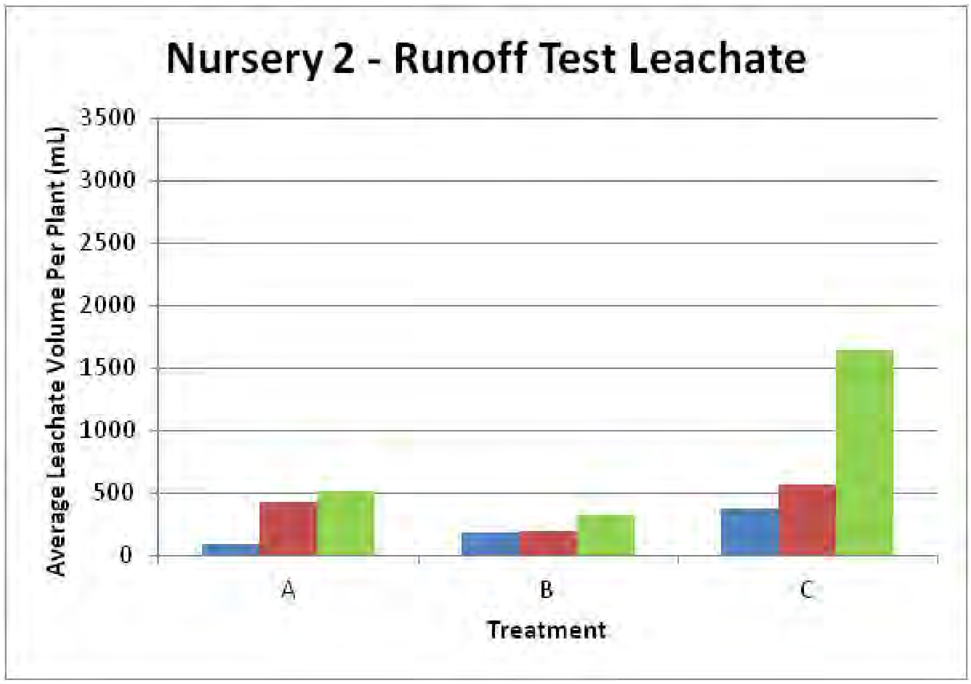

Figure 11. Average volume of leachate collected from 5 plants for each of 3 irrigation treatments in 3 separate runoff tests in nursery 2.

PLoS one

Climate Change Affects Winter Chill for Temperate Fruit and Nut Trees

Eike Luedeling[1]*, Evan H. Girvetz[2], Mikhail A. Semenov[3], Patrick H. Brown[4]

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Abstract

Background: Temperate fruit and nut trees require adequate winter chill to produce economically viable yields. Global warming has the potential to reduce available winter chill and greatly impact crop yields.

Methodology/Principal Findings: We estimated winter chill for two past (1975 and 2000) and 18 future scenarios (mid and end 21st century; 3 Global Climate Models [GCMs]; 3 greenhouse gas emissions [GHG] scenarios). For 4,293 weather stations around the world and GCM projections, Safe Winter Chill (SWC), the amount of winter chill that is exceeded in 90% of all years, was estimated for all scenarios using the ''Dynamic Model'' and interpolated globally. We found that SWC ranged between 0 and about 170 Chill Portions (CP) for all climate scenarios, but that the global distribution varied across scenarios. Warm regions are likely to experience severe reductions in available winter chill, potentially threatening production there. In contrast, SWC in most temperate growing regions is likely to remain relatively unchanged, and cold regions may even see an increase in SWC. Climate change impacts on SWC differed quantitatively among GCMs and GHG scenarios, with the highest GHG leading to losses up to 40 CP in warm regions, compared to 20 CP for the lowest GHG.

Conclusions/Significance: The extent of projected changes in winter chill in many major growing regions of fruits and nuts indicates that growers of these commodities will likely experience problems in the future. Mitigation of climate change through reductions in greenhouse gas emissions can help reduce the impacts, however, adaption to changes will have to occur. To better prepare for likely impacts of climate change, efforts should be undertaken to breed tree cultivars for lower chilling requirements, to develop tools to cope with insufficient winter chill, and to better understand the temperature responses of tree crops.

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Introduction

Commercially successful cultivation of many fruit and nut trees requires the fulfillment of a winter chilling requirement, which is specific for every tree cultivar [1,2,3,4]. In order to avoid frost damage of sensitive tissue in the cold winters of their regions of origin, trees from temperate or cold climates evolved a period of dormancy during the cold season. After a certain duration of cold conditions (chilling), endodormancy is broken and the tree is ready to resume growth in spring. Chilling requirements vary substantially between species and cultivars from different parts of the world and commercial production of temperate tree crops requires selecting appropriate cultivars for the climatic conditions of the planned production site.

Climate change is likely to affect future winter chill and could have a major impact on the US$ 93 billion global fruit and nut industry (only species with chilling requirements, production statistics for 2005 from ref. [5], currencies converted into 2005 US$ according to ref. [6]). Temperatures are expected to increase in most parts of the world, with minimum temperatures rising most rapidly. This development may compromise the ability of many growers of temperate fruits and nuts to successfully produce the same array of crops as in the past. Climate change effects on winter chill have recently been analyzed for California [7,8], Germany [9] and high-mountain oases in Oman [10]. While conditions in Germany were relatively stable during the 20th century, winter chill was found to have declined in California and Oman, and this process was expected to continue in the future. The differences between these studies indicate that different growing regions may be differentially impacted, but to date, no estimates are available at a global scale to indicate which regions will maintain adequate winter chill for temperate fruits and nuts in the future. This study aims to fill this knowledge gap and to provide important information needed to evaluate the future viability of fruit and nut growing regions around the world.

Several models have been developed for quantifying winter chill, e.g. the Chilling Hours Model [11], the Utah Model [12] and the Dynamic Model [13,14]. These models differ greatly in their sensitivity to climate change [15], making the choice of the model a crucial determinant of the predicted extent of climate change effects on winter chill. When using different models for similar climate change scenarios, the Chilling Hours Model and the Utah

Model tend to show much stronger decreases in winter chill than the Dynamic Model, especially in warm growing regions [15]. Using the former two models probably overestimates winter chill losses, because several studies have shown the Dynamic Model to be more accurate, especially in subtropical climates [16,17,18]. One more study found it to be equal to the Utah Model in Spain [19], and another one reported failure of all models on the Tropical island of Réunion [20]. Calculating ratios between winter chill estimates with different models at warm locations shows large differences, with strong variation and strong temperature dependence [21]. For colder regions, however, such ratios tend to be fairly similar and much less variable [21]. Consequently, the Dynamic Model can be used as a proxy of winter chill in both warm and cold growing regions and, among the common winter chill models, is the one most suitable for a global analysis. The Chilling Hours and Utah Models may produce reasonably accurate results in cold regions, but are not applicable for warmer parts of the world, where their use would produce misleading overestimates of likely impacts of climate change [8]. In this study, we therefore only use the Dynamic Model (for equations, see [21]), which quantifies winter chill in Chill Portions (CP).

We quantified winter chill for the entire terrestrial globe using climate scenarios based on observed daily weather from 4293 weather stations around the world and climate projections from three Global Climate Models (GCMs). Based on this analysis we calculated the safe winter chill (SWC) metric [8], which quantifies the amount of winter chill that is exceeded in 90% of years. This metric is meaningful to fruit and nut producers, because failure to meet chilling requirements in more than 10% of years is likely to render production uneconomical. This analysis identifies important fruit and nut producing areas in the world where SWC has already decreased and is projected to decrease further, and

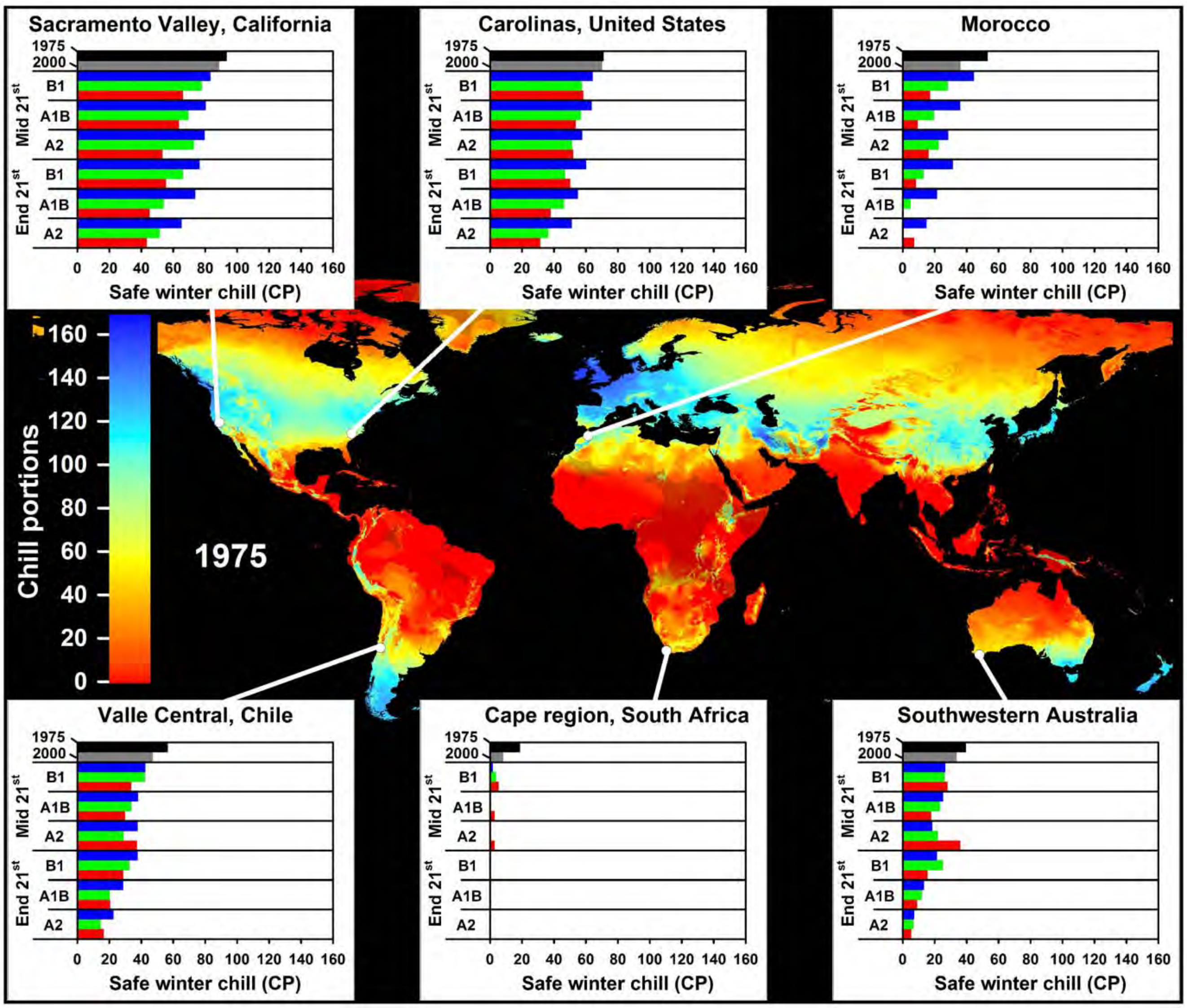

Figure 1. Modeled Safe Winter Chill around the year 1975 (large map), as well as site-specific estimates of Safe Winter Chill for six growing regions and for 20 climate scenarios, representing four points in time (1975, 2000, mid and end 21st century). Future projections include three greenhouse gas emissions scenarios (B1, A1B and A2) and three Global Climate Models (CSIRO - green bars; HADCM3 - blue bars; and MIROC - red bars). Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
doi:10.1371/journal.pone.0020155.g001

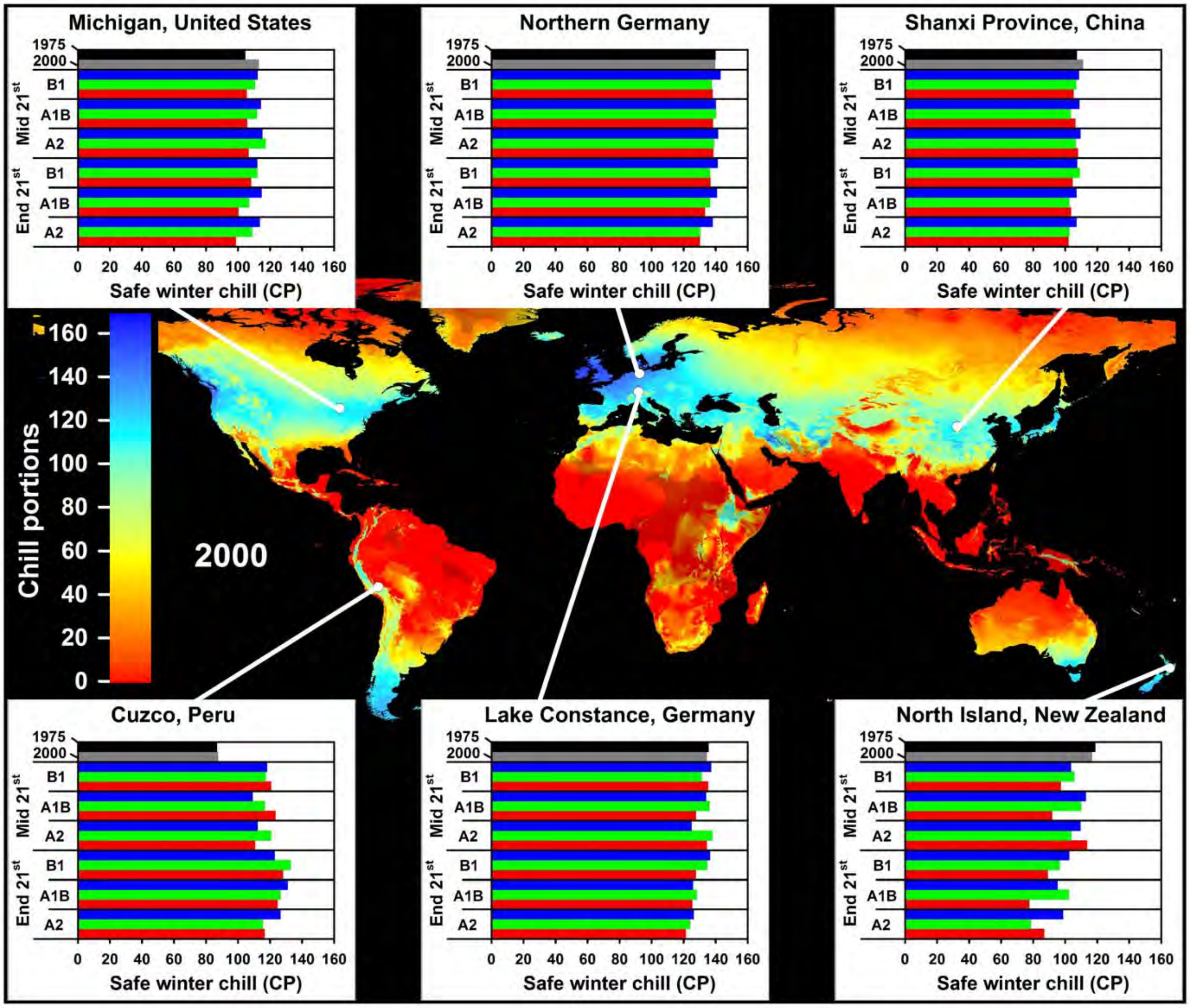

Figure 2. Modeled Safe Winter Chill around the year 2000 (large map), as well as site-specific estimates of Safe Winter Chill for six growing regions and for 20 climate scenarios, representing four points in time (1975, 2000, mid and end 21st century). Future projections include three greenhouse gas emissions scenarios (B1, A1B and A2) and three Global Climate Models (CSIRO - green bars; HADCM3 - blue bars; and MIROC - red bars). Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
doi:10.1371/journal.pone.0020155.g002

provides a comprehensive assessment of the magnitude of changes to winter chill that will likely occur.

Daily weather records for all weather stations were obtained from the National Climatic Data Center of the United States [22], subjected to a data quality filter, and used to calibrate a weather generator [23,24]. Daily weather records were then generated for 20 climate scenarios. Two scenarios represented typical climatic conditions in 1975 and 2000. Eighteen future scenarios were generated by extracting future projections from datasets assembled in the ClimateWizard tool [25]. These included statistically downscaled projections with three GCMs (MIROC3.2 (medres), UKMO-HadCM3 and CSIRO-Mk3.0; referred to as MIROC, HADCM3 and CSIRO in the following) and for three IPCC greenhouse gas emissions scenarios (B1 - global curbing of emissions over the 21st century; A1B - emissions leveling off at mid 21st century; and A2 - continually increasing rate of greenhouse gas emissions). Projections were made for the middle (2040–2059) and end (2080–2099) of the 21st century. Idealized daily temperature curves were used for converting daily to hourly weather records and allow calculation of winter chill. For each scenario, 101 years of weather records were generated and the 10% quantile of the resulting distribution of annual winter chill interpreted as Safe Winter Chill. For each scenario, SWC from all stations was spatially interpolated, and winter chill for all scenarios was extracted from the resulting layers for 24 important growing regions around the world.

Results

In all climate scenarios, estimates of Safe Winter Chill ranged from 0 CP in tropical and very cold regions to about 170 CP in maritime temperate climates of Northwestern Europe (Figs. 1–4).

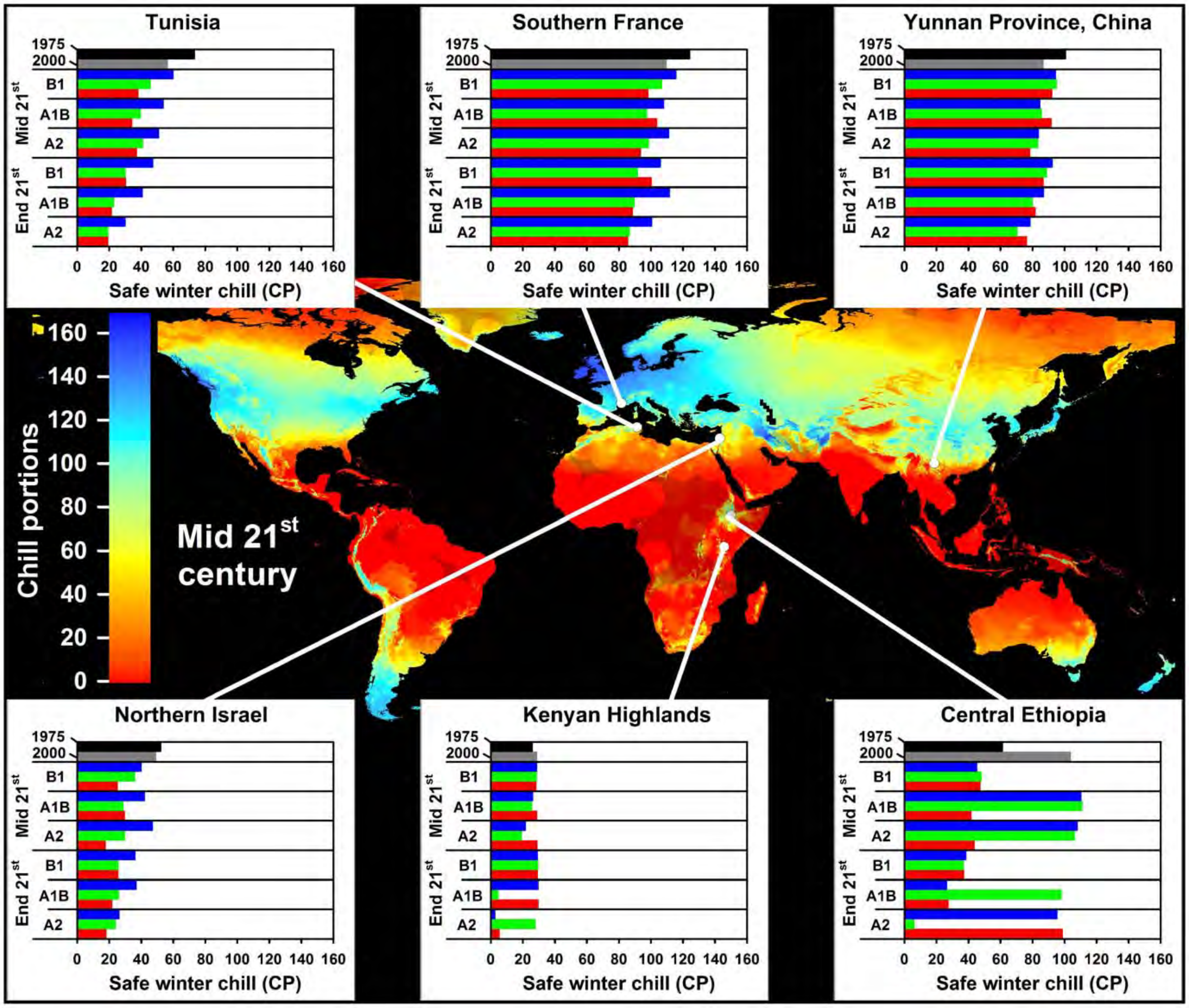

Figure 3. Modeled Safe Winter Chill around the middle of the 21st century averaged over three greenhouse gas emissions scenarios and three Global Climate Models (large map), as well as site-specific estimates of Safe Winter Chill for six growing regions and for 20 climate scenarios, representing four points in time (1975, 2000, mid and end 21st century). Future projections include three greenhouse gas emissions scenarios (B1, A1B and A2) and three Global Climate Models (CSIRO - green bars; HADCM3 - blue bars; and MIROC - red bars). Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
doi:10.1371/journal.pone.0020155.g003

While the overall range of the winter chill distribution did not change much across all scenarios, our results show changes in the global distribution of winter chill, as well as site-specific trends. Because the Dynamic Model does not consider freezing temperatures to be effective for chilling, reduced incidence of frost tends to increase the number of Chill Portions in cold regions. This process is reflected in increasing Safe Winter Chill in cold regions (Fig. 5), which may affect fruit growing regions in Canada, Southern Scandinavia and Eastern Europe (Fig. 4). Decreases are projected for warmer regions, in particular around the Mediterranean Sea (Fig. 6) and in Southwestern North America (Fig. 7), where losses up to 40 CP are expected by the end of the 21st century (Fig. 5). Many warm growing regions are projected to lose most of their winter chill, with South Africa, Southern Australia and Northern Africa particularly affected (Figs. 6 and 8).

Trends in site-specific projections for different growing regions varied substantially (site diagrams in Figs. 1–4). Most warm growing regions of temperate fruits and nuts are expected to experience decreasing winter chill, regardless of the emissions scenario or climate model used. The Sacramento Valley in California, the Southeastern United States, Chile's Valle Central, Yunnan Province in China, as well as South and Southwestern Australia are all projected to lose winter chill. This will likely require growers to transition to different species or cultivars than are grown today or to develop management practices that can help overcome shortages in winter chill. The highest losses relative to current winter chill levels occurred in Morocco, Tunisia, Israel, in the Cape region of South Africa and, for some GCMs, in the highlands of Kenya and Ethiopia. In these regions, climate change is likely to severely challenge current production systems, some of

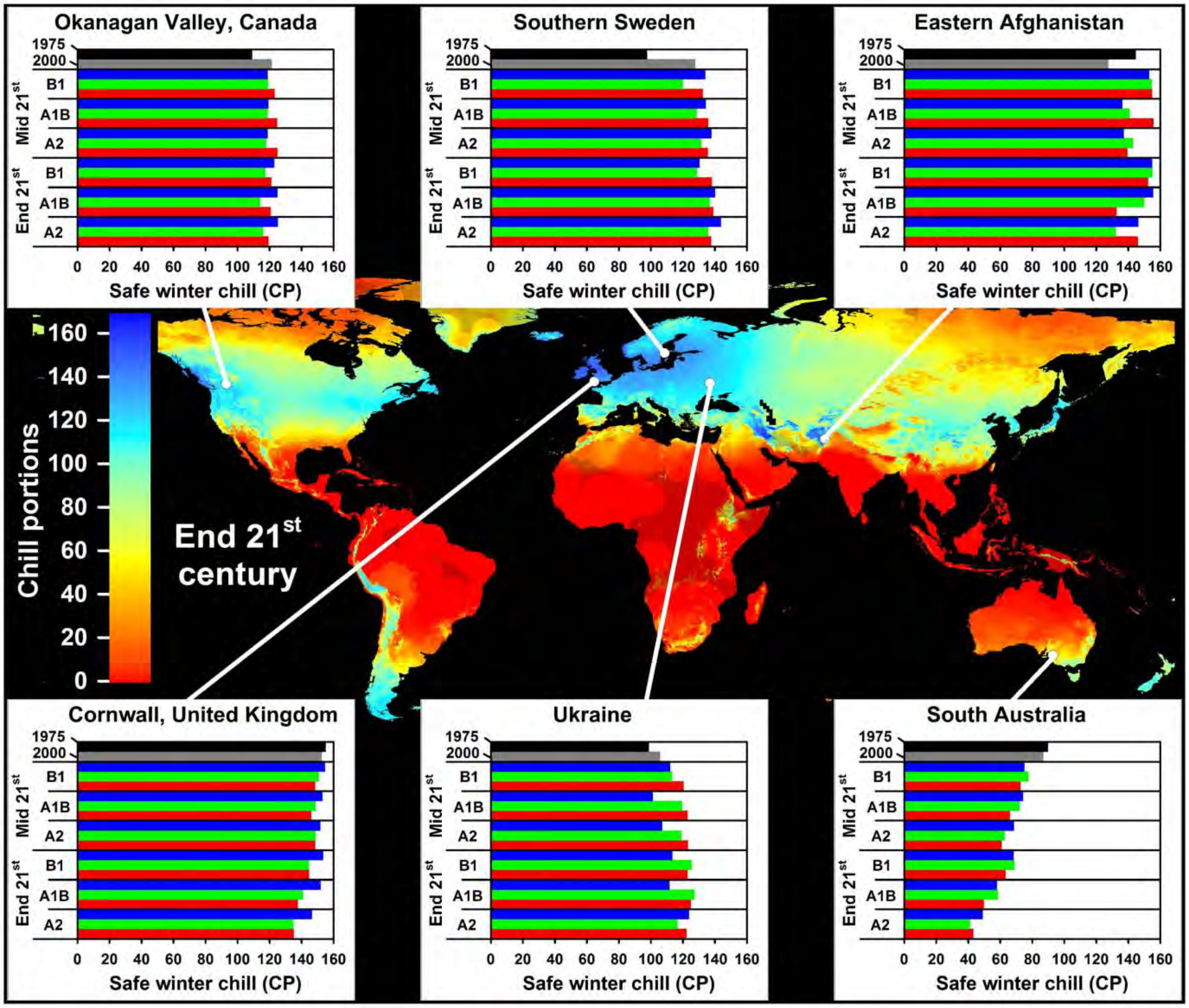

Figure 4. Modeled Safe Winter Chill around the end of the 21st century averaged over three greenhouse gas emissions scenarios and three Global Climate Models (large map), as well as site-specific estimates of Safe Winter Chill for six growing regions and for 20 climate scenarios, representing four points in time (1975, 2000, mid and end 21st century). Future projections include three greenhouse gas emissions scenarios (B1, A1B and A2) and three Global Climate Models (CSIRO - green bars; HADCM3 - blue bars; and MIROC - red bars). Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
doi:10.1371/journal.pone.0020155.g004

which already rely on cultural measures such as rest-breaking chemicals and artificial defoliation.

Cool regions are less likely to experience decreasing winter chill. Growing regions in Germany, the United Kingdom, the Midwestern United States (Fig. 7), Northern China and Central Asia are projected to see little change in SWC levels. Southern France (Fig. 6) and New Zealand (Fig. 8) may experience slight but likely insignificant losses. The coldest current growing regions (e.g. the Okanagan Valley in Canada, Southern Sweden and Eastern Europe) are expected to see more winter chill in the future. Whether these changes will require growers to adapt is currently unclear and is likely to depend more on the effects of summer warming than on winter temperatures.

In addition to the time period analyzed, the amplitude of expected changes also depended on the greenhouse gas emissions scenario. The A2 scenario consistently projected the greatest changes in winter chill, followed by the A1B scenario and the B1 scenario. If emissions are curbed to levels assumed in the B1 scenario, few growing regions are likely to see decreases by more than 20 CP by the end of the 21st century (Fig. 9). If business-as-usual emissions continue (A2 scenario), many subtropical regions will see chilling declines up to 40 CP, which can be expected to disrupt production systems.

The choice of the climate model also influenced model results. The MIROC model produced the greatest changes, followed by HADCM3 and CSIRO (Fig. 10). Within the same time period and emissions scenario, mean absolute differences between winter chill levels projected by CSIRO and HADCM3 were always smaller than for comparisons of either model with MIROC projections (Table 1). By the end of the 21st century, mean absolute differences between all modeled scenarios and historic SWC levels for 1975 were between 12.8 and 29.0 CP, on average

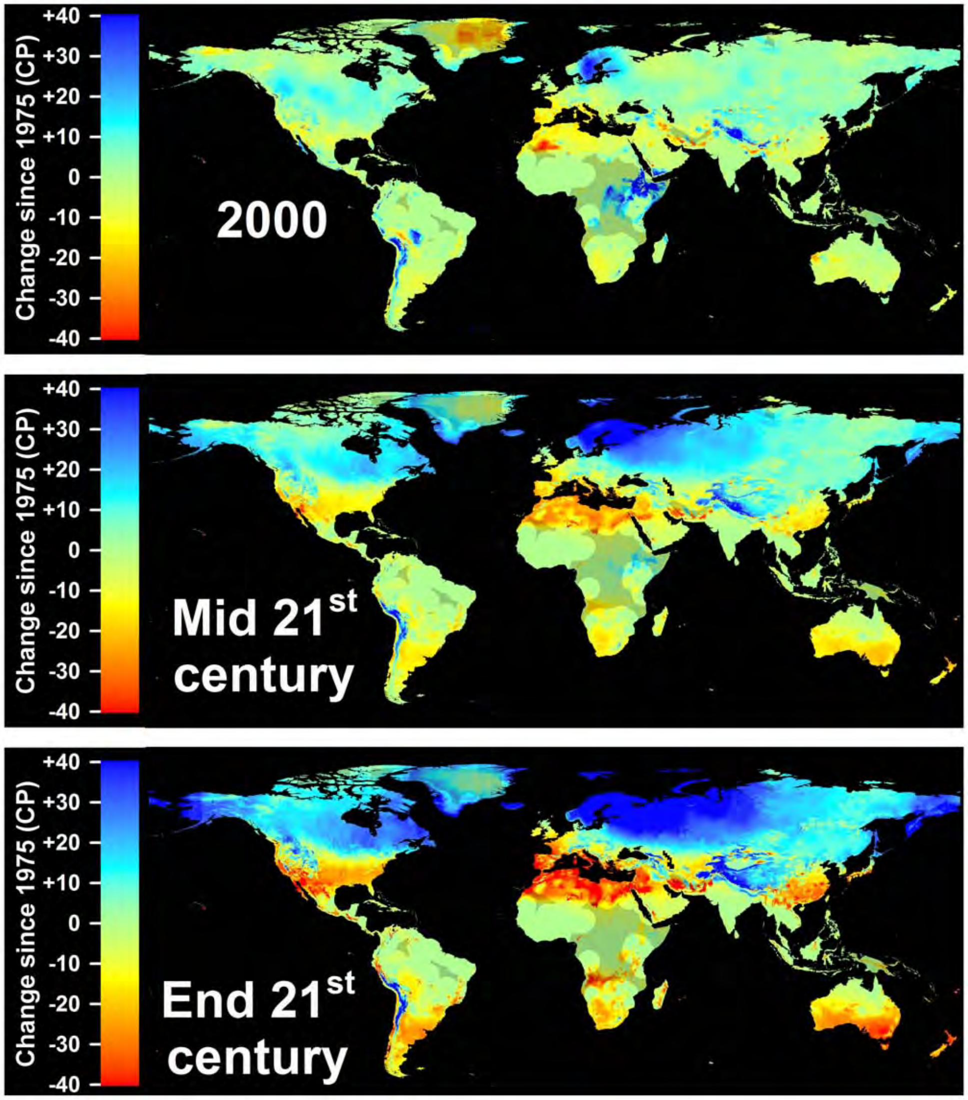

Figure 5. Modeled and projected losses in Safe Winter Chill compared to 1975 for the year 2000 (top), the middle of the 21st century (middle), and the end of the 21st century (bottom). For each point in time, results are averaged over three greenhouse gas emissions scenarios and three Global Climate Models. Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
doi:10.1371/journal.pone.0020155.g005

over all grid cells. These levels of change indicate that vegetation that relies on winter dormancy will experience very different temperature cues in the future than it does now.

Discussion

Our projections indicate that most warm growing regions will experience severe declines in Safe Winter Chill over the course of the 21st century. In contrast to this, cool regions may not see much change, because reductions in winter chill due to warming are compensated for by chilling gains caused by less frequent frost. For cold growing regions, these opposing trends play out to result in more winter chill in response to warming.

Among these changes, reduced winter chill is likely to have the most severe consequences for fruit production. Lack of winter chill can delay or prevent flowering, lead to staggered bloom, and cause various forms of anomalous growth [26,27]. Anecdotal evidence of this has been reported from various growing regions but seldom found its way into the literature.

Increases in winter chill in cold areas are less likely to lead to disruptions in fruit production, but even there, a mismatch between the chilling requirements of common species and cultivars and available winter chill could cause some problems for fruit and nut growers. In all areas, however, even in those where no changes in winter chill are projected, other manifestations of climate change are also likely to affect fruit and nut production. Plantations may be impacted by changes in rainfall, changes to summer and spring heat or increases in pest pressure due to faster reproduction of ectothermic pest organisms [28]. Due to all these additional effects of climate change, we do not attempt to predict future yields, but focus on pointing out potential problems due to lack of winter chill.

Even assuming no additional changes due to climate change, modeling the effect of changes in winter chill on crop yields is not

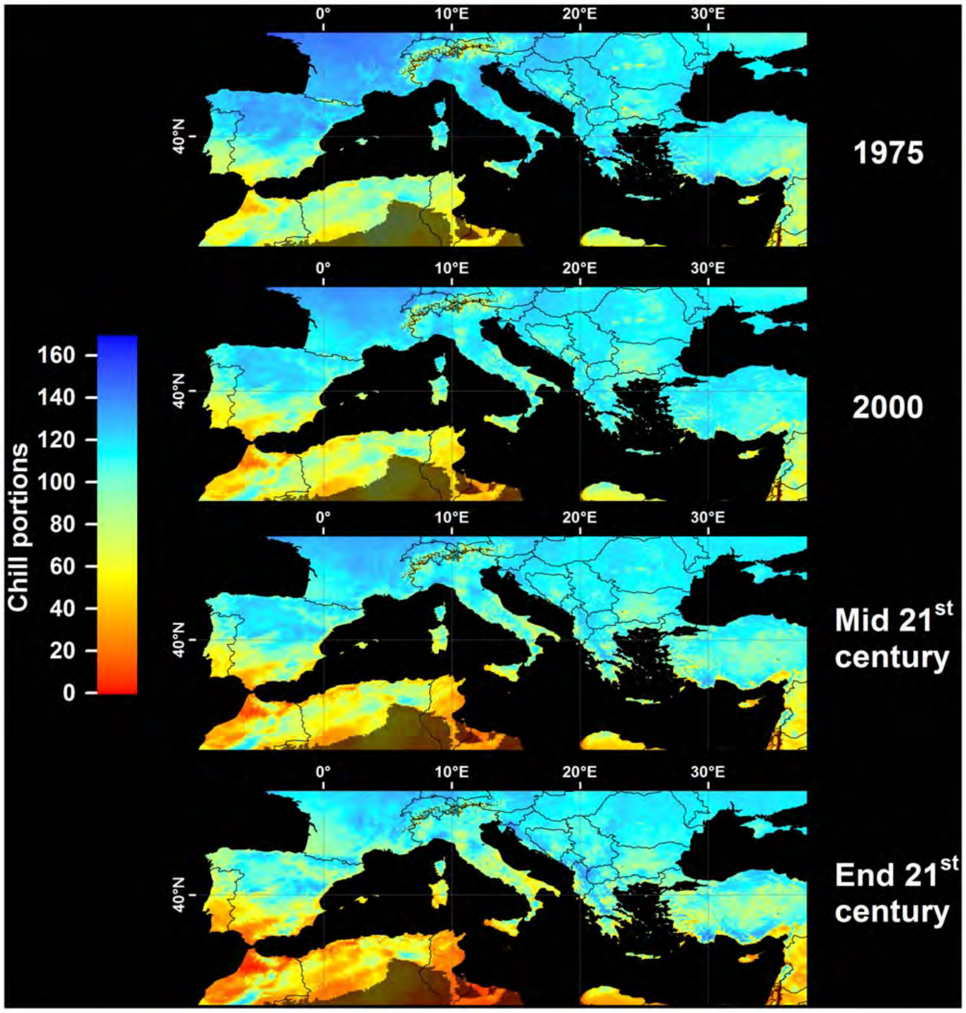

Figure 6. Modeled and projected Safe Winter Chill in the Mediterranean region, for 1975, 2000, the middle of the 21st century (middle), and the end of the 21st century (bottom). For each point in time, results are averaged over three greenhouse gas emissions scenarios and three Global Climate Models. Areas that are more than 5° away from the closest weather station, and areas with mean annual temperatures >20 or <°0C are shaded.
doi:10.1371/journal.pone.0020155.g006

possible at present. In spite of two centuries of research on winter chill, it is still unclear what happens during chilling accumulation, and how exactly this process is influenced by ambient temperatures. There may also be other environmental factors, such as relative humidity, photoperiod or the Red/Far Red light ratio [29], that impact the breaking of dormancy but are not recognized in any dormancy models for tree crops. All chilling models, including the Dynamic Model, were developed to assist fruit and nut growers in selecting appropriate species and cultivars, rather than describing a biological process with scientific accuracy. They are all empirically derived rather than based on a functional understanding of the dormancy process.

Lack of knowledge about the chilling requirements of most species and cultivars, in appropriate units, also precludes detailed projections of future yields or suitable ranges. Most growers and researchers have used Chilling Hours to quantify chilling requirements, but this model has been shown to perform poorly in warm regions [16,17,18,19,20] and to be very sensitive to climate change [15]. Estimates of chilling requirements, when given in Chilling Hours, must also be adjusted before they are useful in a different location or in a warmer climate [21]. Existing lists of species-specific chilling requirements are thus of limited value for estimating future ranges of cultivars and species. Estimates in Chill Portions are less widely available, and we are not aware of a comprehensive list that compiles them. Research efforts are needed to close the pertinent knowledge gaps and allow quantitative projections of the effect that changes in winter chill will have on fruit and nut production.

As much as precise quantitative projections are impossible, changes to available winter chill and summer heat will likely change the suitable ranges of many tree crops, and it seems likely that many growing regions will become unsuitable for the cultivars that are currently produced. However, whether or not tree crops will actually be moved to cooler climates will depend on many factors, such as availability of land and critical infrastructure, land tenure and competition with other crops. For example, the ecological niche of many fruits and nuts in the Western United States is likely to move north, from California's Central Valley towards Northern California, Oregon and Washington. These new potentially suitable areas have adverse topography, poorer soils, and limited water availability compared to the Central Valley, making the economic viability of production there

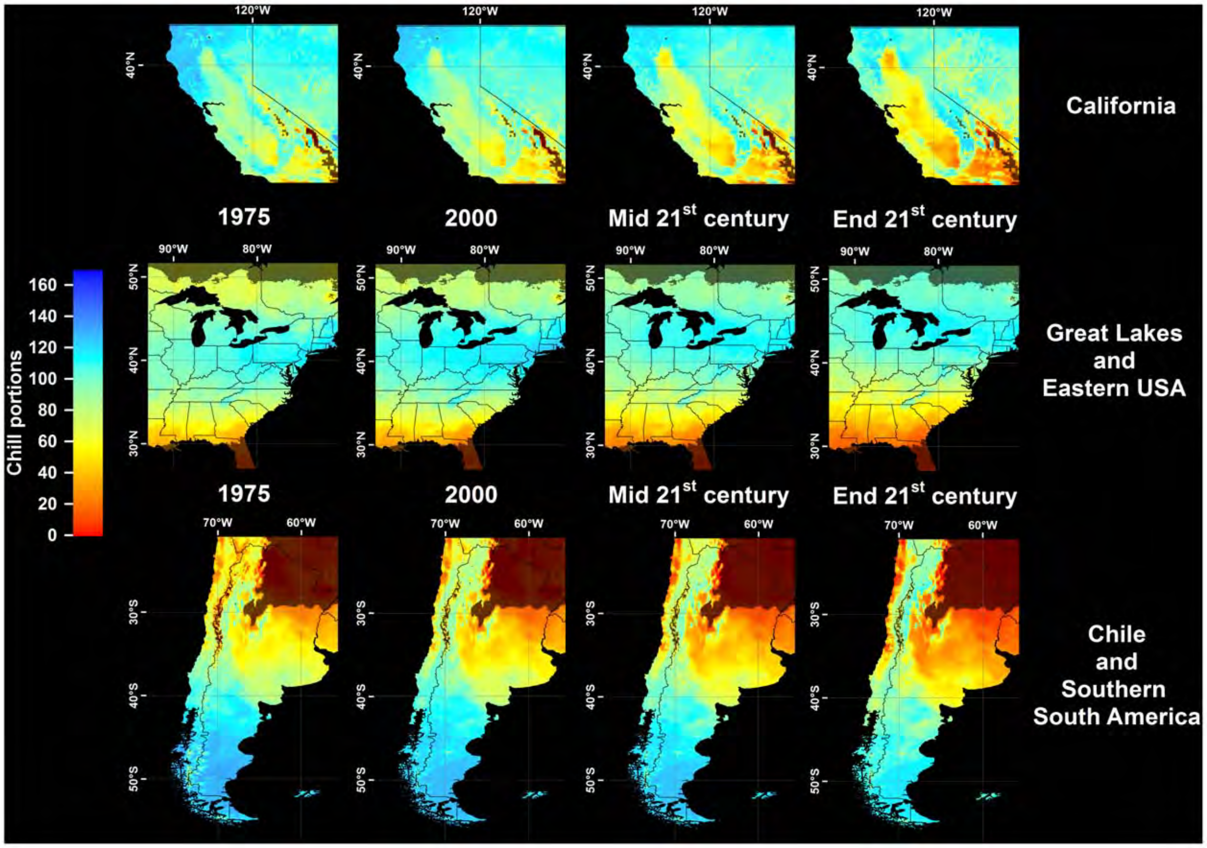

Figure 7. Modeled and projected Safe Winter Chill in California, the Eastern United States and Southern South America, for 1975, 2000, the middle of the 21st century (middle), and the end of the 21st century (bottom). For each point in time, results are averaged over three greenhouse gas emissions scenarios and three Global Climate Models. Areas that are more than 5° away from the closest weather station, and areas with mean annual temperatures >20 or <°0C are shaded.
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questionable. Similarly, other regions, such as parts of Scandinavia, Canada and Siberia, that could potentially become more suitable for these tree crops, may be limited by cold winters, lack of summer heat, or adverse photoperiodic conditions. Production potential of tree crops under many of these novel conditions expected in the future has not been studied sufficiently to be discussed here.

To a certain extent, adaptation to changes in winter chill will be possible. Agrochemicals have been developed to artificially break a tree's dormancy during the later stages of chilling accumulation [30,31], irrigation and shading may influence orchard microclimates favorably [32], and other cultural practices, such as artificial defoliation [33], also have potential for reducing chilling requirements. Inclusion of low chilling requirements as an explicit target in breeding programs is likely to produce cultivars that will remain suitable in a warmer future. It will be necessary, however, to intensify efforts to develop such adaptation strategies. In particular breeding programs for low-chilling cultivars, which can take decades to produce useable results, need more attention and more resources.

The economic cost of climate change incurred by fruit and nut growers could be substantial. Many businesses may be confronted with the decision to either abandon their production or adapt as well as possible to altered climatic conditions. Applying adaptation treatments could be economically unviable. And even if crops move towards more suitable climatic zones, most small orchard operations lack the capital to move their production to a different area, potentially impacting many livelihoods.

Natural plant communities respond to similar temperature cues as fruit and nut trees and will likely be affected as well by changes in the amount of available winter chill. It seems very likely that the projected decreases in winter chill in the Subtropics, but also the increases in the colder regions, will affect local natural vegetation, potentially impacting the suitable areas for many plants. Rapid climate-driven changes in plant communities at the local scale have already been reported [34]. Most studies that have investigated climate change effects on large numbers of plant species have found that most species showed advances in spring phenology, indicating that the impact of reduced chilling is compensated, in most cases, by increases in spring heat [35,36,37]. However, the same studies include a sizeable number of species, which show an opposite trend - delayed spring phenology in response to increases in temperature. For meadow and steppe vegetation on the Tibetan Plateau, Yu et al. [38] have recently shown a clear correlation of such a delay with increases in winter temperature, implicating lack of winter chill as the cause of the delay.

Conclusion

Even under the most conservative emissions scenario examined here the projected substantial decreases in winter chill would negatively impact productivity of current cultivars and viability of fruit and nut industries in warm growing regions. Chemical, mechanical and physical methods to compensate for a loss of chilling are available but add significantly to production costs. A

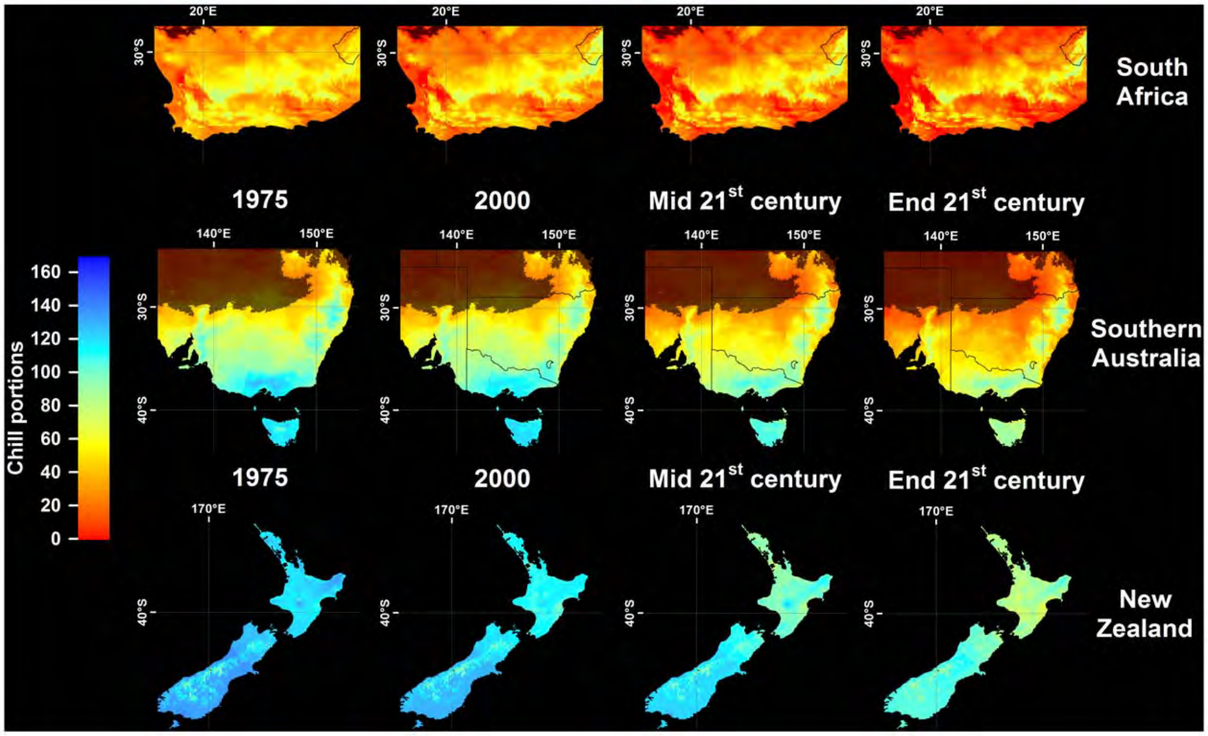

Figure 8. Modeled and projected Safe Winter Chill in South Africa, Southern Australia and New Zealand, for 1975, 2000, the middle of the 21st century (middle), and the end of the 21st century (bottom). For each point in time, results are averaged over three greenhouse gas emissions scenarios and three Global Climate Models. Areas that are more than 5° away from the closest weather station, and areas with mean annual temperatures >20 or <°0C are shaded.
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shift to new production areas may be possible but would incur substantial infrastructure costs. Moreover, production viability depends on many critical factors in addition to climatic suitability, which may not be available in areas with suitable future climates. The most viable approach to adapt to climate change in deciduous fruit and nut species is through the development of new cultivars that are more productive under lower chill conditions. This will require investment in efforts to understand the biological basis for chilling, to develop better models that relate environmental cues with yield and phenology, as well as renewed emphasis on breeding programs.

Materials and Methods

Weather data

Daily temperature and rainfall records were downloaded for all 11,361 available weather stations at the National Climatic Data Center [22]. This dataset was filtered, removing all stations that had less than 5000 daily records between 1973 and 2002, and excluding all stations with more than 25% of daily minimum or maximum temperatures or 50% of daily rainfall data missing. For the remaining 5078 weather stations, all available temperature and precipitation records were used to calculate site parameters for use in the LARS-WG stochastic weather generator [23,24]. A stochastic weather generator (WG) is a model which, after calibration of site parameters with observed weather at that site, is capable of simulating synthetic time-series of daily weather that are statistically similar to observed weather [39]. By altering the site parameters of the WG using changes in climate predicted from a global climate model (GCM), it is possible to generate synthetic daily weather for the future. WGs are extensively used as a computationally inexpensive tool to produce daily site-specific climate scenarios for impact assessments of climate change [40,41,42,43]. Because the generation of daily weather is dependent on the site-specific duration of wet and dry spells, the modeling procedure required precipitation records in addition to temperatures.

Following Luedeling et al. [8], for each station we evaluated the entire weather record for all days between 1973 and 2002, calculating separate linear regression equations between time (in years) and the minimum temperature, maximum temperature and precipitation for each month of the year. We then used these regression equations to develop climate scenarios representing typical climatic conditions in 1975 and 2000. These scenarios do not represent actually observed temperatures and precipitation in these years, but rather typical conditions at these times that are representative of long-term trends over the calibration period (1973–2002). The climate scenarios contain the mean deviation of monthly minimum and maximum temperatures and precipitation from the mean of the calibration period for each station.

Using the same method, we evaluated the weather record for 18 future scenarios, based on projections by three Global Climate Models (GCMs; MIROC3.2 (medres), UKMO-HadCM3 and CSIRO-Mk3.0) that had been statistically downscaled to a 0.5 degree resolution using the CRU TS 2.0 data set to calibrate the downscaling (R. Neilson, unpublished data). Using the Climate Wizard tool (www.climatewizard.org; ref. [25]), we extracted projected minimum and maximum temperatures and precipitation for three greenhouse gas emissions scenarios of the IPCC Special Report on Emissions Scenarios [44]: the A2 scenario (continually increasing rate of greenhouse gas emissions), the A1B scenario (emissions leveling off at mid 21st century) and the B1 scenario

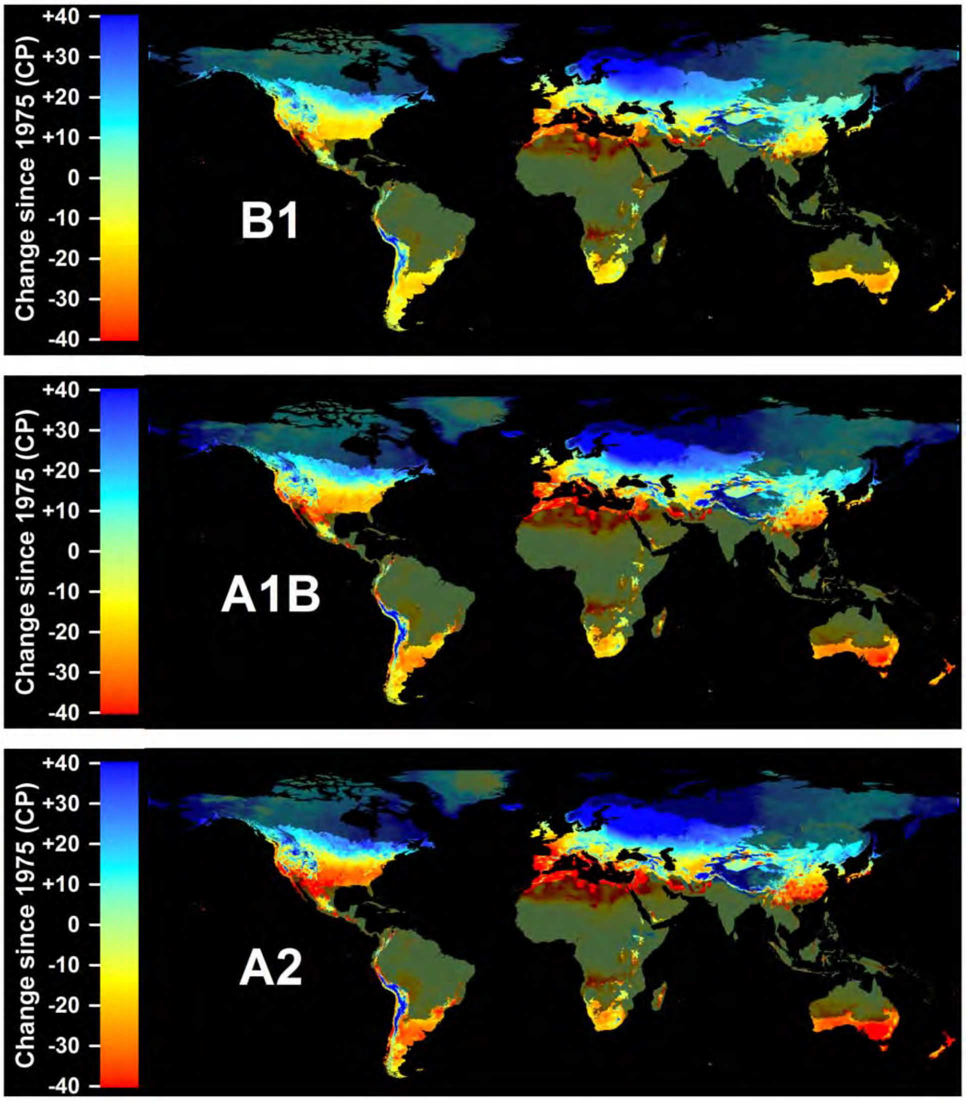

Figure 9. Projected losses in Safe Winter Chill at the end of the 21st century compared to 1975, for three greenhouse gas emissions scenarios: B1 (top), A1B (middle) and A2 (bottom). For each scenario, results are averaged over projections from three Global Climate Models. Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
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(global curbing of emissions over the 21st century). For each weather station, emissions scenario and GCM, mean monthly anomalies of minimum and maximum temperatures and precipitation relative to the calibration period were obtained for two periods of time: 2040–59 and 2080–2099, representing conditions at mid and end 21st century. For several weather stations, mostly along coast lines, no GCM projection data were available. These stations were excluded, bringing the total number of weather stations down to 4293.

For each station and for each of the 2 past and 18 future scenarios, we then generated 101 years of synthetic daily weather data using a command line version of the LARS-WG weather generator [24]. Synthetic daily maximum and minimum temperatures were converted into hourly temperatures using the idealized temperature curve proposed by Linvill [9,45]. Linvill's equations, which use a sine curve for daytime temperatures and a logarithmic decline curve for nighttime cooling, require sunset and sunrise hours, as well as daylength, as input parameters. These data were generated using equations by Spencer [46] and Almorox et al. [47]. Resulting from these processing steps were 101 years of synthetic hourly temperature for each weather station, representing typical weather conditions for each climate scenario.

Winter chill

Based on the generated hourly temperature, we calculated winter chill for 100 winters for each weather station and climate scenario, with start and end dates of the winter season set to October 1st and May 1st, respectively, for stations in the Northern Hemisphere, and to April 1st and November 1st, respectively, for stations in the Southern Hemisphere. In a global analysis, effective times of winter chill accumulation often deviate from these dates, depending on local temperature curves. Since the Dynamic Model contains a self-regulating mechanism, which only allows accumulation of Chill Portions during times with appropriate temperatures, this variability should not affect the accuracy of our results.

For the resulting distribution over 100 winters, we then calculated Safe Winter Chill (SWC), the 10% quantile of the distribution [8]. This metric is more meaningful for growers than

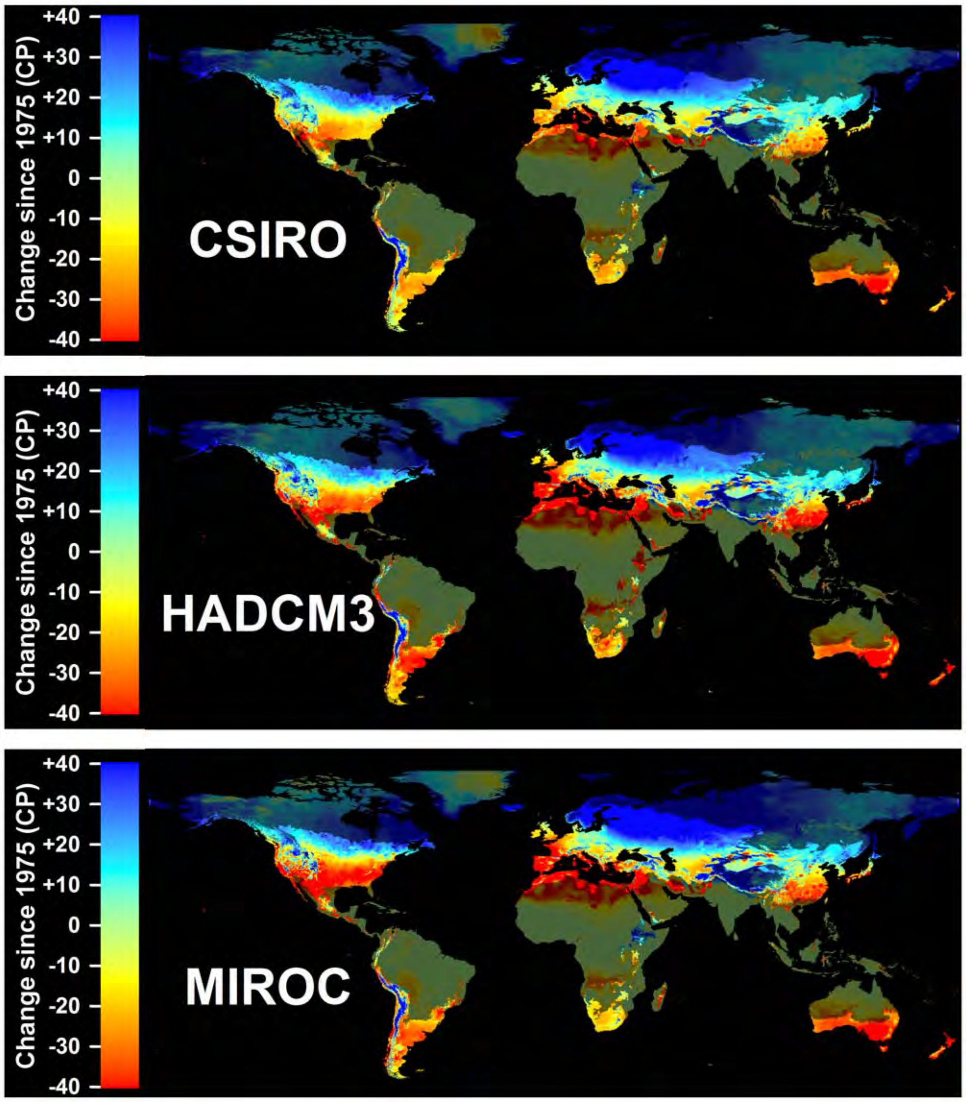

Figure 10. Projected losses in Safe Winter Chill at the end of the 21st century compared to 1975, for three Global Climate Models: CSIRO (top), HADCM3 (middle) and MIROC (bottom). For each scenario, results are averaged over projections for three greenhouse gas emissions scenarios. Areas that are more than 5° away from the closest weather station are shaded, because interpolated results are unreliable.
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mean winter chill, because economic success of an orchard operation relies on fulfillment of chilling requirements in most years (e.g. 90% of all years), rather than in an average year. For all trees with lower chilling requirements than available SWC, the dormancy season should be sufficiently long and cold to allow fulfillment of tree-specific temperature needs. All data processing was implemented in JSL, the scripting language of JMP 8 (SAS Institute, Cary, NC, USA).

Spatial analysis

Based on estimates of SWC for every weather station, SWC was spatially interpolated for each climate scenario, using 12-neighbor Kriging with a spherical semivariogram at 0.1 degree spatial resolution (ArcGIS 9.3, ESRI, Redlands, CA, USA). A simple interpolation based on only the available weather stations would not be a very accurate representation of winter chill around the world, because temperatures at many locations may differ substantially from those of the closest weather station, which is often far away. We therefore used a high-resolution temperature dataset obtained from the WorldClim database [48] to correct for temperature variation that was not accounted for by the simple interpolation procedure. We calculated mean annual temperatures at a spatial resolution of 1/24 degree from monthly mean temperatures for the year 2000 given in the database. Because mean annual temperature explains much of the variation in winter chill [21], this dataset was useful for correcting the chilling estimates. To do this, we used the same Kriging procedure as for the winter chill estimates to interpolate a temperature surface from mean annual temperatures at all weather stations. The resulting grid represents the temperatures that correspond to the interpolated chill portion surface (SWC_{int}). Subtracting this grid from the original dataset of mean annual temperatures produced an estimate of the temperature variation that was not accounted for in the original interpolation of chill portion values (T_{diff}). For the correction, the effect of temperature on chill portion numbers was then estimated by a 5^{th} order polynomial regression between mean annual temperatures at all weather stations and the amount of safe winter chill calculated for

Table 1. Mean absolute differences (in Chill Portions) between different climate scenarios [combination of time, greenhouse gas emissions scenario (GHG) and Global Climate Model (GCM)], over all relevant 0.1°×0.1° pixels of the global Safe Winter Chill projections.

Time			1975	2000	mid 21st century									end 21st century								
	GHG				B1			A1B			A2			B1			A1B			A2		
		GCM			C	H	M	C	H	M	C	H	M	C	H	M	C	H	M	C	H	M
1975				6.7	10.0	10.5	15.5	11.1	14.5	17.5	12.8	15.7	17.5	12.8	18.1	20.9	17.8	22.5	27.3	23.3	26.6	29.0
2000			6.7		7.5	7.2	11.9	6.2	9.5	13.9	7.7	10.6	13.7	9.2	14.0	17.1	13.8	18.1	23.5	18.6	22.6	24.8
mid 21st century	**B1**	**C**	10.0	7.5		4.0	6.4	4.4	6.1	8.3	4.9	6.5	9.1	3.4	8.4	11.4	8.1	13.4	18.0	13.9	17.3	20.0
		H	10.5	7.2	4.0		6.0	4.9	5.2	7.9	5.3	6.5	8.9	3.8	7.8	11.0	8.1	12.8	17.5	13.6	16.8	19.5
		M	15.5	11.9	6.4	6.0		7.7	5.2	3.1	7.0	6.0	5.5	4.5	3.6	5.9	5.5	8.4	12.4	9.1	12.1	14.6
	A1B	**C**	11.1	6.2	4.4	4.9	7.7		4.7	9.3	2.5	5.4	9.7	4.7	9.2	12.1	8.8	12.9	18.3	13.2	17.3	19.5
		H	14.5	9.5	6.1	5.2	5.2	4.7		6.5	4.4	2.8	7.4	4.8	5.8	8.9	7.0	9.0	14.8	9.6	14.0	15.9
		M	17.5	13.9	8.3	7.9	3.1	9.3	6.5		7.8	6.5	5.5	5.9	4.0	3.7	4.6	6.7	10.2	7.3	10.0	12.7
	A2	**C**	12.8	7.7	4.9	5.3	7.0	2.5	4.4	7.8		4.4	8.9	4.3	7.8	10.4	7.0	11.2	16.5	11.3	15.5	17.7
		H	15.7	10.6	6.5	6.5	6.0	5.4	2.8	6.5	4.4		7.4	5.1	5.7	8.5	6.0	8.1	14.0	8.5	12.9	15.0
		M	17.5	13.7	9.1	8.9	5.5	9.7	7.4	5.5	8.9	7.4		7.4	6.0	7.2	7.0	8.8	12.4	9.4	11.9	14.2
end 21st century	**B1**	**C**	12.8	9.2	3.4	3.8	4.5	4.7	4.8	5.9	4.3	5.1	7.4		5.8	8.8	5.4	11.0	15.4	11.3	14.6	17.5
		H	18.1	14.0	8.4	7.8	3.6	9.2	5.8	4.0	7.8	5.7	6.0	5.8		5.2	4.9	6.9	10.6	7.9	10.3	13.2
		M	20.9	17.1	11.4	11.0	5.9	12.1	8.9	3.7	10.4	8.5	7.2	8.8	5.2		5.3	5.9	6.8	5.2	8.0	9.5
	A1B	**C**	17.8	13.8	8.1	8.1	5.5	8.8	7.0	4.6	7.0	6.0	7.0	5.4	4.9	5.3		7.5	10.8	6.8	10.1	13.2
		H	22.5	18.1	13.4	12.8	8.4	12.9	9.0	6.7	11.2	8.1	8.8	11.0	6.9	5.9	7.5		7.7	4.9	6.8	8.0
		M	27.3	23.5	18.0	17.5	12.4	18.3	14.8	10.2	16.5	14.0	12.4	15.4	10.6	6.8	10.8	7.7		7.5	6.2	4.2
	A2	**C**	23.3	18.6	13.9	13.6	9.1	13.2	9.6	7.3	11.3	8.5	9.4	11.3	7.9	5.2	6.8	4.9	7.5		8.0	8.0
		H	26.6	22.6	17.3	16.8	12.1	17.3	14.0	10.0	15.5	12.9	11.9	14.6	10.3	8.0	10.1	6.8	6.2	8.0		7.1
		M	29.0	24.8	20.0	19.5	14.6	19.5	15.9	12.7	17.7	15.0	14.2	17.5	13.2	9.5	13.2	8.0	4.2	8.0	7.1	

GCMs: C – CSIRO; H – HADCM3; M – MIROC.

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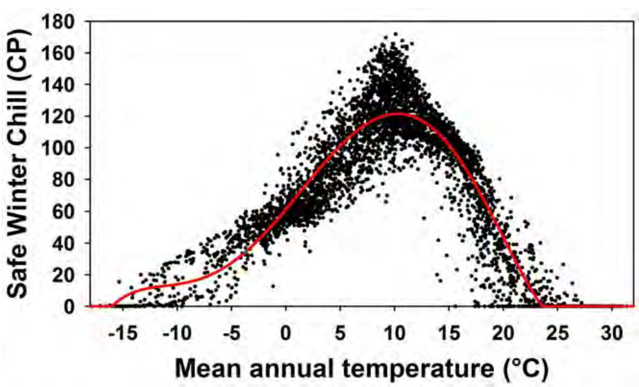

Figure 11. Correlation between mean annual temperature and modeled Safe Winter Chill for the year-2000 scenario. The red line indicates the equation used to correct for unaccounted for variation in temperature during spatial interpolation of site-specific Safe Winter Chill estimates.

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them (Fig. 11). The resulting regression equation was:

$$CP(T) = 116.71 + 0.00005 \cdot (T - 10.005)^5 + 0.0015 \cdot (T - 10.005)^4 - 0.0180 \cdot (T - 10.005)^3 - 0.8395 \cdot (T - 10.005)^2 + 0.4690 \cdot T$$

for $-15.996 < T < 23.594$, and $CP(T) = 0$ for temperatures outside this range. In this equation, T is the temperature and CP(T) is the corresponding number of chill portions. The final correction equation was then:

$$SWC_{corr}(x,y) = SWC_{\text{int}}(x,y) + CP\left(T_{mean}(x,y) + T_{diff}(x,y)\right) - CP(T_{mean}(x,y)),$$

with T_{mean} being a Kriging surface calculated from mean station temperatures of the respective climate scenario, and x and y the longitude and latitude of each grid cell. SWC_{corr} is the temperature corrected estimate of safe winter chill. On all maps, areas where mean annual temperatures were below 0°C or above 20°C were shaded, because such regions are not suitable for the production of fruits and nuts with chilling requirements. Likewise, all areas that were further than 5° away from the closest useable weather station were shaded, because interpolation results for such grid cells were deemed unreliable. All gridded SWC layers are available from http://treephenology.ucdavis.edu/.

Scenario evaluation

From the surfaces of safe winter chill, site-specific results were extracted for 24 point locations representing important growing regions around the world. Comparing safe winter chill estimates for different combinations of GCM, GHG emissions scenario and point in time provides an impression of the agreement between scenarios, on a case-study basis. We also evaluated differences between scenarios based on the entire distribution over all relevant grid cells (excluding all that were shaded in the maps). Because differences between models in site specific estimates can be both negative and positive, we evaluated the mean absolute difference among all grid cells. The results are indicative of the agreement between models.

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Author Contributions

Conceived and designed the experiments: EL PHB. Performed the experiments: EL. Analyzed the data: EL. Contributed reagents/materials/analysis tools: EL EHG MAS. Wrote the paper: EL EHG MAS PHB.

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Review

Climate change impacts on winter chill for temperate fruit and nut production: A review

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ABSTRACT

Temperate fruit and nut species require exposure to chilling conditions in winter to break dormancy and produce high yields. Adequate winter chill is an important site characteristic for commercial orchard operations, and quantifying chill is crucial for orchard management. Climate change may impact winter chill. With a view to adapting orchards to climate change, this review assesses the state of knowledge in modelling winter chill and the performance of various modelling approaches. It then goes on to present assessments of past and projected future changes in winter chill for fruit growing regions and discusses potential adaptation strategies. Some of the most common approaches to modelling chill, in particular the Chilling Hours approach, are very sensitive to temperature increases, and have also been found to perform poorly, especially in warm growing regions. The Dynamic Model offers a more complex but also more accurate alternative, and use of this model is recommended. Chill changes projected with the Dynamic Model are typically much less severe than those estimated with other models. Nevertheless, projections of future chill consistently indicate substantial losses for the warmest growing regions, while temperate regions will experience relatively little change, and cold regions may even see chill increases. Growers can adapt to lower chill by introducing low-chill cultivars, by influencing orchard microclimates and by applying rest-breaking chemicals. Given substantial knowledge gaps in tree dormancy, accurate models are still a long way off. Since timely adaptation is essential for growers of long-lived high-value perennials, alternative ways of adaptation planning are needed. Climate analogues, which are present-day manifestations of future projected climates, can be used for identifying and testing future-adapted species and cultivars. Horticultural researchers and practitioners should work towards the development and widespread adoption of better chill accumulation and dormancy models, for facilitating quantitatively appropriate adaptation planning.

Contents

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1. Introduction

Fruit and nut trees that originate in cold-winter climates fall dormant in winter, enabling them to tolerate freezing temperatures in their native habitats (Vegis, 1964). During plant dormancy, visible growth is suspended (Samish, 1954) and all physiological processes are halted or slowed. They must be reactivated in spring for trees to produce leaves and flowers, and ultimately bear fruit (Samish, 1954). In order to avoid frost damage, it is crucial for trees to only resume growth when the cold season is over. For determining this moment, trees have evolved mechanisms to sense temperature, and they appear to be able to integrate over phases of cold and phases of warm temperatures (Vegis, 1964). In other words, they can sense 'how long it has been how cold' (chilling) and 'how long it has been how warm' (heat). Trees must fulfill their chilling and heat requirements in order to break dormancy (Samish, 1954; Vegis, 1964; Saure, 1985; Campoy et al., 2011b).

Both requirements are attuned to a certain climate regime. They must work together to ensure that dormancy is broken late enough to keep trees from starting to grow in winter. On the other hand, growth must be resumed early enough to allow trees to complete their annual reproductive cycles before the onset of the following winter season. Given these climatic requirements, productive cultivation of each tree cultivar is confined to a certain agroclimatic zone (Rumayor-Rodriguez, 1995), and choosing the right tree cultivar for a given climate regime is crucial for orchard productivity. Chilling requirements in particular are vital, especially where trees are grown in areas that are substantially warmer than their regions of origin (Chandler, 1942). This is true for a wide range of species, such as apples, pears, apricots, peaches, pomegranates, plums, walnuts, almonds and pistachios. Within each species, different cultivars have different chilling requirements (Guerriero et al., 2010), and identifying an appropriate cultivar is essential for anyone planting trees for commercial production.

Climate change is likely to affect chilling (Schwartz, 1999; Baldocchi and Wong, 2008; Luedeling et al., 2011a). With global temperatures expected to rise by up to 6 °C by the end of the 21st century, compared to pre-industrial levels (IPCC, 2007), it is unlikely that this agroclimatic metric will remain stable (Else and Atkinson, 2010; Luedeling et al., 2011a). Advancing trends in bloom dates of many trees indicate that dormancy breaking processes are indeed changing, most likely in response to climate change (Guédon and Legave, 2008; Legave et al., 2009). This article reviews approaches to estimate winter chill, studies on the performance of different approaches and analyses of historic and projected future changes in winter chill. Finally, it assesses the state of knowledge about tree dormancy for adaptation to future changes and points out knowledge gaps that urgently need to be closed.

2. Modelling winter chill

Due to the importance of chill in fruit production, a number of efforts have been made to model this agroclimatic factor (summarized in Table 1). Samish (1954) and Vegis (1961) provide reviews of early scientific attempts to understand chill accumulation during the nineteenth and early twentieth centuries. Initially, temperatures below a certain threshold were considered to contribute to fulfillment of chilling requirements (Lammerts, 1941, 1945). The realization that freezing temperatures are not effective led to the development of the Chilling Hours Model (Bennett, 1949), also known as Weinberger Model (Weinberger, 1950), or Weinberger–Eggert Model (Valentini et al., 2001) or 0–7.2 °C Model (Darbyshire et al., 2011). In this model, temperatures between 0 and 7.2 °C are assumed to have a chilling effect, with each hour at temperatures between these thresholds contributing one Chilling Hour. Chilling Hours are then summed throughout the dormant season.

The next significant advance in understanding the temperature response of trees during the chilling phase was the discovery that warm temperatures had a negative effect on chill accumulation (Overcash and Campbell, 1955). From this insight arose the Utah Model, which is characterized by differential weighting of temperature ranges, including negative weights for temperatures above 15.9 °C (Richardson et al., 1974). Variations of the Utah Model have been developed for a number of different regions, fruits and contexts (Gilreath and Buchanan, 1981; Shaltout and Unrath, 1983; Linvill, 1990; Anderson and Seeley, 1992; Linsley-Noakes and Allan, 1994; Warmund and Krumme, 2005). All these variations accumulate Chill Units over the course of the season. Campoy et al. (2011b) list several crop-specific chilling models in their comprehensive review on fruit tree dormancy.

The third modelling approach that is widely applied in practical horticulture is the so-called Dynamic Model (Fishman et al., 1987a, 1987b; Erez et al., 1990). This model is based on the assumption that chill accumulates as a result of a two-step process: in the first step, an intermediate chill product is produced in a process that is most efficient at low temperatures. This process is reversible, and the intermediate product can be destroyed by heat. Once it is exposed to moderate temperatures, however, the intermediate product can be transformed in an irreversible process into a Chill Portion. Chill Portions are accumulated, contributing to fulfillment of chilling requirements. This model is the only one among the common models that can explain the observed negative effect of high temperatures (Vegis, 1961; Thompson et al., 1975; Couvillon and Erez, 1985), the apparent limit to how much chill can be reversed (Erez et al., 1979), and the chill-enhancing effect of moderate temperatures when cycled with cool conditions (Erez and Couvillon, 1987). A major difference between the Dynamic Model and the earlier approaches is the importance given to the sequence of temperatures during the cold season. According to the Chilling Hours and Utah Models similar temperatures always have exactly the same effect, regardless of when they occur. In the Dynamic Model, several processes interact and the production of a Chill Portion is contingent on the existence of a certain quantity of the intermediate product. Similar temperatures at different times of the season can thus have very different effects on chill accumulation. Zhang and Taylor (2011) referred to this quality of the Dynamic Model as time-inhomogeneity, as opposed to the time-homogeneous nature of the other models.

In particular when including efforts outside the field of horticulture, numerous additional modelling approaches have been proposed, e.g. by Bidabé (1965), Cesaraccio et al. (2004), Chmielewski et al. (2011), Chuine et al. (1998), Linkosalo et al. (2010), Legave et al. (2008) and Hänninen and Kramer (2007). These models have not widely been applied on fruit and nut trees, and will therefore not be discussed further in this article. However, it may be worthwhile for horticultural modellers to examine these models for insights into how chilling models can be improved.

3. Equivalence of chill models

While all of the common horticultural models have been successful to a certain extent in guiding orchard management and cultivar selection, they are quite different and not all equally credible. For example, the sharp thresholds in the Chilling Hours Model and most versions of the Utah Model are unlikely to reflect biological reality. It should also be noted that most models are exclusively based on observations in the field, while systematic controlled-environment experiments seem to only have happened for the Dynamic Model. This is also the only one among the commonly used

Table 1
Overview of major chilling models and comparison with regard to the inclusion of major scientific insights into temperature effects on chill accumulation.

Model names and authors	Time step	Differential temperature weights	Continuous weights	Chill negation by heat	Limit to chill negation	Enhancement by moderate temps.	Two-phase chilling
Chilling Hours Model (Bennett, 1949; Weinberger, 1950)	h	–	–	–	–	–	–
Utah Model (Chill Units; Richardson et al., 1974)	h	+	–	–	–	–	–
Variations of theUtah Model							
North Carolina Model (Shaltout and Unrath, 1983)	h	+	–	+	–	–	–
Anderson and Seeley, 1992	h	+	+	+	–	–	–
Positive Utah Model (Linsley-Noakes and Allan, 1994)	h	+	–	+	+	–	–
Modified Utah Model (Linvill, 1990)	h	+	+	+	–	–	–
Regional models in Georgia and Florida	m	–	–	–	–	–	–
Chmielewski et al. (2011)	d	–	–	–	–	–	–
Legave et al. (2008)	d	±	±	–	–	–	–
Cesaraccio et al. (2004)	d	+	+	–	–	–	–
“non-horticultural” dormancy models (e.g. Chuine and Cour (1999), Linkosalo et al. (2008)	d	±	±	±	–	–	–
Dynamic Model (Chill Portions; Fishman et al. (1987a, 1987b)	h	+	+	+	+	+	+

+ indicates that the respective characteristic is included in the model; − indicates that it is not included; ± means that different versions exist, with only some including the characteristic.
Model characteristics are temperature step (h = hourly, d = daily, m = monthly), differential weighting of different temperature ranges, continuous (as opposed to step-wise) distribution of weights, negation of earlier chill by high temperatures, a limit to how much chill can be negated, enhancement of earlier chill by moderate temperatures and an assumed two-step process of chill accumulation.
The authors given in the table are not necessarily the model developers.

models that can be called ‘process-based’ (as opposed to purely empirical), even though the development of the model was based on hypothetical processes (Fishman et al., 1987a, 1987b), rather than on processes with a sound scientific basis.

In the context of climate change projections, it is concerning that different models produce different results. Luedeling et al. (2009d, 2010) analysed the response of four common chilling models to climate change projected for several sites in California. For warming projected by three general circulation models for the A2 greenhouse gas emissions scenario, losses projected by the Chilling Hours Model were up to 2.5 times, and by the Utah Model 1.5 times as severe as losses projected by the Dynamic and the Positive Utah Models, when expressed relative to a 1950 baseline. Choice of the model was thus the most important determinant of projection results, casting serious doubts on the suitability of at least some of the models for climate change projection. Even for historically observed winter chill, estimates with different models are not proportional. On average over six weather stations in California, Luedeling et al. (2009e) showed that over a period of 57 years, ratios between winter chill estimated with different models were strongly variable, ranging for example between 8 and 18 for the ratio of Chilling Hours to Chill Portions. Assuming that one of these models is ‘correct’, chilling estimates by a grower using the wrong model could thus be off by a factor of more than 2, in extreme years. Similar patterns were found for ratios between all four tested models. In the same context, the authors also explored the ratio between the same metrics for an environment, in which a constant temperature of 6 °C is maintained. Such treatments are occasionally used as artificial chilling treatment (Vergara and Pérez, 2010). The corresponding Chilling Hours to Chill Portions ratio was greater than 20 and thus outside the range of ratios observed in the field. Luedeling et al. (2009e) used these considerations to argue that chilling requirements determined under controlled constant temperature conditions are unlikely to be applicable to orchard conditions.

Variation in ratios between chilling metrics across the world is also substantial. Luedeling and Brown (2011) showed that the ratio of Chilling Hours to Chill Portions varied between 0 and 34, Utah Chill Units to Chill Portions between −155 and 25 and the ratio of Utah Chill Units to Chilling Hours between −10 and +5. While these are the extreme ends of the spectrum, ratios were substantially different between major growing regions, to a large degree responding to mean annual temperature. This temperature dependence confirms that models may react quite differently to warming. The heterogeneity of ratios between metrics also implies that at least most of the models are not fit for global use and do not describe the chilling process in a way that can be generally applied across time, space or climate. Luedeling and Brown’s (2011) global maps of chill metric ratios provide an opportunity to convert chilling requirements determined with one model to units of another model. Due to the different structures and different ranges of effective temperatures used in the different models, however, the extent to which such conversions are possible is limited, in particular in warm growing regions.

4. Performance of phenology models

Chilling models alone cannot explain bloom dates, but in some studies, they have been combined with forcing (heat) models to predict bloom and leafing phases. Applying statistically derived chilling and heat requirements sequentially, Luedeling et al. (2009e) tried to reconstruct bloom dates of walnuts in California, using 1297 observed phenological dates. For four different chilling models (Chilling Hours Model, Utah Model, Positive Utah Model and Dynamic Model), predicted dates were between 5.4 and 7.2 days off observed dates, with standard deviations of these errors between 5.2 and 6.2 days. Considering that the mean range of phenological dates within the dataset, across cultivars and growth stages, was only 32 days, with a standard deviation of 7.2 days, the accuracy of predictions was fairly low.

Chmielewski et al. (2011) compared the performance of 5 phenology models for reproducing apple blossom dates in Germany. The authors used data for about half of 5630 phenological stations in Germany, each of which had between 1 and

45 years of data, for calibrating their models. The remainder of the dataset was used for validation. The model that performed best was the approach by Chuine et al. (1998), in which most attention was paid to the forcing function, while chilling was dealt with by simply classifying days into chilling and non-chilling days. Root mean square errors according to this model ranged from 3.05 to 6.88 days across growing regions, with an average of 4.40 days. Again, these estimates must be evaluated in the context of overall variation in the dataset. The standard deviation of blossoming of the cultivar Boskoop in Esteburg seems to be on the order of 8.5 days, with overall range of bloom dates around 35 days (reconstructed from a figure in the paper). With bloom variation in this range, model accuracy thus cannot be considered very high. The authors rightly concede that error estimates were 'within a range which is usually acceptable for this kind of model' (Chmielewski et al., 2011), hinting at the difficulty of producing accurate phenology models.

Legave et al. (2008) tested the performance of a number of chilling/forcing model combinations for explaining apple bloom in France and Belgium, selecting three models for further analysis. After adjusting parameters for all models in an automated procedure based on phenology recordings from France, they validated models using 23 years of bloom data from Gembloux in Belgium. Root mean square errors estimated from absolute errors given in the paper ranged between 3.1 and 5.5 days. According to data extracted from a figure in the paper, the standard deviation of bloom dates in Angers, the station with the most complete record (annual observations between 1963 and 2006), was on the order of 8 days. Again, the model leaves a large part of the variation in the bloom dataset unexplained.

While the above-mentioned studies used relatively large datasets for validating models, shorter datasets have also been used. For example, Anderson et al. (1986) validated a sequential chilling/forcing model, in which an adjusted version of the Utah Model was used for chill accumulation, based on between 2 and 5 observed phenological dates for sour cherry in Utah and Michigan. Mean errors of predictions were only between 2.2 and 4 days, but the small sample size makes it difficult to evaluate the results. In this particular study, it is also not clear how the chilling and forcing requirements were determined, and whether or not the calibration dataset included those dates used for validation.

In summary, most studies that have evaluated the performance of combined chilling/forcing models have found that some model combinations are able to predict bloom dates to within a few days of actual bloom dates. However, since variation in observed bloom dates is not very large, all model combinations have left a large part of this variation unexplained. The occurrence of this situation even when models were calibrated with large observed datasets casts some doubts on the mathematical structure of the models and the assumptions underlying the different modelling approaches. All approaches published to date are almost entirely based on empirical observations rather than on thorough understanding of tree physiology. Some models still performed reasonably well in reproducing observed bloom patterns, but their suitability for climate change projections must be questioned. Empirical models are only valid for the range of conditions, from which observations were used to develop the models. Climate change scenarios are almost by definition not included within this range. This lack of calibration for future climates, combined with the substantial variation in historic bloom dates that all models leave unexplained, indicates that climate change projections of tree phenology should be interpreted with caution.

5. Chill model comparisons

A number of studies have evaluated the performance of commonly used horticultural chilling models (summarized in Table 2). Several authors have argued that the structure of the Dynamic Model, or its homogeneous rate of chill accumulation, make it the most plausible among the common models (Erez et al., 1990; Allan et al., 1995, 1997; Perez et al., 2008; Luedeling et al., 2009a, 2009c, 2009d, 2011a, 2011b; Darbyshire et al., 2011; Luedeling and Brown,

Table 2
Comparative evaluations of horticultural chilling models.

Location	Species	Models tested	Approach	Best model	Author
South Africa	Generic, case study for nectarines	UM, DM	Theory-based	DM	Erez et al. (1990)
Réunion Island and France	Peach	UM, DM	Controlled forcing trials	All models failed	Balandier et al. (1993a)
South Africa	Generic	CH, UM, PUM, DM	Theory-based	DM	Allan et al. (1995)
South Africa	Generic	UM, PUM, DM	Theory-based	PUM, DM	Allan et al. (1997)
South Africa	Eucalyptus	UM, PUM, DM	Multi-site field trials	DM	Gardner and Bertling (2005)
Spain	Apricot	<7 °C, UM, DM	Controlled forcing trials	UM, DM	Ruiz et al. (2007)
Chile	Generic	CH, UM, PUM, DM	Theory-based	DM	Perez et al. (2008)
Spain	Cherry	<7 °C, UM, DM	Controlled forcing trials	UM, DM	Alburquerque et al. (2008)
Germany	Generic	DM, UM, PUM, DM + several others	Theory-based	DM	Luedeling et al. (2009a)
California	Generic	CH, UM, PUM, DM	Theory-based	DM	Luedeling et al. (2009c)
California	Generic	CH, DM	Theory-based	DM	Luedeling et al. (2009d)
California	Walnut	CH, UM, PUM, DM	Statistical evaluation of phenology records	DM	Luedeling et al. (2009e)
Spain and Italy	Apricot	UM, DM	Controlled forcing trials	DM	Viti et al. (2010)
Australia	Generic	CH, MUM, PUM, DM	Theory-based	DM	Darbyshire et al. (2011)
Global	Generic	CH, UM, DM	Theory-based	DM	Luedeling and Brown, 2011
Global	Generic	CH, UM, DM	Theory-based	DM	Luedeling et al. (2011a)
Germany	Generic	CH, UM, DM	Theory-based	DM	Luedeling et al. (2011b)
Australia	Pistachio	CH, UM, DM	Controlled forcing trials; statistical correlations	DM	Zhang and Taylor (2011)
Spain and South Africa	Apricot	<7 °C, UM, DM	Controlled forcing trials	DM	Campoy et al. (2012)

CH = Chilling Hours Model (Bennett, 1949), UM = Utah Model (Richardson et al., 1974), MUM = Modified Utah Model (Linvill, 1990), PUM = Positive Utah Model (Linsley-Noakes and Allan, 1994), DM = Dynamic Model (Fishman et al., 1987a, 1987b).

2011). On several occasions, chilling model performance has also been tested in experiments.

Working on *Eucalyptus nitens*, Gardner and Bertling (2005) found that among three models tested (Utah Model, Positive Utah Model and Dynamic Model), the Dynamic Model was most successful in explaining the percentage of trees that had umbels, as well as the umbel score per tree (based on multiple regression analysis). These results were based on observations during a single season (2001) at 4 sites, with 5 trees per site.

Alburquerque et al. (2008) determined chilling requirements of seven cherry cultivars during two years at one location in Spain, by taking branches from dormant trees at various times during the winter, and exposing them to forcing temperatures. They found that the Utah Model and Dynamic Model produced equally consistent results, whereas the '<7 °C Model' (approximately equivalent to the Chilling Hours Model) performed poorly.

Ruiz et al. (2007) determined chilling requirements of apricots in Spain based on three years of experimentation. Branches were picked every 3–4 days during the dormancy season and exposed to forcing conditions. For the '<7 °C Model', the Utah Model and the Dynamic Model, chilling requirements were then compared. Mean coefficients of variation of chilling requirements over all ten tested cultivars were 26.4% for the '<7 °C Model', 7.2% for the Dynamic Model and 6.3% for the Utah Model. Even though the Utah Model provided the most consistent estimates, the authors concluded that the Dynamic and the Utah Model are equally suitable for calculating chill in this area.

Using a similar approach, Viti et al. (2010) compared the performance of the Utah and Dynamic Models in explaining budbreak of apricots under artificial forcing conditions in Murcia, Spain and Tuscany, Italy. Chill accumulation in the field was monitored using temperature loggers, and shoots were extracted at weekly intervals to be forced in a warm environment. The authors reported chilling requirements separately for each of two years and each of four cultivars, but they provided all necessary data for a cross-site evaluation. For individual cultivars, chilling requirements varied among site/year combinations with coefficients of variation of 8–14% for the Utah Model and 3–11% for the Dynamic Model, with the Dynamic Model providing a more precise estimate for all four cultivars.

Also with a similar methodology, Campoy et al. (2012) evaluated chilling requirements of twelve apricot cultivars in Murcia, Spain, based on 4 years of observation. For three of these cultivars, as well as for one not grown in Spain, 2 years of observations were also available from South Africa. Shoot samples were taken from trees at 3–4 day intervals and forced under controlled conditions. Based only on results from observations in Spain, chilling requirement estimates had coefficients of variation between 8% and 41% for the Utah Model, between 7% and 79% for the Chilling Hours Model, and between 5 and 12% for the Dynamic Model. In all cases, coefficients were lowest for the Dynamic Model. When adding observations from South Africa, two of the cultivars confirmed this impression, with coefficients of variation of chilling requirement estimates of 14% and 38% for the Utah Model, 19% and 43% for the Chilling Hours Model and 11% and 10% for the Dynamic Model. Only for the cultivar 'Palsteyn', the Chilling Hours Model had the lowest coefficient of variation at 14%, compared to 21% for the Dynamic Model and 42% for the Utah Model. The overall impression from this study is that for all cultivars except one (and then only when combining observations from both sites), the Dynamic Model provided the most precise estimate of the cultivars' chilling requirements.

Zhang and Taylor (2011) determined the date of fulfillment of the chilling requirement in 'Sirora' pistachios in New South Wales, Australia. They exposed branches taken from orchards at weekly intervals to forcing temperatures in a greenhouse. When 50% of buds broke on branches taken during three consecutive weeks, the chilling requirement was considered fulfilled. Over five years of experimentation, chilling requirements estimated by the Dynamic Model showed a coefficient of variation of only 3%, compared to 15% for the Utah Model and 18% for the Chilling Hours Model. Comparison of evenness of budbreak over 7 years of observation with accumulated chill totals also produced conclusive results.

Luedeling et al. (2009e) statistically evaluated a dataset of 1297 phenological dates for seven developmental stages of four walnut cultivars at eight locations in California. Their analysis was based on the assumptions that chilling and heat requirements are fulfilled in sequence, that heat accumulation can be described according to Anderson et al. (1986), and that heat and chilling requirements do not vary across sites and years. Under these assumptions, the Dynamic Model was most successful at explaining observed phenological dates, closely followed by the Positive Utah Model. The Utah Model and the Chilling Hours Model were much less suitable for explaining observed variation in phenological dates.

All models failed in trying to explain chilling accumulation for peach production at three different altitudes on the island of Réunion and at Clermont-Ferrand, France (Balandier et al., 1993a). This highlights that the commonly used chilling models cannot explain budbreak across the full climatic range, in which peaches can be grown. In addition to pointing out potential shortcomings in the models, this study makes it seem likely that climatic conditions during dormancy induction or other stages of the growth cycle affect chilling requirements (Balandier et al., 1993b). Rea and Eccel (2006) showed that several existing chilling models did not explain apple bloom along an elevation gradient in Northern Italy, leading them to propose a new model for this region based on the Utah Model. Unfortunately, the Dynamic Model was not among those tested in this study.

In spite of a lack of standardization among the model comparison studies (Dennis, 2003), it can be concluded that the majority of studies have found the Dynamic Model to be relatively accurate in different climates, in particular in comparison with the most commonly used Chilling Hours approach. However, all of the models still leave a lot to be desired in terms of accuracy, and some dormancy-breaking behaviour at warm sites could not be explained at all. While studies on marginal production sites are scarce, evaluation of common modelling approaches for production at such sites could yield important insights into the empirical relationship between temperature and chill accumulation. For example, temperate fruits and nuts are grown under marginal conditions in the highlands of Oman (Gebauer et al., 2009), Kenya (Griesbach, 2007) and Ethiopia (Ashebir et al., 2010), in Northwest Vietnam (Newman et al., 2008), Thailand (Nissen et al., 2006) and many other locations throughout the Subtropics and even in the Tropics. At some sites, temperate fruits are even grown without winter chill, with dormancy induced artificially by manual or chemical defoliation (Edwards, 1987). Observations at these marginal production sites could contribute greatly to the development of new chilling models that more accurately represent the response of dormant trees across the full range of possible habitats of temperate tree crops.

6. Climate change impacts on winter chill

A number of authors have analysed historic changes in winter chill based on temperature records, or projected future chilling losses for climate change scenarios for several important growing regions, using a wide range of methods to quantify winter chill (summarized in Table 3). In light of the above discussions, not all of these projections are equally credible.

Sunley et al. (2006) evaluated winter chill changes across several locations in the United Kingdom between 1950 and 2002, using the Chilling Hours Model, the <7.2 °C Model, the Utah Model and the so-called 'Lantin' model. They compared winter chill of the

Table 3
Evaluations of past and projected future changes in chill availability.

Region	Chilling model	Time frame/climate	Principal finding	Authors
United Kingdom	<7.2 °C, CH, UM, Lantin	1950–2002	Moderate historic chill losses for most models; slight increases according to the Utah Model	Sunley et al. (2006)
United Kingdom	No model	Future	Fruit production in UK at risk from chill losses	Else and Atkinson (2010)
Southern Brazil	CH	Historic climate +1 °C, +3 °C, +5.8 °C	Severe chill decline; for higher warming scenarios, very few areas remain viable	Wrege et al. (2010)
Western Cape (South Africa)	PUM	1967–2007 + 0.5, 1.0 and 1.5 °C warming	Mean chill losses by 26% during historic record; future losses projected at 10–30% for cool sites, 10–60% for warm locations	Midgley and Lötze (2011)
Mountain Oases in Oman	CH	1983–2008 +1 °C and +2 °C (WG)	Chill conditions marginal for most fruits; under warming scenarios most fruits no longer viable	Luedeling et al. (2009b)
Mountain Oases in Oman	DM	1983–2008 +1 °C and +2 °C (WG)	Severe chill losses, but much less pronounced than in the above study; production will probably remain possible	This article
Germany	CH, DM	1876–2009	High variation in annual chill, but no significant trends over time	Luedeling et al. (2009a)
Meckenheim, Germany	CH, UM, DM	1958–2011	Slight decrease over time for the CH (around −3 CH/year), no changes for UM and DM	Luedeling et al. (2011b)
California	CH	1950–2100	Severe historic and projected losses; production of most tree crops at risk	Baldocchi and Wong (2008)
California	CH, DM	1950, 2000, 2050, 2090 (WG)	Substantial losses historically and particularly for future scenarios; losses much more severe for CH than for DM	Luedeling et al. (2009c)
Australia	MUM	Historic climate +1 °C, +2 °C, +3 °C, + regionalized CM outputs	Severe losses projected for warm production sites; moderate losses for cooler sites; adaptation measures are recommended	Hennessy and Clayton-Greene (1995)
Australia	CH, MUM, PUM, DM	1911–2009	Historic chill decline at almost all sites, for all models; slight gains for MUM and PUM at two sites, DM at one site; big variation among models	Darbyshire et al. (2011)
Australia	CH, MUM, PUM, DM	1911–2009 + warming caused by 1, 2 and 3 °C global temperature increase	Chill losses projected for all sites, in particular warm locations; substantial variation across sites; DM typically indicated smallest change	Darbyshire et al. (in press)
Egypt	0–10 °C	1969/70, 1989/90, 2008/09 +CM outputs	Some historic losses, but no trend analysis possible; substantial losses projected for future scenarios	Farag et al. (2010)
Global	DM	1975, 2000, 2050, 2090 (WG)	Severe losses in warm growing regions (historically and projected); little change in temperature regions; chill gains in cold regions	Luedeling et al. (2011a)

CH = Chilling Hours Model (Bennett, 1949); UM = Utah Model (Richardson et al., 1974); PUM = Positive Utah Chill Units Model (Linsley-Noakes and Allan, 1994); DM = Dynamic Model (Fishman et al., 1987a, 1987b); Modified Utah Model (Linvill, 1990); WG = weather generator used for making climate scenarios; CM = climate model.

decade 1969–1979 with chilling of 1987–1997, finding changes between −5.7 and −12.2% for the <7.2 °C model, between +2.3 and −10.9% for the Chilling Hours Model and between −1.6 and −4.8% for the Lantin Model. The Utah Model behaved differently, with change estimates ranging between −0.9% and +5.1%. Also working on the United Kingdom, Else and Atkinson (2010) predicted chill losses that might jeopardize the ability of fruit trees to satisfactorily break dormancy. They offer no quantitative projections and appear to base their conclusions on the assumption that temperatures between 3 and 7 °C are effective for chilling accumulation. Considering that other studies project no or only small changes in winter chill in cool temperate climates (Luedeling et al., 2011a), more work, including model comparison studies, is needed on projecting future occurrence of chill in this region.

Wrege et al. (2010) calculated winter chill changes in Southern Brazil using the Chilling Hours Model. Based on weather station records, they expressed minimum temperature as a function of latitude, longitude and elevation. The number of Chilling Hours (CH) was then expressed as a function of minimum temperature, and mapped for the states of Paraná, Santa Catarina, and Rio Grande do Sul. In addition to current climate, the authors added warming scenarios of +1, +3 and +5.8 °C. In these scenarios, the respective temperature increments were added to all daily minimum temperatures. Projections indicated that the proportion of the study area that received more than 300 CH will decline from 70.1% (current), to 61% under the +1 °C scenario and to 4.3% under the +3 °C scenario. Assuming a 5.8 °C warming, no place within the study area was expected to receive more than 300 CH, and only 4.4% received more than 50 CH.

Midgley and Lötze (2011) analysed winter chill trends in the Western Cape region of South Africa using the Daily Positive Utah Chill Units Model (Linsley-Noakes and Allan, 1994), based on daily temperature records from 12 weather stations taken between 1967 and 2007. Chill Units (CU) were read from a conversion table, which assumes that hourly temperatures follow a sine curve during the day and a logarithmic decay function at night (Linvill, 1990). On average, they found a chill decline by 224 CU for all stations between May and September. Relative to 40-years means, these losses corresponded to 26% on average, with losses as high as 36–47% for individual stations. In the coolest growing regions, trends were not significant, but strong reductions in May, at the beginning of the dormancy season, were observed even there. For uniform warming scenarios (same warming applied to all temperature readings) of 0.5, 1.0, 1.5 and 2.0 °C, the authors projected pronounced chill losses for all stations, with seasonal losses ranging between 10% and 30% for cool sites, across all four scenarios, and between 10% and 60% for warm sites. The highest relative losses were projected for warm sites and warm months. Midgley and Lötze (2011) report that growers are already transitioning to lower chill crops, such as grapes. They expect this trend to continue and the use of rest-breaking chemicals to increase in importance.

Luedeling et al. (2009b) evaluated the current and future potential of high-mountain oases in Oman to produce temperate fruit and nut crops. Such tree crops are only grown in very few settlements in Oman (Gebauer et al., 2007), because the hot desert climate in the rest of the country only allows production of subtropical and tropical species (Nagieb et al., 2004). Because of their particular climatic setting, the mountain oases of Al Jabal al Akhdar have expanded their fruit and nut production in recent decades (Luedeling and Buerkert, 2008a). Using long-term daily temperature data calibrated with a shorter record of hourly measurements, Luedeling et al. (2009b) analysed the number of Chilling Hours that were historically available in these oases, as well as Chilling Hours for two future climate scenarios, in which all temperatures were increased by 1 and 2 °C, respectively. They compared results to minimum chilling requirements for important species from the literature. Results indicated that in the current scenario, winter chill was only rarely sufficient to sustain walnuts and apricots. In the +1 °C scenario, chilling requirements of peach were only rarely fulfilled, and in the +2 °C scenario, even pomegranate, the most widely cultivated tree crop, appeared unable to receive enough chilling in most winters. Because oasis agriculture is only possible where natural water sources are available (Luedeling and Buerkert, 2008b), and there are no locations at higher altitude where this is the case, the prospect for the production of temperate fruits in Oman's mountain oases was projected to be bleak. However, as shown in the above discussion, use of the Chilling Hours Model is not recommendable in such a hot climate. Recalculating winter chill according to the Dynamic Model produces quite different results. This model reduced projected losses in mean annual winter chill from 43% to 26% for the +1 °C scenario, and from 71 to 50% for the +2 °C scenario. Rather than with 80 Chilling Hours, the warmest scenario left farmers with 25 Chill Portions, which may be enough to sustain at least some of the currently grown species. This case study illustrates the importance of using appropriate models in projecting winter chill.

Historic changes in winter chill have been analysed for 43 weather stations in Germany and interpolated for the whole country (Luedeling et al., 2009a). This analysis relied on idealized daily temperature curves constructed from daily minimum and maximum temperatures. Chill changes were quantified in Chilling Hours and in Chill Portions, for records going back to the 1870s. While according to both models mean winter chill over all stations varied substantially over the years, neither model detected a significant trend. The number of Chilling Hours declined by 0.06 per year (r^2 = 0.00) and the number of Chill Portions by 0.04 per year (r^2 = 0.03). The lack of significance in these trends, in spite of a warming trend, probably stems from the structure of the chilling models, which do not count frost hours as effective for chilling. Given typical winter temperatures in Germany, warming may just as well lead to more chilling (if frost hours become non-freezing) as to less chilling (if cool hours become too warm to be effective). Apparently, these two processes have historically cancelled each other out in Germany.

Similar findings were reported by Luedeling et al. (2011b) for the Meckenheim fruit growing region in Germany. These authors used hourly temperature records to establish correlations between hourly and long-term daily records. Based on these relationships, long-term hourly temperature records since 1958 were reconstructed. Again, there was no significant trend in chilling over time, but the authors reported a correlation between mean winter temperature and the amount of chilling that accumulated. According to the Dynamic and Utah Models, maximum chill accumulated when mean temperatures (for the whole winter and for 15-day intervals during the winter) were around 6–7 °C. At colder and warmer temperatures, less chill was accumulated. For the Chilling Hours Model, the most effective temperature was around 2–3 °C, substantially lower than for the other models. The authors concluded that warming from a cold baseline may lead to increases in winter chill, whereas warming from a fairly warm baseline should lead to decreases.

Production in California, one of the world's most productive growing regions, in particular for nut crops, may also be threatened by winter chill losses (Baldocchi and Wong, 2008). Using the Chilling Hours Model, Baldocchi and Wong (2008) projected chill losses for weather stations within the state for future scenarios, and they detected historic declines for the majority of stations they analysed. They found historic losses between 50 and 260 Chilling Hours per decade, and projected further losses in the future at a rate of around 40 Chilling Hours per decade. Their projections indicate that by the end of the 21st century, orchards in California will experience less than 500 Chilling Hours, making the state marginal or unsuitable for many currently grown species and cultivars.

Also for California but using a different methodology, Luedeling et al. (2009c) projected future changes in winter chill. They used long-term daily weather records from weather stations all over California to calibrate a stochastic weather generator. This generator was then used to produce 100 replicates of daily weather records for a number of scenarios, representing typical climatic conditions around 1950, 2000, 2050 and 2090. For future scenarios, three General Circulation Models and two greenhouse gas emissions scenarios were considered. Using statistical relationships between measured hourly and daily temperature values, daily data were then converted to hourly data and winter chill was quantified according to the Chilling Hours and Dynamic Models. Based on the resulting distribution of winter chill estimates over 100 years of synthetic weather data, the authors defined a 'Safe Winter Chill' value as the 10% quantile of the distribution. This value is the amount of winter chill that is exceeded in 90% of all years, representing the assumed maximum chilling requirements of trees that can be produced with reasonable economic success. Luedeling et al. (2009c) detected changes in historic Safe Winter Chill by 2000 of up to −30%, compared to the 1950s baseline, according to the Chilling Hours Model. For future scenarios, losses were estimated at 30–60% by the middle of the 21st century, and up to 80% by the end of the century. Using Chill Portions, losses were much lower, at a maximum of 30–60% by the end of the 21st century. Both models agreed that Safe Winter Chill is likely to decline. However, losses according to the Chilling Hours Model painted a much bleaker picture for California's fruit producers than the Dynamic Model.

A few studies have focused on winter chill in Australia. Hennessy and Clayton-Greene (1995) provided the first estimate of climate change impacts, including an analysis of the sensitivity of fruit growing locations to three warming scenarios (+1, +2 and +3 °C, applied to all temperature readings), and an application of regionalized climate model outputs for 2030 to historic temperature records. The authors used the Modified Utah Model (Linvill, 1990) for quantifying chill. They found that warm sites, and sites with wide diurnal temperature ranges, were more strongly affected by chilling decline than cooler sites with more homogenous temperature profiles. For climate change scenarios, Hennessy and Clayton-Greene expected chilling declines for all sites, and for the stronger warming scenarios, they anticipated that these losses should impact production. They recommended that growers should explore ways to artificially break dormancy and consider introducing lower-chill cultivars into Southern Australia.

Darbyshire et al. (2011) evaluated historic winter chill trends at 13 locations in Australia, using four common chilling models, the Chilling Hours Model, the Modified Utah Model, the Positive Utah Model and the Dynamic Model. They used idealized daily temperature curves to produce from daily temperature records the hourly data that is required for using common chilling models. A striking result of this study was that the ranking of the 13 stations differed substantially, depending on which model was used. For the extreme case of Lenswood, South Australia, the Chilling Hours Model ranked 4th among the stations analysed, while the other models placed this site between ranks 9 and 11. This result shows that models differ substantially and that not all model can be accurate. Darbyshire et al. (2011) report a declining winter chill trend in response to warming at most sites, most notably at the warmest locations, according to all chill models. The only exceptions were the two versions of the Utah Model, which showed increasing chill for two sites. The Dynamic Model also indicated a slight increase for the coldest location (winter temperature 3.8–6.2 °C). Overall, the study indicated chill declines for almost all weather stations, which varied strongly according to which chilling model was chosen.

Darbyshire et al. (in press) also evaluated likely effects of future warming on chill accumulation. Using the Chilling Hours Model, the Modified Utah Model and the Dynamic Model, they quantified expected chill losses for three warming scenarios, in which global temperatures were raised by 1, 2 and 3 °C. These global temperature increases were translated into localized warming at 13 sites across Southern Australia, using a collection of 21 General Circulation Models. Out of this population, six models were strategically selected to bracket the range of temperature changes that must be expected. Historic daily temperature records, extracted from a gridded Australia-wide dataset (for 1911–2009), were then modified by adding localized temperature changes expected for the respective climate change scenarios. Linvill (1990)'s equations were used to translate daily temperature records into hourly values, and winter chill was summarized for all 99 winter seasons included in the records. Following Luedeling et al. (2009c), results were expressed as Safe Winter Chill, the 10% quantile of the distribution across all years of the weather records. Chilling estimates for the various climate scenarios with the three models varied widely. For the +3 °C scenario, chill changes across all 13 locations ranged from −20 to −84% according to the Chilling Hours Model and from −3 to −99% for the Modified Utah Model. The Dynamic Model projected losses between −7 and −77%. Chill losses were consistently projected for all locations, with in particular the warmer sites experiencing severe chill decline.

Farag et al. (2010) calculated historic and projected future changes in winter chill for Egypt. While claiming to use the Chilling Hours Model of Weinberger (Bennett, 1949), they used a chilling model, in which temperatures between 0 and 10 °C were considered equally effective for chilling, while temperatures outside of this range were considered ineffective. Using historic hourly temperature records for 14 weather stations, the authors calculated historic chill accumulation in 1969/70, 1989/90 and 2008/09. Three future climate scenarios for the 2050s were generated by raising the means of temperatures for these three past winter seasons by mean annual temperature changes according to three GCMs. Interpretation of the results is difficult because the description of the methodology is somewhat incomplete, and because the authors arbitrarily selected three past winters from the historic record, which may or may not be representative of long-term trends in temperature and winter chill. The data presented is thus not sufficient for analysis of historic trends, but mean winter chill over all stations was lower by 4% in 1989/90 and by 11% in 2008/09, compared to the 1969/70 baseline. For 2050s scenarios, losses were estimated at between 28 and 42%, compared to the baseline.

A global analysis of historic and projected future changes in winter chill has been provided by Luedeling et al. (2011a). Based on more than 4000 weather stations around the world, the authors used a weather generator calibrated with daily weather station data to produce daily weather data for 18 climate scenarios, for 1975, 2000, as well as scenarios for the middle and the end of the 21st century. For future projections, three General Circulation Models and two Greenhouse Gas Emissions scenarios were considered. For each scenario, 100 replicate years of daily weather data were produced and transformed into hourly temperature records using idealized daily temperature curves. In this study, only estimates produced by the Dynamic Model are reported. This circumstance was justified by the higher credibility of projections with the Dynamic Model, in particular across climate gradients, than with all other major models. Projections indicated major chilling losses in all warm growing regions of temperate fruits, both in the past and in the future. In particular the warmest growing regions, in North Africa, South Africa, the Southern United States, Northern Mexico, Southern China and Southern Australia are projected to suffer substantial losses in winter chill during the 21st century. Cold growing regions, in contrast, may experience little change, or even increases in winter chill, as increasing numbers of days become frost-free.

While the studies listed above used different metrics to quantify chill changes and worked in different regions, some general conclusions can be drawn. For most fruit growing regions analysed, winter chill is expected to decline. The only exception among the published case studies is Germany, where little change has occurred in the past. Only the global analysis by Luedeling et al. (2011a) indicated that cold growing regions may experience increases in winter chill. This is likely due to a geographic bias among published case studies, which have focused on growing regions where chilling is considered an important factor in orchard management. This is the case predominantly in warm growing regions, while growers in colder locations have traditionally paid little attention to winter chill. From the array of case studies, it clearly emerges that the Chilling Hours Model consistently detected the strongest changes in winter chill, while in particular the Dynamic Model was more moderate in the amount of change it projected. In light of the studies that have shown the Dynamic Model to be more accurate, in particular in warm climates (see Section 5), the latter, more moderate estimates are more likely to be accurate.

7. Adaptation strategies

The need to anticipate and adapt to climatic changes is much more urgent for growers of tree crops than for farmers engaging in annual crop production. Annual farmers can change their crop species or varieties from one season to the next, or they can plant their crops earlier or later if they sense changes in the duration of the growing season. In contrast, once orchard managers have selected and planted their tree cultivars, they require these trees to remain in production for decades. Orchard establishment is expensive, especially when low fruit or nut yields during the first few years are considered. Short-term adjustments in tree cultivars are thus very costly and would be a severe economic blow to many growers. Growers must therefore pay very close attention to growing the right trees in the right places, or they must be equipped with an arsenal of management tools to overcome slight climatic mismatches of cultivar and climate.

7.1. Better metrics

Strategies that have been used to expand the range of temperate fruit species offer potential applications in adapting production to climate change. The first strategy worth mentioning in this respect is careful selection of cultivars that are adapted to the particular climate conditions of a production site. In a slight modification of traditional practice, however, this adaptation should now consider future projected agroclimate, rather than historically observed conditions. This of course requires accurate concepts of the climatic requirements of tree crops. While this is equally true for heat requirements, this review is only concerned with chilling. As outlined above, substantial work is still needed to produce and widely introduce accurate chill metrics. Where growers use inaccurate metrics, species and cultivar selections may be poorly informed. For example, assuming that the Dynamic Model is the appropriate choice of model, the notion that one Chilling Hour indicates exactly the same amount of chill everywhere could be a problem. When using inadequate chill metrics for selecting new cultivars for a particular growing region, growers might import trees that turn out to be very poorly adapted, even though – according to the chosen chill metric – chilling requirements should be similar to those of traditional cultivars in the region. A lot of experimentation is still needed to come to a consensus of which approach to modelling winter chill is appropriate. Until this experimental gap is closed, it appears that the Dynamic Model is preferable among the existing approaches, and it would be advantageous to determine chilling requirements in Chill Portions for many more cultivars than have been characterized to date. Where long-term bloom records and matching temperature records are available, statistical methods can help determine the chilling requirements of tree cultivars (Luedeling et al., 2009e; Yu et al., 2010; Luedeling and Gassner, 2012).

7.2. Low-chill cultivars

Breeding for low chilling requirements has also been successful in the past. The array of cultivars that is available for many species spans a wide range of climatic requirements. For example, Guerriero et al. (2010) evaluated bloom dates of 229 apricot varieties, grown in a germplasm collection in Venturina, Italy, during the warm winter of 2006/07. They found that many genotypes from northern climates did not flower at all in that year, whereas cultivars from Southern Italy flowered more profusely than in normal years. Such trials can certainly identify valuable genetic resources for further breeding. In pursuing this strategy, it must be considered that breeding for new tree cultivars can take a long time. Modern breeding techniques, as well as advances in mapping the genetic determinism of chilling are required to speed up the breeding process, so that appropriate cultivars can be developed for all major fruits within a reasonable time frame. Due to past efforts to expand cultivation to warmer regions, low-chill cultivars are already available for several species (e.g. Lesley and Winslow, 1952; Sharpe, 1961; Scorza and Miramendy, 1981; Stino et al., 1982; Griesbach, 2007).

7.3. Dormancy avoidance

In tropical climates without pronounced seasonality, it is possible to artificially induce tree dormancy by defoliating trees after harvest (Edwards, 1987; Griesbach, 2007). If this is practiced, trees appear to be able to resume their annual cycle without requiring chill. This type of management has enabled the production of temperate fruits in places like India and Kenya, but it cannot be recommended at colder sites with pronounced seasonal cycles. However, research into effects of certain management practices, such as defoliation, during the dormancy induction period should be explored. Research has shown a quantitative effect of temperature treatments during this period on the depth of dormancy (Westergaard and Eriksen, 1997; Heide and Prestrud, 2005; Tanino et al., 2010), and it may be possible to exploit such effects for practical orchard management.

7.4. Microclimate manipulation

Microclimate manipulation can also affect chill accumulation. Campoy et al. (2010) showed that shading during endodormancy can slightly advance bloom dates of apricots in Spain. Targeted irrigation can also influence microclimates. Overhead irrigation has successfully been applied in Israel for cooling buds during the hottest hours of the day (Erez, 1995).

7.5. Chemical rest-breaking

A number of chemicals have been found to promote budbreak. Many of these compounds can be phytotoxic, when applied at the wrong time, but some have been very successful in breaking dormancy, even when chilling requirements were not fulfilled (Erez et al., 2008). For example, application of hydrogen cyanamide spray has been effective in promoting bloom in Ethiopia (Ashebir et al., 2010), Israel (Erez et al., 2008), Tunisia (Chabchoub et al., 2010) and the Southern United States (Dozier et al., 1990). The same compound also proved effective in Italy (de Salvador and di Tommaso, 2003). However, hydrogen cyanamide has also been shown to be phytotoxic and to cause strong yield reductions (George et al., 1992; Siller-Cepeda et al., 1992), and due to health hazards it has already been banned in several countries. Alternative chemicals, such as plant growth regulators containing thidiazuron (Campoy et al., 2010) or certain nitrogen compounds (de Salvador and di Tommaso, 2003), have also proven effective, and human toxicity has not been reported. Rest-breaking chemicals are widely used for compensating for insufficient budbreak and for promotion of homogeneous fruit set.

8. Adaptation in the absence of thorough understanding

In spite of over 200 years of scientific interest in tree dormancy (at least since Knight, 1801), the process itself as well as the environmental factors that induce and break dormancy are not completely understood (Campoy et al., 2011b). Major knowledge gaps concern the genetics of chilling requirements (in spite of recent advances, e.g. by Celton et al., 2011; Leida et al., 2012), the timing of bud responsiveness to chilling (Campoy et al., 2011a), the effects of dormancy induction conditions on chilling requirements (Heide and Prestrud, 2005) and possible interactions between chilling and forcing during the dormancy season (Harrington et al., 2010). Due to these knowledge gaps, none of the common chilling models can strictly be called process-based; all are merely empirical. As long as models are developed without a thorough understanding of the underlying processes, we should not be surprised if they turn out to be inaccurate. Moreover, with purely empirical models, extrapolating beyond the climatic ranges that models were developed in is quite risky, and the validity of locally calibrated chilling models for climate change adaptation planning is questionable.

Given the width of prevalent knowledge gaps, it seems unlikely that a thorough understanding of which tree cultivars will be best adapted in the future will emerge soon. It should also be considered that in addition to chilling, knowledge about climate responses during several other phases of the growing cycle needs to be available in order to project yields with relative certainty (Hänninen and Tanino, 2011). Also in light of the relatively scarce resources being invested in adapting tree crops to climate change (at least compared to cereals), growers certainly cannot wait for science to produce models that will be sufficient for adaptation planning. Particularly in marginal growing regions, trees planted today will experience changes in climate that may render their production unprofitable.

An elegant way around the need for exhaustive knowledge is climate analogue analysis, a novel approach to adaptation planning (Ramirez-Villegas et al., 2011). The premise of this strategy is that most climatic settings that are projected for a given location can already be found at present, though in a different location. For example, the climate projected for a particular target growing region for 2050 (according to a given climate model and greenhouse gas emissions scenario) can currently be found at a different location. These analogue locations can inform adaptation planning at the target growing region. Tree cultivars that are grown successfully at the analogue location may be candidates for planting in the target region today, and new cultivars slated for introduction into the target region should possibly be tested at the analogue site rather than the target site, to ensure that they are viable in a warmer climate. Lastly, observations of tree phenology and productivity across target and a suite of analogue sites (for different climate models and greenhouse gas emissions scenarios) can help develop models that actually are suitable for climate change projections. Such empirical models would be valid for the range of climates that can plausibly be expected at the target site. Geospatial procedures for identifying analogue locations exist (Luedeling and Neufeldt, in press), but to my knowledge they have not been applied for planning the adaptation of tree crop systems to climate change. In the face of the substantial knowledge gaps in tree physiology, climate analogues may be a useful strategy for ensuring productive orchards in the future.

9. Concluding remarks

Temperate orchards are in urgent need of climate change adaptation strategies because of the high investments incurred in orchard development and the long productive life span of trees. Yet scientific understanding of the complex processes involved in tree physiology lags far behind knowledge about processes in annual crops. While winter chill has been studied more than many other weather-dependent processes, all existing modelling approaches are purely empirical, and there is little reason to believe that their mathematical equations are related in a biologically meaningful way to tree physiology. Yet even within the array of existing models, accuracy differs substantially, as indicated by the model comparison studies mentioned above (Section 5). The Dynamic Model currently seems to be the frontrunner in terms of accuracy, but it seems like a far greater number of growers use the Chilling Hours approach to chilling quantification. The latter is easy to understand and intuitive, while explaining the Dynamic Model to practitioners (or anyone else) is quite a challenge. Nevertheless, temperate fruit and nut industries should attempt to make the transition, in particular in marginal growing regions. Time series analyses and projections have shown dramatic losses in the number of Chilling Hours for California, Australia, South Africa and most warm growing regions. The extent of these projected losses, in combination with assumed chilling requirements of tree cultivars, makes the future look very bleak for many growers, and adaptation seems barely possible. The Dynamic Model typically also projects problems, but not nearly the catastrophic losses indicated by the Chilling Hours approach. Finding suitable tree species and cultivars looks much more possible.

The considerable number of studies that have shown the Chilling Hours Model to be inferior to the other approaches, especially when considering different climatic settings, provides a strong indication that the Chilling Hours Model should not be used for climate change projections. Moreover, its usefulness for comparing chilling requirements across growing regions appears very limited, and even for practical orchard management under stationary climatic conditions, other models have consistently proven more accurate. It may thus be time for tree crop industries to transition to the more accurate models. This is particularly important for avoiding misleading projections about the impacts of climate change, which growers are likely to increasingly consider in the future due to the long planning horizons involved in orchard operations. The Dynamic Model seems like the best bet for all growing regions at the moment.

Currently, locating adapted germplasm is hindered by the lack of estimates of chilling requirements in accurate units. As shown in particular by Luedeling and Brown (2011), Chilling Hour estimates, which are available for many cultivars, cannot easily be transferred to a new location other than where requirements were determined. Standardization is needed in order to facilitate effective deployment of appropriate cultivars to places that will need these trees in the future, and the Dynamic Model seems like a good approach for producing such standardized estimates. A global effort is needed to determine chilling requirements of cultivars and assemble a comprehensive database of these. Such a database should contain climatic requirements as well as information on where and how these were determined. It would also be desirable to collect multi-locational datasets on the breaking of dormancy and tree phenology, coupled with detailed weather records. If such records were available for a wide range of climates, statistical means (e.g. Luedeling and Gassner, 2012) could be applied for expanding our understanding of the temperature responses of trees during the dormancy phase. Such a compilation will be particularly valuable if it includes records of other environmental factors that may influence dormancy and if it expands into marginal production sites where common modelling approaches often fail.

Overall, a lot more research is needed into what exactly drives the progression of trees through the dormancy phase, what physiological processes and genetic mechanisms underlie this progression, and how these processes can be manipulated. In the (probably long) meantime, until knowledge gaps are filled, more work is needed on manipulating orchard climates and the breaking of individual buds. Another approach that can be effective in the absence of good scientific understanding is climate analogue analysis. For complex agricultural systems, searching for future climates among present-day locations and extracting adaptation lessons from such sites, may be the most promising strategy for ensuring that production remains viable in a climatically changing future.

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Using non-parametric regression to model dormancy requirements in almonds

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ABSTRACT

Bud dormancy, by which buds must experience a certain amount of chill and heat before blooming or leafing out, affects orchard management, cultivar planting choices and will be an important component to the effects of climate change on tree crops. Previous work has found there to be a partially compensatory relationship between chill and heat requirements in bud dormancy, as opposed to the common conception of one numeric combination of chill and heat alone resulting in bud-break. To date this relationship has not been satisfactorily modeled for horticultural crops in a Mediterranean climate. This work aims to address one of the first questions in defining this relationship – when do chill and heat accumulation start. Previous models have assumed start dates based on historic conditions or fitted these dates as model parameters. We have instead worked with a number of non-parametric approaches not previously utilized. This study used bloom timing data for *Prunus dulcis* 'Nonpareil' from three locations spanning the Central Valley of California over ten years (1996-2005). We first used a fitted spline to help identify the most promising start dates of chill and heat accumulation. Then, we used LOESS to fit polynomial regression functions based on local neighborhoods of data points. Using the Dynamic Model for chill accumulation starting in October and the ASYMCUR GDH heat accumulation model starting in January, bloom timing was well modeled in ninety percent of the site-years. These dates differ from many found in the literature, suggesting pomologists and growers may be mis-calculating when dormancy requirements have been met. Our results further support the theoretical model of a partially compensatory relationship between chill and heat towards stimulating bud-break.

INTRODUCTION

For the last several decades there has been growing concern that emissions from human activities are changing the climate of the planet. In 2007, the Intergovernmental Panel on Climate Change released their Fourth Assessment Report, stating "Warming of the climate system is unequivocal" (IPCC, 2007). Global Circulation Models project that the earth's climate will continue to change as human activity continues to emit greenhouse gases. Agricultural production, including management practices, the location of crop cultivation and cultivar selection, has been based on experiences of past climates. To ensure economically viable agricultural production in the future, research is necessary to anticipate how production practices will need to change to match projected conditions.

One of the primary concerns of temperate tree crop production as global temperatures rise is the meeting of dormancy requirements. Dormancy, as defined by Lang et al. (1987), is "a temporary suspension of visible growth of any plant structure containing a meristem." The flower and leaf buds of temperate tree crops enter endodormancy in the fall and require exposure to winter chill, specific to species and cultivar, to exit this state (Westwood, 1993). As global temperatures rise, many areas will experience warmer winters (Luedeling et al., 2011). According to the most extreme emissions scenario California can expect tree-perceived cold to decrease from historic averages by approximately half by the end of the century (Luedeling et al., 2009a).

In addition to meeting requirements for exposure to winter chill, a threshold amount of heat accumulation is also required for plants to begin active growth (Cannell, 1989). Across a number of species, there appears to be an inverse relationship between the amount of chill the buds of a tree experience and the amount of heat necessary to flower or leaf-out (Cannell, 1989; Sparks 1993). Following high chill accumulation, less exposure to heat is required for bud-break. More pertinent to climate change concerns, following low accumulation of chill, high accumulation of heat can lead to flowering and leaf out (Figure 1). Thus, projecting effects of climate change based on changes in chill alone may not be sufficient. However, this chill-heat relationship has not yet been defined for temperate tree crops in a Mediterranean climate.

One of the first steps in defining this relationship is to determine when to start counting chill and heat accumulation. In previous models, the start dates have either been assumed or fitted as a parameter (Hanninen, 1990, Legave et al., 2008). Assuming accumulation start dates based on historic conditions is problematic for climate change work. Changing conditions are likely to affect the timing of dormancy induction in the fall and the conditions that bring about sensitivity to heat accumulation. Fitting these start dates as parameters is also problematic. Chill and heat accumulation are not independent, and particularly given the small datasets often used to develop most phenology models, over-fitting of these parameters may lead to spurious results. This work aims to take a new approach, to answer the "when to start counting" question using non-parametric regression.

MATERIALS AND METHODS

The bloom data used in this work comes from the University of California's almond breeding program's Regional Almond Variety Trials. Bloom date for *Prunus dulcis* 'Nonpareil' was collected for ten years (1996-2005) in three locations that span the growing regions of the Central Valley of California: near Chico, Modesto and Shafter, CA. The date of 50% bloom was used to represent full bloom, hereafter referred to simply as "bloom." Temperature data was drawn from the California Irrigation Management and Information System (www.cimis.water.ca.gov), a network of over 120 state-run weather stations in California. Hourly temperature data was collected from the station nearest to each of the variety trial sites.

Two chill accumulation models, the Positive Utah model and the Dynamic model, and one heat accumulation model, the Growing Degree Hours model, were used. The Positive Utah model (Allan et al., 1995) uses an optimum temperature (6º C) at which an hour counts for a full Chill Unit and a minimum (1º C) and maximum (19º C) temperature that define an interval of chill accumulation. Within this interval chill accumulates at fractions of a unit. We used the curve functions of Anderson and Richardson (1982), which have the same temperature thresholds but a curved relationship between thresholds. Below the minimum temperature chill does not accumulate and temperatures warmer than the maximum negate the cooling effects. Whereas the Richardson et al. (1974) model cancels previous chill for any temperature above the maximum, in the Positive Utah model the negation can only occur within a day, if the accumulation of a day is negative then the chill accumulation for that day is set to 0.

The Dynamic model of Fishman et al. (1987) is a two-step process. It integrates a bell-shaped relationship of hourly temperature to a chill value, the promotion of chilling by short periods of high temperature or long periods of moderate temperatures, and the possible negating effect of long exposure to high temperature. A chill intermediate is first accumulated. This intermediate can be negated in the course of accumulation; however, once it reaches a threshold value it is fixed as a non-negate-able Chill Portion. The intermediate count then returns to zero and accumulation begins anew. Both the Positive Utah model and the Dynamic model have been shown to accurately approximate chill accumulation in Mediterranean climates (Allan et al., 1995, Luedeling et al., 2009b).

The Growing Degree Hours (GDH) model of Anderson et al. (1986), an asymmetric curvilinear model, also referred to as the GDH ASYMCUR model, is a modified cosine curve consisting of two cosine equations defined by an optimum hourly temperature (25º C) that counts for a full Growing Degree Hour and minimum (4º C) and maximum (36º C) temperature above and below which (respectively) heat accumulates at fractions of a full unit.

Rather than seeking an exact start date for accumulation of chill or heat, the goal with this work was to estimate an approximate start date, understanding that in specific years it would be slightly earlier or later. To estimate when chill accumulation begins, candidate start dates of October 1st, November 1st and December 1st were used; for heat accumulation we used November 1st, December 1st and January 1st. Because almonds in California always bloom in February, the chill (and heat) accumulation from each start date to every day in February for each site and year (site-year) was then calculated. These accumulations were our independent variables. Each day in February was also assigned a value of 0 if it had not bloomed and 1 if it had. This was our dependent variable. For example, in 1996 near Chico, February 26th was a 0 because the site had not bloomed. At this same site on this same day, starting from October 1st, 1618 Positive Chill Units and 60 Chill Portions had accumulated, starting from November 1st, 1496 Positive Chill Units and 60 Chill Portions, and so on.

Previous works have modeled the relationship between chill and heat as a logistic or an exponential function (Chuine, 2000, Hanninen, 1990). Rather than arbitrarily scaling chill or heat logarithmically or exponentially while not scaling the other variable, we approached the chill-heat relationship simply as an inverse function:

$$f\left(Heat\right)=\frac{Cons\tan t}{f\left(Chill\right)} \qquad \text{(Equ. 1)}$$

For more simplistic graphic representation, and to treat chill and heat symmetrically, we took the natural logarithm of this relationship to create a linear relationship:

$$\ln(Heat) = \alpha * \ln(const) - \ln(Chill) \qquad \text{(Equ. 2)}$$

Because bloom was scored as either 0 (not bloomed) or 1 (bloomed), the evaluation of bloom was a logistic:

$$Bloom = \frac{P}{1-P} \qquad \text{(Equ. 3)}$$

With a probability of 0.5, the assumed probability of bloom when chill and heat requirements are met, the natural log of the logistic is zero. Re-arranging Equ. 2 yields:

$$Bloom = \alpha * \ln(cons\tan t) - \ln(Chill) - \ln(Heat) \qquad \text{(Equ. 4)}$$

Thus when evaluating variables we considered the natural log of the accumulation values. The cheap Score chi-square test statistic derived from the Logistic Stepwise Regression approach in the Fit Model platform of JMP 9.0 (SAS Institute Inc., Cary, NC, USA) was used to determine which chill and heat variable to include in the model. These variables were then fit using splines (Takezawa, 2006) to examine the plausibility of the linear model approach. Once confirmed as plausible, LOESS, a nearest-neighbor local-linear regression approach (Takezawa, 2006), was used to fit a regression surface to the data without making assumptions about the parametric form of the regression. The spline, fit using the General Additive Models method (Proc GAM), and the LOESS Procedure (Proc LOESS) were both run in SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

RESULTS

In terms of variable selection, heat accumulation starting in January had the highest chi-square (12.4202), whether heat accumulation was paired with the Positive Utah model or the Dynamic model. The next nearest variable, heat since December, had a chi-square value of only 7.0851. Once heat since January was selected, the next highest value for variables in the Positive Utah-GDH model pairing was a near-match between chill accumulation starting in October (chi-square = 7.8578) and November (chi-square = 7.7995). A second criteria was thus examined, the corrected Akaike information criterion (AICc) value (Hurvich and Tsai, 1989). Because the model with chill after November had a higher AICc value (233.496) than the model starting in October (233.554), chill after November was selected. For the Dynamic-GDH model pairing, chill accumulation starting in October had the highest chi-square value (13.4596), with November chilling having the nearest score (10.6816).

There was an approximately linear relationship between the natural log of Positive Utah chill starting in November and bloom, shown by the relationship between the spline function of Positive Utah November Chill "f(logPUNov)" and the variable itself, "logPUNov" (Figure 2a) The relationship between bloom and the natural log of Dynamic Chill Portions starting in October was approximately linear between 3.9 and 4.4, though not within 3.6 to 3.9 (Figure 2b). The relationship between bloom and heat accumulation starting in January was approximately linear between 8.0 and 8.5, though not between 8.5 and 8.8

(Figure 2a & b). This was taken as indication that the relationships were linear enough to proceed.

The LOESS procedure yielded a regression surface with zones of probability of bloom and the series of days that had bloomed or not for every site-year. In Figure 3 a & b, if the relationships were fit well, the transitions from not bloomed to bloom would line up along the 0.5 probability. Site-years where the transition from not bloomed to bloomed took place either below the 0.2 probability zone (bloomed early) or above 0.8 (bloomed late) were designated as poorly predicted years.

With the Positive Utah-GDH pairing, there were four site-years that bloomed earlier than the regression predicted – 1997 and 2005 at Modesto and Shafter. Five site-years bloomed later than the regression predicted – 1996 at Chico, 1998 and 2000 at Modesto, and 2001 and 2004 at Shafter. With the Dynamic-GDH pairing, there was one site-year that bloomed earlier than the regression predicted –2005 at Shafter. Two site-years bloomed later than the regression predicted – 1998 and 2004 at Modesto.

DISCUSSION

The fact that heat accumulation starting in January was the variable selected, by a sound margin, as most important in explaining the dependent variable of bloomed or not bloomed makes sense in the context of almonds. Almonds are a very low-chill crop, the first temperate tree crop, along with some low-chill varieties of peaches, to bloom in California. Heat accumulation beginning in January suggests that the chilling requirement was easily met well before the end of winter in all site-years in this study.

Previous work in almonds reported different start timing for heat accumulation. Alonso et al. (2005) estimated the mean transition date from endo- to eco-dormancy by correlations between average temperatures during dormancy and date of full bloom, assuming a sequential model of chill requirement being met, directly followed by heat accumulation. They found in Zaragoza, Spain, heat accumulation begins in ‘Nonpareil’ almond around November 30th. Ramirez et al. (2010), working in Santiago, Chile, also assuming sequentiality of accumulation, estimate a chilling requirement for ‘Nonpareil’ with the Dynamic model that would be met in mid-to-late December in California. It is possible that in the Central Valley of California, chilling requirements are met later than in Santiago or Zaragoza. However it seems more likely that the difference in results stems from the fact that heat accumulation does not actually start right after the minimum chill requirement is met. Alternatively, it is possible that in California there is not enough heat accumulation during most of December to have a statistically significant impact on model predictions.

Rattigan and Hill (1986) and Ramirez et al. (2010) in Angle Vale, Australia, and Santiago, Chile, respectively, began their chill accumulation count in May (equivalent to November in the Northern hemisphere). Rattigan and Hill started their count on the first full day that positive Chill Units accumulated according to the Utah model of Anderson and Richardson (1982). Ramirez et al. used May 1st as their start date, equivalent to November 1st, the date traditionally used in California (Luedeling et al., 2009b).

The fact that chill after October was fairly even in its chi-square score with chill after November under the Positive Utah model, and that it was clearly the most significant under the Dynamic model, indicates that in many year in California pomologists and growers may be starting their chill accumulation count later than the tree buds. This could be problematic both from a modeling perspective and a management perspective. In pistachios, for example, growers often apply dormancy breaking oil toward the end of chill accumulation if it is thought that there will be marginally insufficient chill. The efficacy of these treatments is reliant on timing the spray to coincide with a certain amount of chill accumulation. If not sprayed in the right window, it can have no effect, or deleterious effects (Beede and Ferguson, 2002).

The fact that the linear model fit better using the Dynamic model may suggest that the Dynamic model better models chill accumulation in almonds in a Mediterranean climate than the Positive Utah model. It is also interesting to note the areas of linearity and non-linearity in the LOESS regression. There was a clear relationship between chill and heat at and above approximately 4.0 on the logDynOct axis in Figure 3b, with less heat being necessary to achieve bloom in the site-years where more chill accumulated. Below this amount of chill a fairly consistent amount of heat was necessary for bloom. This is more evidence for the conceptual model in Figure 1, with a critical chill requirement and an inverse, compensatory relationship at chill levels above that minimum. A similar pattern is decipherable on the Positive Utah-GDH LOESS graph, though because of the generally poorer fit, it is not as clear-cut.

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Figures

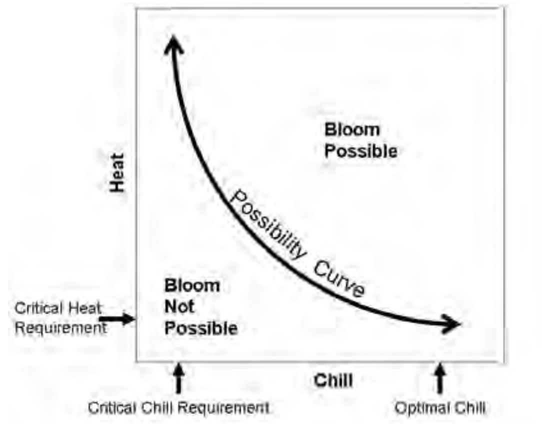

Fig. 1. A conceptual model of the inverse relationship between the amount of chill the buds of a tree experience and the amount of heat necessary to reach flowering or leaf-out, where any point along or to the right of the "Possibility Curve" is an adequate combination of chill and heat accumulation. Figure adapted from Cannell (1989) and Harrington et al. (2010).

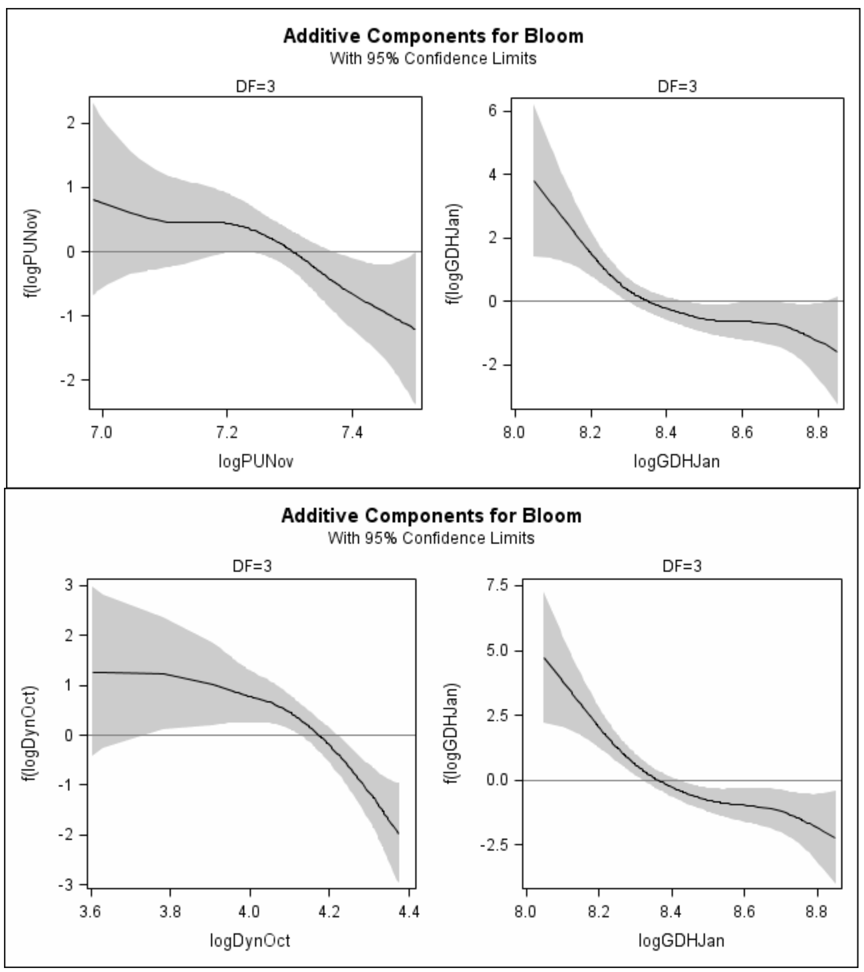

Fig. 2a & b. The relationship between the spline function of each chill and heat variable selected and the original variable. Top left, the spline function for Positive Utah Chill starting from November 1st ,"f(logPUNov)," plotted against original values, "logPUNov." Bottom left, the spline function for Dynamic Model chill starting from October 1st, "f(logDynOct)," plotted against original values, "logDynOct." Top and bottom right, the spline function for Growing Degree Hours starting from January 1st, "f(logGDHJan)," plotted against original values, "logGDHJan," in their respective Positive Utah or Dynamic model – GDH pairing. The more linear the relationship between the spline function and the original values, the more plausible the linear model.

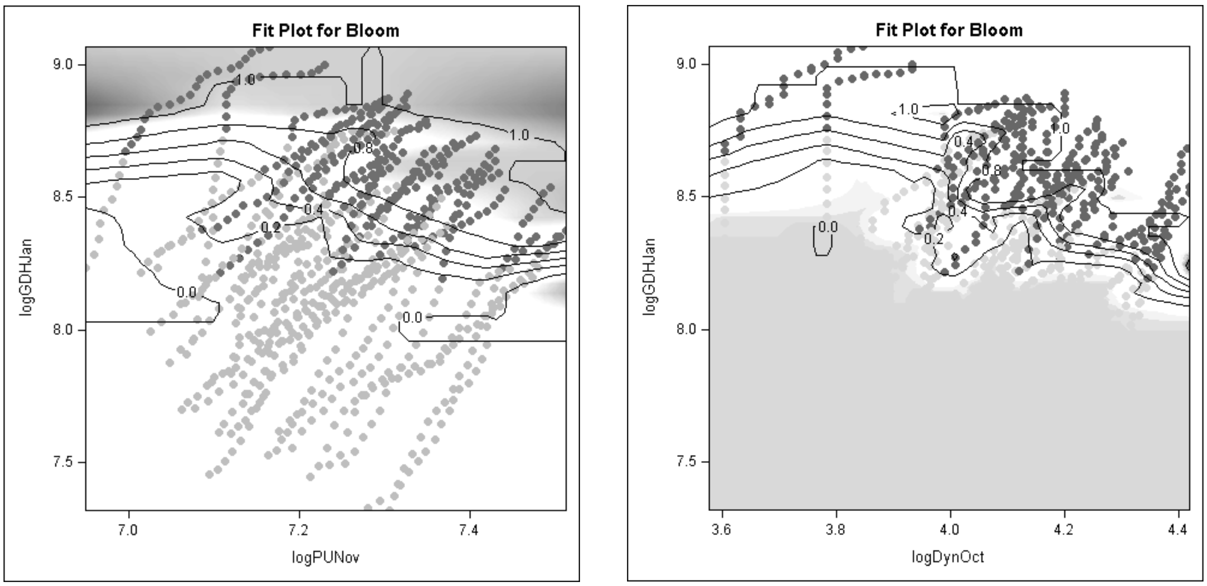

Fig. 4a & b. Probability of bloom fitted using LOESS, a nearest-neighbor local-linear regression approach, shows zones of probability of bloom and the series of days that either had or had not bloomed for any given site-year, with the chill accumulation on the x-axis (natural log of Positive Utah Chill Units starting November 1^{st} – figure a, left – and natural log of Dynamic Model Chill Portions starting October 1^{st} – figure b, right) and the heat accumulation, the natural log of GDH starting in January, on the y-axis. The probability of bloom is the z axis represented by lines much like as topographical lines on a map, where lines close together indicate a sharp, rapid transition. In figure a, using the Positive Utah model, four site-years bloomed much earlier than the regression would predict, transitioning from light to dark grey below the 0.2 probability line, and five site-years bloomed later than the regression would predict, transitioning above the 0.8 probability line. In figure b, using the Dynamic Model, one site-year bloomed earlier than the regression would predict, and two site-years bloomed later than the regression would predict.

Detecting non-linear response of spring phenology to climate change by Bayesian analysis

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Abstract: The impact of climate change on the advancement of plant phenological events has been heavily studied in the last decade. While the majority of spring plant phenological events have been trending earlier, this is not universally true. Recent work has suggested that species that are not advancing in their spring phenological behavior are responding more to lack of winter chill than increased spring heat. One way to test this hypothesis is by evaluating the behavior of a species known to have a moderate to high chilling requirement and examining how it is responding to increased warming. This study used a 60-year data set for timing of leaf-out and male flowering of walnut (*Juglans regia*) cultivar 'Payne' to examine this issue. The spring phenological behavior of 'Payne' walnut differed depending on bud type. The vegetative buds, which have a higher chilling requirement, trended towards earlier leaf-out until about 1994, when they shifted to later leaf-out. The date of male bud pollen shedding advanced over the course of the whole record. Our findings suggest that many species which have exhibited earlier bud-break are responding to warmer spring temperatures, but may shift into responding more to winter temperatures (lack of adequate chilling) as warming continues.

I. Introduction

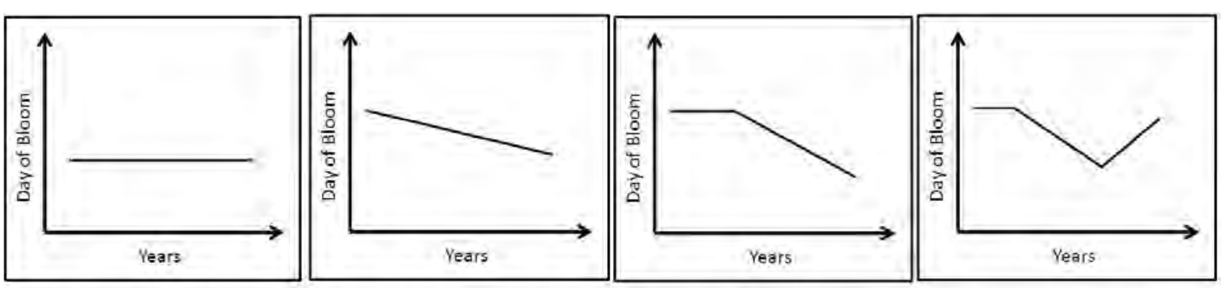
Phenology, the study of the timing of biological events in a plant's life cycle and the causes of that timing (Lieth, 1974), has in recent times, been examined as both a signal of climate change and a gauge of how plants (and animals) will respond to warmer conditions (Parmesan & Yohe, 2003, Root *et al.*, 2003, Rosenzweig *et al.*, 2008). The majority of spring plant phenological events studied are trending towards coming earlier than in previous decades across Europe (Gordo & Sanz, 2009, Menzel *et al.*, 2006), North America (Abu-Asab *et al.*, 2001, Schwartz *et al.*, 2006) and Asia (Ma & Zhou, 2012, Primack *et al.*, 2009). Researchers have extrapolated from these studies that bloom and leaf-out will continue to march forward, resulting in spring phenological events occurring weeks or months earlier than before industrial era global warming (e.g. Crepinsek *et al.* (2009)).

However, the forward march of spring has not been consistent or universal, with some phenological events coming later or remaining unchanged, depending on species or location (Ahas *et al.*, 2002, Doi & Katano, 2008, Schleip *et al.*, 2009, Zhang *et al.*, 2007). Furthermore, the advancing response of phenology to increased temperatures is not linear. In many experiments and observations, spring phenology advances more days per degree with an initial temperature increase than with a second temperature increase of equal magnitude (Gunderson *et al.*, 2012, Morin *et al.*, 2010, Schwartz & Hanes, 2010). Satellite data from North America and Asia has shown, *en masse*, ecosystems greening earlier or later, depending on temperature thresholds, over the course of the last thirty warming years (Haiying *et al.*, 2010, Zhang *et al.*, 2007).

The flower and vegetative buds of temperate trees become dormant in the fall and require exposure to winter chill, of an amount specific to species and cultivar, to exit this state (Westwood, 1993). The response of a given temperate perennial species to warmth in spring differs depending on how close that species is to meeting its chilling requirement (Landsberg, 1974, Murray *et al.*, 1989). Cook *et al.* (2012) have recently provided a framework for viewing the varying behaviors of different species in response to global warming. They categorized species into four groups; “spring-only responders” – advancing phenological events in reaction to increased spring temperatures with no sensitivity to temperatures during other season, “vernalization-only responders” – delaying phenological events in reaction to decreased winter chilling, “divergent responders” – advancing of some processes due to increased spring heat but delaying of other processes due to decreased fall and winter chilling, and “non-responders” – no phenological response to changing temperature trends in any season. While 72% of the 490 species they analyzed were spring-only responders, 17% were divergent responders, 4% vernalization-only, and 8% non-responders.

However, spring-only responders may simply be potential divergent responders with chill accumulation well above what the genotype requires. Across a number of temperate perennial species, there is an inverse, compensatory relationship between the amounts of chill the buds of a tree experience and the amount of heat necessary to flower or leaf-out (Cannell, 1989, Harrington *et al.*, 2010, Sparks, 1993), with high chill accumulation (henceforth “optimal chill”) necessitating minimal spring heat for bloom or leaf-out and chill below a certain threshold (henceforth “sub-optimal chill”) necessitating a higher accumulation of heat in spring. One way to examine whether spring-only responders, as a category, could be sensitive to temperatures outside of the spring season is by examining the historic phenological response of vernalization-only or divergent responders. A vernalization-only or divergent responder would behave like a spring-only responder during years with warmer springs and above-optimal chill, but behave differently as winter chill became sub-optimal and spring temperatures continued to increase.

Bayesian change-point analysis provides an ideal way to detect this manner of response. Bayesian change-point analysis has been used to detect whether plant phenology has responded to increased temperatures over several decades by comparing the probability of three models: no change in phenological event timing, a linear response over the entirety of the record, or period of stability followed by a period of changed event timing (Dose & Menzel, 2004). By adding the possibility of a two-change-point model, and comparing the probability of four different models (Fig. 1a-d), spring phenological responses to warming of both winter and spring can be evaluated. Furthermore, responses to warmer winters and the influence of warmer springs can be separately detected. A constant model should describe a species that does not respond to warming conditions, a "non-responder". Given adequate chill, spring warming should advance spring phenology. A linear model should provide a good fit if the record were not long enough to show stable pre-warming phenological timing. A one-change point model would be most probable if the data included stable, pre-warming years. High probability for either of these types of models would indicate a "spring-only" responder species. If, over the course of the record, chill becomes sub-optimal, a "divergent responder" would first exhibit earlier phenological timing, then shift towards events occurring later. Given the inclusion of stable, pre-warming years in the data-set, a two-change-point model should be most probable in this situation.



a. Constant Model – No Response to Temperature Change

b. Linear Model – Response to warmer spring temperature given dataset that does not include pre-warming years

c. One Change-Point Model – Stable conditions, then response to warmer spring temperatures

d. Two Change-Point Model – Stable conditions, then response to warmer spring temperatures, then response to decreased winter chill

Figure 1. Theoretical framework of detecting changing spring phenology based on spring heat and winter chill accumulation using Bayesian change-point analysis.

The ideal dataset for testing this framework would be the spring phenology record of a mid-to-high chill requirement crop, in a location where spring and winter has been warming. Annual spring temperatures in the Sacramento Delta have increased significantly, both over the last century and more recently (Table 1), with similar trends across the whole of Northern California (data not shown). Since 1918 there has been a significant increase in daily minimum and maximum temperatures in all seasons, including the winter and summer. This trend has been increasing since 1970.

A 60-year-long data set (1953 to 2012) from the California Walnut Improvement Program was used for this study. This data set contained the dates of spring leaf-out and male flowering for the *Juglans regia* cv. 'Payne' in Davis, California. This dataset includes years before temperature trends were significantly warmer, which for Davis in particular is since about 1986 for maximum daily temperatures and 1978 for minimum daily temperatures (Cordero *et al.*, 2011).

Table 1. Temperature trends in the Delta region of California's Central Valley. Adapted from Cordero et al. (2011).

Location	Season	1918-2006		1970-2006	
		Maximum	Minimum	Maximum	Minimum
Sacramento-Delta Region	Annual	0.17*	0.26*	0.34*	0.37*
	DJF	0.14*	0.19*	0.25	0.33
	MAM	0.21*	0.23*	0.34	0.41*
	JJA	0.16*	0.32*	0.32*	0.38*
	SON	0.17*	0.29*	0.40*	0.34*

Note: Asterisk denotes 95% confidence.

The objective of this study was to determine if chill accumulation in California's Central Valley has decreased to a level that is sub-optimal for walnuts, such that increased temperatures initially caused earlier spring phenological behavior while chilling was above optimal and later spring phenological behaviors in more recent years when chilling accumulation was substantially reduced. The high chilling requirement of walnut cultivars grown in California makes these cultivars an ideal test case for this phenomenon. Given the high chilling requirement of California walnuts, we expect to find that walnut leaf-out and male flowering was stable before the 1970s, but advanced after the late 1970s and early 1980s, responding to warmer springs, and then changed again, receding as warmer winters and the lack of chilling began to outweigh the advancing force of warm spring conditions.

II. Methods

A. Phenological Data

The data set we used for our analysis came from records kept by researchers in charge of the California Walnut Improvement Program, a cooperative effort of the University of California at Davis, the United States Department of Agriculture and the California Walnut Marketing Board, in operation since 1948. Beginning in 1953, the phenological timing of events of existing cultivars and experimental crosses were recorded. Walnut have two bud types – male buds or 'catkins' are borne laterally, while mixed vegetative-female flower buds can be borne terminally or laterally, depending on the cultivar. Phenological events recorded included 5% bloom, 50% bloom and 95% bloom for both male and female buds, as well as 50% leaf-out date. For male buds, 50% bloom was when the maximum number of catkins were shedding pollen, equivalent to Stage 6, Code 65 on the BBHC scale (Meier, 2001). For vegetative buds, 50% leaf-out was judged when 50% of terminal buds showed a leaflet reflexed from the bud, equivalent to Stage 1, Code 10 on the BBCH scale. We have chosen to exclude analysis of the female bloom record because the female flowers are borne at the end of vegetative growth and thus their timing is reliant on the timing of vegetative bud-break and weather conditions thereafter.

The longest record from this program was that of *Juglans regia* cv. 'Payne' for the observational site on the University of California at Davis campus, Davis, CA. The data were continuous aside from missing data for both bud types in 1996, and for the male buds in 1973. Only 5% and 95% bloom was recorded for male buds until 1989. We thus interpolated the date of 50% bloom by simple linear regression. The consistency of the data was assured by the fact that only five individuals, Gene Serr, Harold Forde, Benjamin Irwikiri, Ronald Snyder and Charles Leslie, collected these data and each person was trained by the preceding one. Trees were visited twice weekly. New trees were integrated periodically, as trees aged. Phenological event data were not recorded until trees were at least two to three years of age.

Observation plots were within a mile of one another for the entirety of the record. Each record is the average date of the event for two to four trees. Trees were on 'Paradox' or black walnut rootstock. No significant difference in the timing of events was detected on these rootstocks.

B. Bayesian Analysis

The analysis of our data is based on an article by Dose and Menzel (2004). These authors analyzed phenology time series in terms of three models: a constant model, a linear model and a change point model. The latter employs a function consisting of two linear sections which match at the change point t_c where t_c can be any time from the second to the $N-1^{st}$ entry in the time series where N is the number of observation years. A specific element of these N-2 possible functions is a simple triangle with peak at the change point time t_c. The generalization of this model consists of allowing for polygons with an arbitrary number of change points. The data model at year t_i for $t_k \leq t_i \leq t_{k+1}$ is then

$$d_i - f_k * \frac{(t_{k+1}-t_i)}{(t_{k+1}-t_k)} + f_{k+1} * \left(\frac{t_i - t_k}{t_{k+1}-t_k}\right) = \varepsilon_i$$

where f_k, f_{k+1} are the functional values at change points t_k, t_{k+1}, d_i the observation in year t_i and ε_i the uncertainty of d_i . In the notation of Dose and Menzel (2004) the coefficient of f_k is the (i,k) element of a matrix **A** and correspondingly f_{k+1} the $(i,k+1)$ element where i is the row index and k the column index of matrix **A** (capital bold face letters denote matrices, lower case bold face letters vectors).

Application of Bayesian methods to this model is very different from conventional least squares fitting. While the least squares result for a one-change point model would be a triangle with peak at the change point t_{ML} and in the generalized case a polygon with change points $\mathbf{t}_{\mathbf{ML}}$, the Bayesian treatment considers not only the most likely change points but also neighbouring, hence less optimal configurations. The probability of a particular configuration can be calculated within the Bayesian theory.

The calculation of this quantity needs the specification of a prior probability for the support functional values **f**. Our experience with multiple change point problems has shown that the choice in Dose and Menzel (2004) was much too simplified to provide a reasonable probability assignment as a function of model complexity. We have therefore used in this paper a prior distribution successfully employed by Bretthorst (1990) in his work on nuclear magnetic resonance (NMR) signal detection and model comparison. In the notation of Dose and Menzel (2004) this reads

$$p(f|\mathrm{A}, E, \lambda) = \left(\frac{\lambda}{\pi}\right)^{\frac{n}{2}} \left(\det \mathbf{A}^{\mathrm{T}}\mathbf{A}\right)^{\frac{1}{2}} exp\left(-\lambda \mathbf{f}^{\mathrm{T}}\mathbf{A}^{\mathrm{T}}\mathbf{A}\mathbf{f}\right)$$

where E is the change point configuration and λ an unknown hyperparameter. λ may be removed from the calculation by marginalizing with Jeffreys' prior

$\frac{d\lambda}{\lambda}$ to yield

$$p(f|\mathrm{A}, E) = \frac{1}{2}\Gamma\left(\frac{n/2}{\pi}\right)^{\frac{n}{2}} * \frac{\left(det\mathbf{A}^{\mathrm{T}}\mathbf{A}\right)^{\frac{1}{2}}}{(\mathbf{f}^{\mathrm{T}}\mathbf{A}^{\mathrm{T}}\mathbf{A}\mathbf{f})^{\frac{n}{2}}}$$

Note that this function is varying very slowly with **f** compared to the variations exhibited by the likelihood. Following Bretthorst (1990), in integrals involving likelihood and prior, the prior may be taken constant with **f** set to maximum likelihood value $\mathbf{f}_{\mathbf{ML}}$ **.** With these specifications the calculation of a change point configuration E, the corresponding un-normalised probability of a model given the change point configuration E, the estimate of the functional behaviour and its derivative including uncertainties follows exactly the path of Dose and Menzel (2004) with two exceptions. The first exception concerns the average over change point configurations. In the one change point case the number of choices is exactly $n-2$ and the average can easily be calculated in a deterministic way. For more than one change point the number of configurations scales approximately as N^{n-2}. With $N \approx 60$ and $n = 10$ this would mean the order of 10^{14}! Since this is not easily tractable we have employed for all $n \geq 3$ Monte Carlo evaluations of averages. For these calculations we need random numbers in $[0,1]$ which add up to one. The appropriate generator is

$$j = 1 \ldots (n-1)$$
$$z(j) = -\ln\big(1 - u(0,1)\big)$$

where $u(0,1)$ are uniform random numbers with $0 < u(0,1) < 1$. $z(j)$ is then normalised to one and used to calculate the partial sums

$$\mathbf{t}_k = \sum z(j), j = 1 \ldots k$$

$\mathbf{t}_k$ are then shifted $t_i \to t_{i+1}$ and provide then with $t_1 = 0$an ordered set of random numbers in [0,1] which lastly needs translation and dilation to match the support of the actual time series. The sought after averages are then calculated by summing up the results of N_{MC} change point configurations weighted by their respective probabilities and divided by N_{MC}. This is the second difference from Dose and Menzel (2004) for estimation of function (trend) and derivative (rate of change) for the time series but not for their uncertainties. For uncertainties, the moments m_1 and m_2 are then re-estimated by $function(j) = m_1(j)$ and $riance(j) = m_2(j) - \big(m_1(j)\big)^2$. The averages over moments are then weighted by the probabilities of the corresponding change point configuration to yield $M_1$and $M_2$and obtain finally

$$function(j) = M_1(j), variance(j) = M_2(j) - \big(M_1(j)\big)^2$$

The same scheme applies to the derivative.

III. Results

Analysis of the 60 years of leaf-out and male flowering data from 1953 to 2012 revealed a distinct one-change point trend for the leaf-out data and a linear trend for the male data. There was a trend toward earlier leaf-out until approximately 1994, and subsequently leaf-out started coming later, with a much steeper slope than the initial earliness. Thus, by the middle of the first decade of the 21st Century, the leaf-out trend was later than ever previously recorded. This corresponds to theoretical framework of Fig. 1d, except without the initial period of stability. A linear model (Fig. 1b) fit the male data better than a constant model, both of which are more likely than either change-point model.

The four model options fit the leaf-out data with varying amounts of probability (Fig. 2a-c). The constant model had a probability of 0.134, a residual sum of squares (RSS) of 1980.6. The linear model had a probability of 0.033, with an RSS of 1976.6. The one-change-point model had a probability of 0.804 and an RSS of 1564.7. The two-change-point model had a probability of 0.027 and an RSS of 1542.0 (fit not shown). Rather than selecting the model with the highest probability and drawing conclusions from that model, disregarding the non-negligible probability of other models, the Bayesian approach instead draws conclusions from a model averaged function, averaging function and derivative of the respective models with model probabilities as weights. Because the relative probability of the one-change-point model is so much higher than the other models the average model is virtually indistinguishable from the one-change-point model (Fig. 2d).

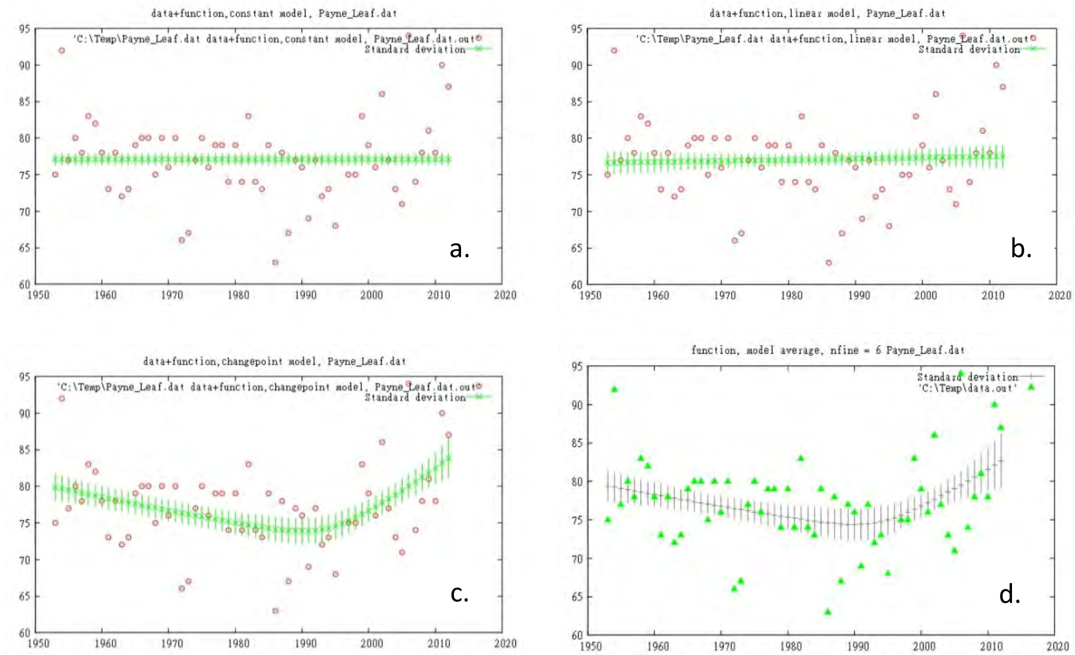


Figure 2 a-d. Model fits of leaf-out data.

The probability distribution of the potential change points for the leaf-out data has a maximum likelihood at 1994. The residuals had no pattern to their scatter. The distribution of the residuals followed a Gaussian distribution, satisfying an assumption of the analysis. The data was also analyzed for autocorrelation. The autocorrelation function was different from zero only for delay 0, meaning the data were independent.

The four model options fit the male flowering data differently (Fig. 3a-c). The constant model had a probability of 0.367 and an RSS of 2659.1. The linear model had a probability of 0.542 and an RSS of 2485.4. The one-change-point model had a probability of 0.090, an RSS of 2449.1. The two-change-point model had a probability of 0.002, an RSS of 2413.6 (fit not shown). Because the probabilities of the constant and linear models do not differ as much as with the leaf-out data, it is worth noting that in Bayesian model comparison, if the natural logarithm of the probabilities differ by less than 1.0, they are considered not significantly different (Kass & Raftery, 1995). The difference between the natural logarithm of the constant and linear model was 0.4, thus they were not significantly different. However, the model averaged function has a distinct linear slope (Fig. 3d). It is from this model averaged function that we draw the conclusion of linearity of the male flowering trend.

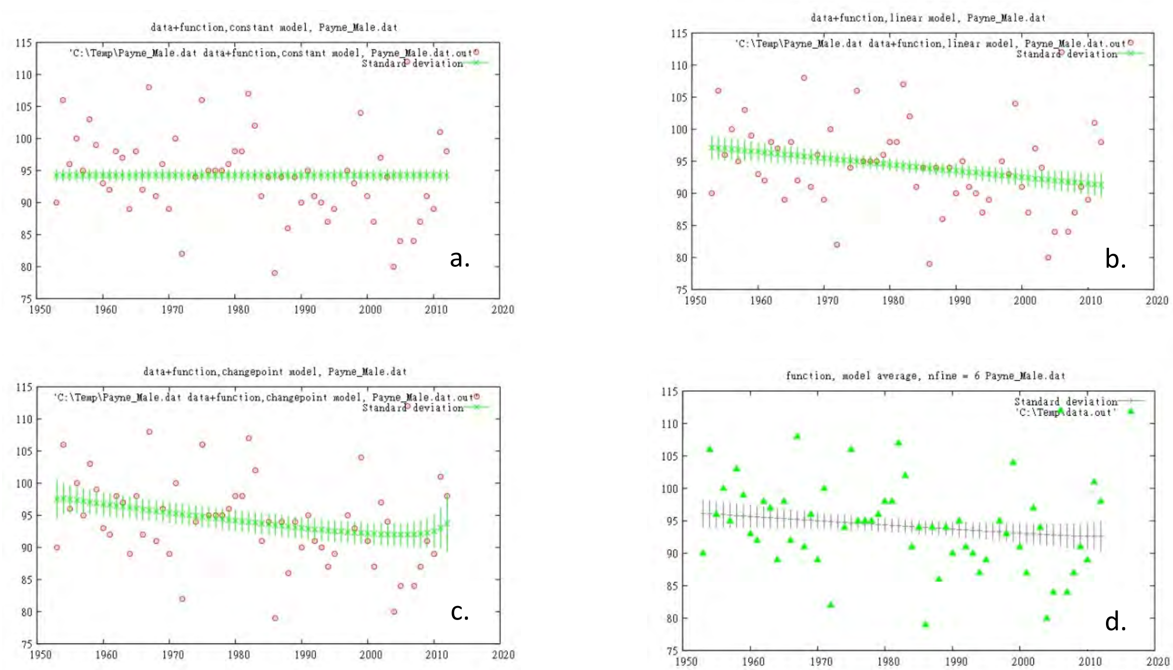


Figure 3 a-d. Model fits of male bud data

IV. Discussion

The walnut cultivar presently studied appears to have responded to recent global warming with two very different phenological behaviors. The date of leaf-out was first advanced and then delayed while the date of male flowering only advanced. These results were somewhat unexpected. While it is generally accepted that walnuts grown commercially in California have a higher chilling requirement than most cultivated temperate tree crops in this region (Charrier *et al.*, 2011, Hasey, 1994), recent works (Aslamarz *et al.*, 2009, Luedeling & Gassner, 2012, Pope, 2012) have indicated that 'Payne' and the closely related 'Serr' cultivar have a moderate chill requirement, generally satisfied in early to mid-January. Thus we would have expected this species and specific cultivar to advance in the timing of male flowering and leaf-out in response to warmer temperature patterns, indicative of a “spring only” responder. Instead it appears that captured in the record of one cultivar is one bud type (male) that is more representative of a spring-only responder, with a satisfied chilling requirement, and another bud type (vegetative) with a divergent response, behaving like a spring-only responder until about 1994, when chilling apparently became sub-optimal.

The duality of our dataset is in keeping with the global literature regarding phenology and climate change. While the forward march of spring has often been cited as ecological evidence that climates are warming (Rosenzweig, 2007), numerous species have not been found to have advanced spring phenological stages (Abu-Asab *et al.*, 2001, Menzel, 2000, Primack *et al.*, 2009, Rumpff *et al.*, 2010). Nor is the change-point nature of the phenological stage trends unusual. In a Bayesian analysis of 2600 time series from 181 stations in Central and Eastern Europe, 62% of the time series were best represented by a one-change-point model, 24% by a linear model and 14% by a constant model (Schleip *et al.*, 2009).

While many species have been shown to have a change-point in their phenological record, and many have had increasingly delayed phenological events, the present study is the first reported case of a spring phenology record for a species getting earlier, and then later. These ground-based data support conclusions drawn from Normalized Difference Vegetation Index ratios derived from satellite images that spring phenological event timing has been advancing and then delaying (Haiying *et al.*, 2010, Zhang & Taylor, 2011). This also supports experimental evidence that the temperature response of spring phenological timing is not linear (Gunderson *et al.*, 2012, Morin *et al.*, 2010, Schwartz & Hanes, 2010). A lack of winter chilling was often speculated to be at least a partial determinant of this phenomenon.

Here, too, the likely mechanisms responsible for this behavior are the chilling requirements of the species involved. The flower and vegetative buds of temperate trees enter endodormancy in the fall and require exposure to winter chill, of an amount specific to species and cultivar, to exit this state (Westwood, 1993). Higher heat requirements under sub-optimal chill (Harrington *et al.*, 2010, Sparks, 1993), along with possibly an increased chilling requirement due to warmer autumn temperatures (Heide, 2003, Walser *et al.*, 1981), and a longer amount of time necessary to accumulate chill with warmer winters, can all contribute to a longer amount of time necessary to achieve leaf-out or flowering, depending on the chilling requirement of the species and cultivar.

Our findings differ significantly from those of similar studies that have been conducted on walnut. Crepinsek *et al.* (2009) found earlier leaf bud-break by 3 and 7 days respectively in 'Franquette', a late cultivar, and 'G-139', a cultivar with mid-season leaf-out. Gordo and Sanz (2009) also reported that leaf-out advanced linearly by 0.262 days per year since 1943, and flowering became progressively later from 1943 until 1974, when it began to occur earlier. These disparate results could be attributed to differences in climate and differences among cultivars. 'Payne' is an earlier variety than 'Franquette' (Hendricks, 1998) and winters in Slovenia, where the Crepinsek *et al.* (2009) was conducted, are generally not as mild as in Davis, California. It is difficult to account for the disparity with the results of Gordo and Sanz (2009) because the cultivar was not cited.

The divergent behavior of the two bud types of walnut, within one cultivar, provided a serendipitous comparison. The chilling requirement of protandrous male buds, are lower than the chilling requirement of leaf buds in walnut (Aslamarz *et al.*, 2009, Luedeling & Gassner, 2012). Thus it would appear that chilling is still optimal for the male buds, and for this reason male buds behaved as a "spring-only" responder. The results presented here suggest that chill was also adequate for the leaf buds until about

1994, causing leaf-out timing to advance with warmer spring temperatures, consistent with a "spring-only" responder. However, around 1994 chilling apparently became sub-optimal, and spring phenological timing of the leaf buds became a balance of both fulfilling chill requirements and heat requirements, behaving as a "divergent" responder. Thus, for the 'Payne' leaf buds, whether they were classified as divergent responders or spring-only responders depended on how much of the record was examined.

The implications of these findings are numerous. In terms of methods of analysis for phenology and climate change, it makes the case for avoiding reliance solely on linear regression to model and estimate the response of plant behavior to temperature changes. Linear regression of our leaf-out data yielded an insignificant model, with a probability of 0.5503. Thus simple linear regression would have missed the trends in the data. Whether by Bayesian analysis, some other change-point analysis, adding a second-order polynomial option, or novel approaches, analyses need to allow for the possibility of a shift in the response to temperature changes after a specific year or thermal experience while not presuming there will certainly be one.

In terms of climate change in California, this study confirms that the climate has been changing in the Central Valley of California and that the phenological behavior of some plants (or organs of plants) has changed with it. It also suggests that for some varieties of walnuts and other varieties of species with high chilling requirements, the Central Valley may be shifting towards being an unsuitable area for cultivation and growth. More globally, but specific to walnuts, it suggests that the chilling requirement of the 'Payne' cultivar and similar genotypes is higher than reported by Aslamarz *et al.* (2009) and Luedeling and Gassner (2012).

Finally, from a much broader view, these findings suggest that conclusions based on previous findings of the forward march of spring may be misguided for some species and climates. As with many areas of climate change research, the story lies more in a tipping point than a linear progression. While the timing of spring phenology has been advancing in some cases, this trend should not be automatically projected into the future. For example, Crepinsek *et al.* (2009), having found that bloom had advanced 3-7 days (depending on cultivar) in walnut over the course of their 22 year record, speculated that the average bud-break date of walnut could advance as much as four weeks by 2060, triggering concerns regarding frost hazard. Our findings would instead suggest that advancement of bud-break will likely be followed by a delay in the timing of bud-break, and possibly eventually by bud failure resulting from a lack of chill.

The implications of this work in a global sense can be seen as devastating or hopeful. Certainly it indicates that the continued warming of climates can have deleterious consequences for cultivated plants. As a species grown outside of the range in which it evolved, however, cultivated walnuts may serve as a harbinger of the future, showing behavioral changes that are a step ahead of those that native temperate species will likely exhibit under increased temperatures. As global temperatures rise, many areas will experience warmer winters (Luedeling *et al.*, 2011). As winter chill decreases, more spring heat will be necessary to cause bud-break. At a certain point, winter chill accumulation may shift from sub-optimal, just causing delayed phenology, to below the requirement, eventually leading to loss of the species in specific areas.

There are still many unknowns in quantifying chilling requirements and optimal chill in temperate perennial species (Campoy *et al.*, 2011). Future work should focus on better quantifying chill and heat requirements and optimums for specific species and cultivars. Analyzing phenology records henceforth with a change point or similar analysis should also be undertaken, not only to better elucidate trends to-date, but to gauge how many species are near or below accumulation of optimal chill.

V. Acknowledgements

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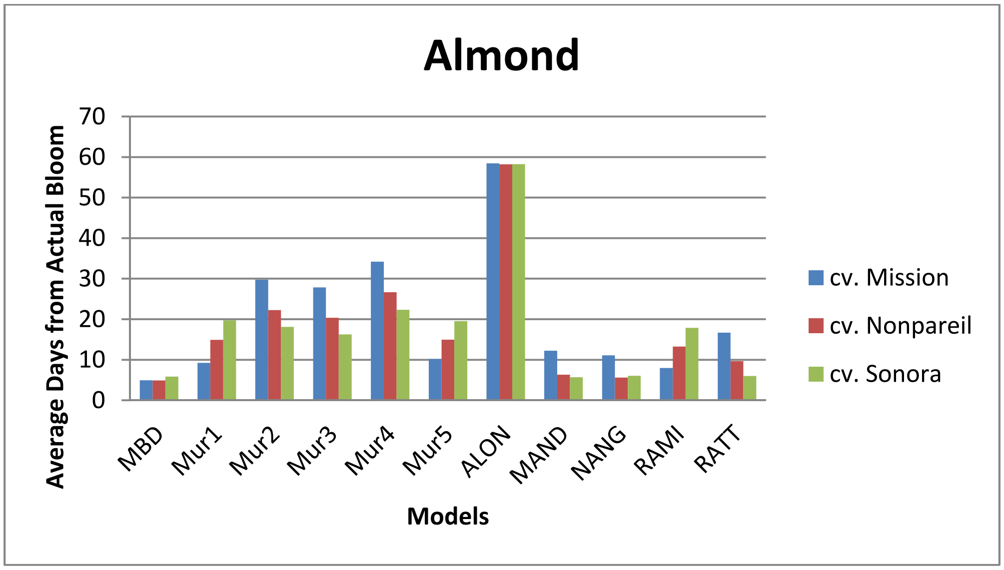

Figure 1. Average difference in almond between the actual bloom date at a given location and year and the bloom date predicted by each respective model based on temperature data for the given year and location. Bloom data gathered from three different locations from 1996-2005. See Table 1 for model details.

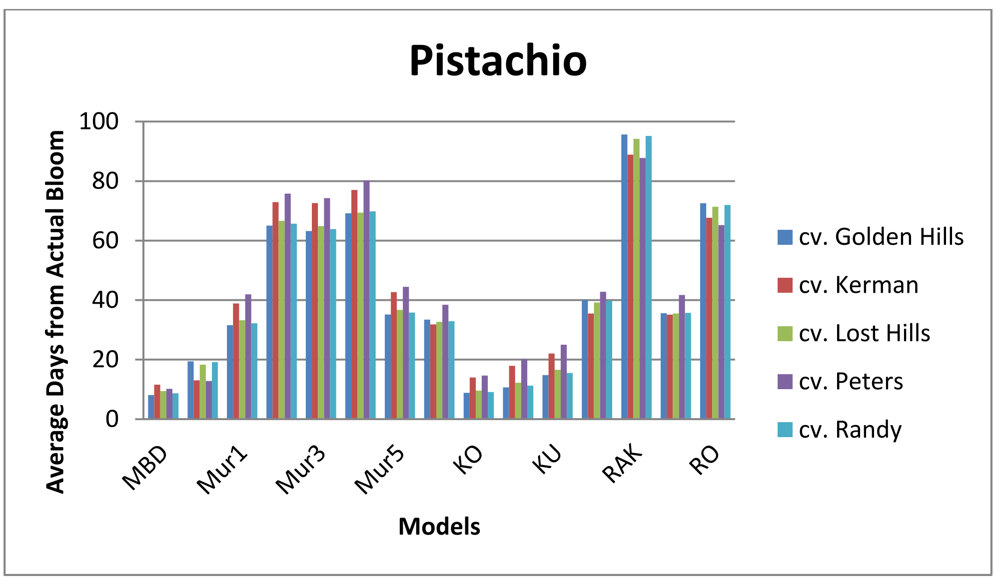

Figure 2. Average difference in pistachio between the actual bloom date at a given location and year and the bloom date predicted by each respective model based on temperature data for the given year and location. Bloom data gathered from four different locations between 2005 and 2011. See Table 1 for model details.

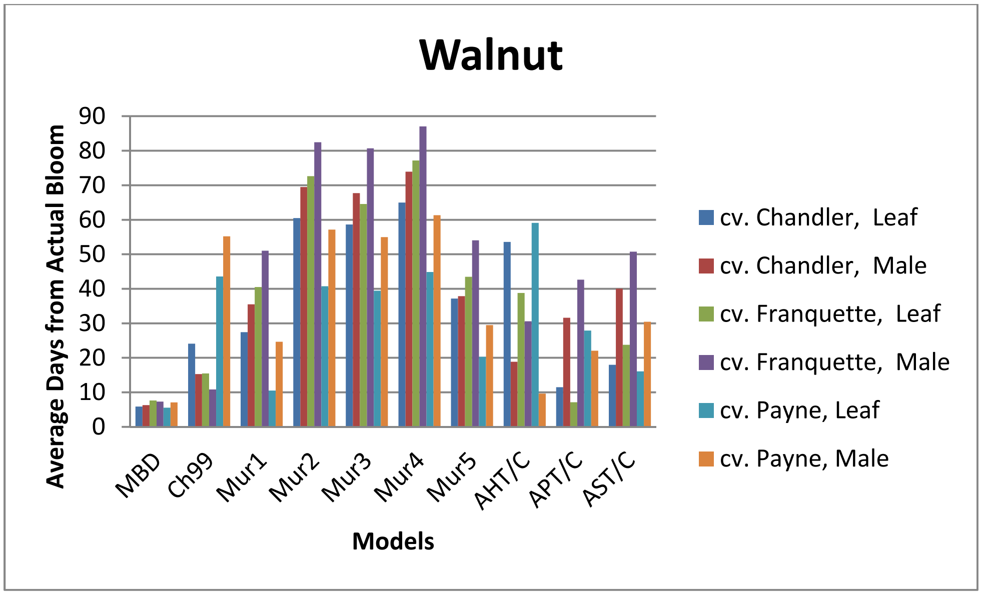

Figure 3. Average difference in walnut between the actual bloom date at a given location and year and the bloom date predicted by each respective model based on temperature data for the given year and location. Bloom data gathered from six different locations between 1953 and 2011. See Table 1 for model details.

Table 1. Model names and sources

Figure Code	Model Name	Model Type	Model Source
MBD	Mean Bloom Date		
Mur1	Murray Dormancy Group 1	Curved	Murray *et al.* (1989)
Mur2	Murray Dormancy Group 2	Curved	Murray *et al.* (1989)
Mur3	Murray Dormancy Group 3	Curved	Murray *et al.* (1989)
Mur4	Murray Dormancy Group 4	Curved	Murray *et al.* (1989)
Mur5	Murray Dormancy Group 5	Curved	Murray *et al.* (1989)
ALON	Alonso	Sequential	Alonso *et al.* (2005)
MAND	Manduel	Sequential	Rattigan and Hill (1987)
NANG	Nangiloc	Sequential	Rattigan and Hill (1987)
RAMI	Ramirez	Sequential	Ramirez *et al.* (2010)
RATT	Rattigan	Sequential	Rattigan and Hill (1986)
Ch99	Chuine 1999	Curved	Chuine *et al.* (1999)
Dy	Pistachio Dynamic	Sequential	Zhang and Taylor (2011)
KO	Kuden cv. Ohadi	Sequential	Küden *et al.* (1995)
KS	Kuden cv. Siirt	Sequential	Küden *et al.* (1995)
KU	Kuden cv. Uzun	Sequential	Küden *et al.* (1995)
RAH	Rahemi cv. Ahmad-Ahgaei	Sequential	Rahemi and Pakkish (2009)
RAK	Rahemi cv. Akbari	Sequential	Rahemi and Pakkish (2009)
RK	Rahemi cv. Kalle-Ghuchi	Sequential	Rahemi and Pakkish (2009)
RO	Rahemi cv. Owhadi	Sequential	Rahemi and Pakkish (2009)
AHT/C	Aslarmarz cv. Hartley	Sequential	Aslamarz *et al.* (2010)
APT/C	Aslarmarz cv. Pedro	Sequential	Aslamarz *et al.* (2010)
AST/C	Aslarmarz cv. Serr	Sequential	Aslamarz *et al.* (2010)

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Figures from Pope, K. S., Dose, V., Brown, P., DeJong, T.M. (unpublished). "Examining chilling requirements through historic yield records of California nut crops. "

Figure 1. Almond chill accumulation and percent change from five-year average yield with probability of simple linear regression model and associated R-squared value. State-wide (left) and Kern County (right).

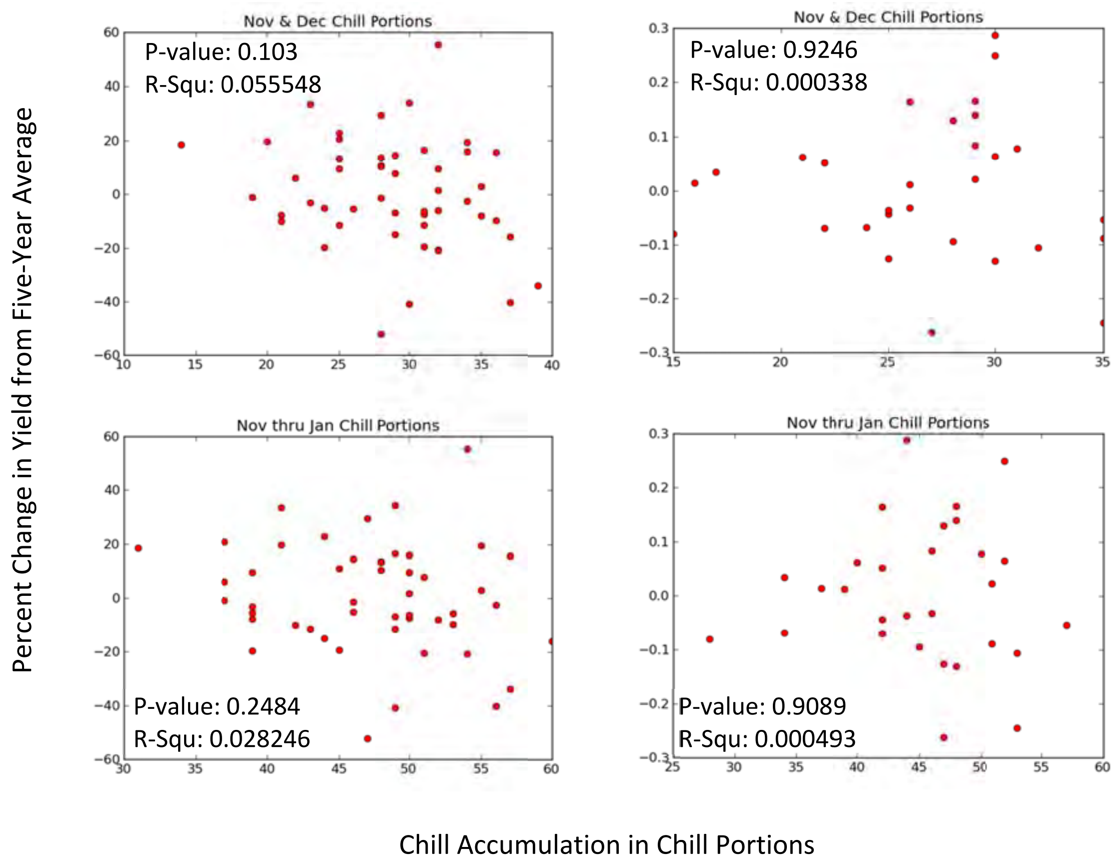


Figure 2. Pistachio chill accumulation and percent change from five-year average yield with probability of simple linear regression model and associated R-squared value. State-wide (left) and Kern County (right).

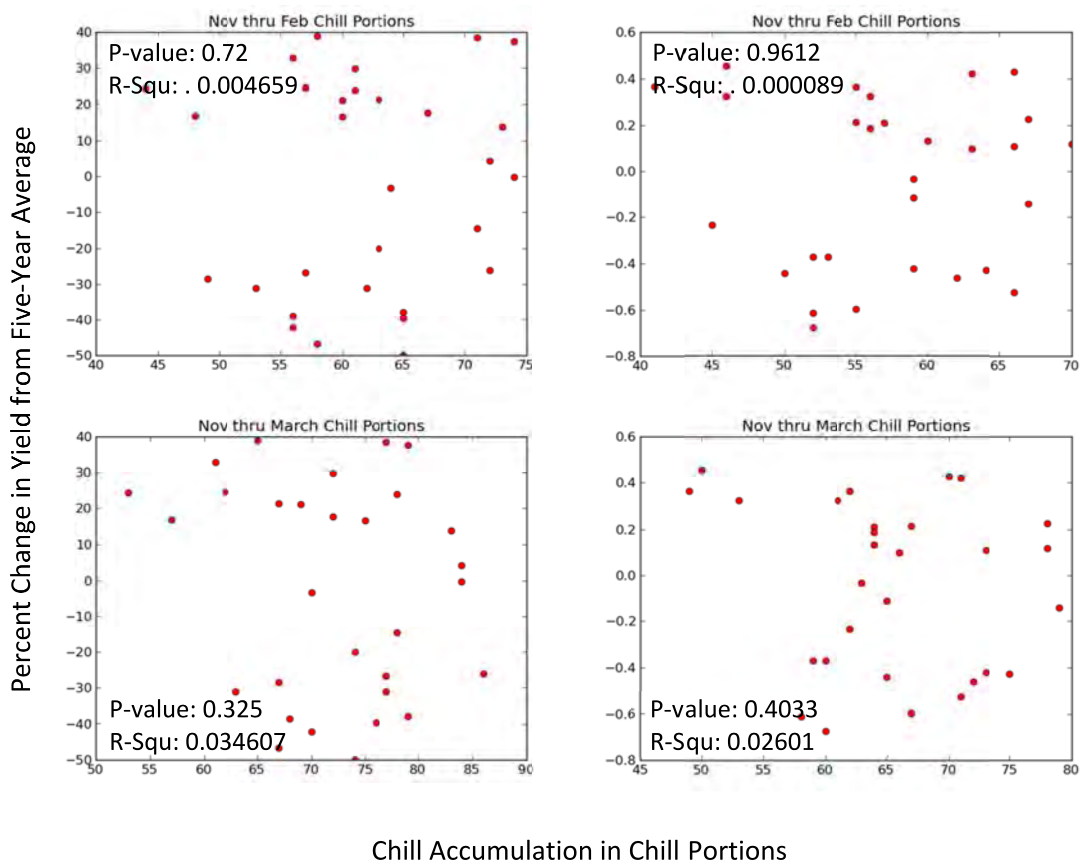
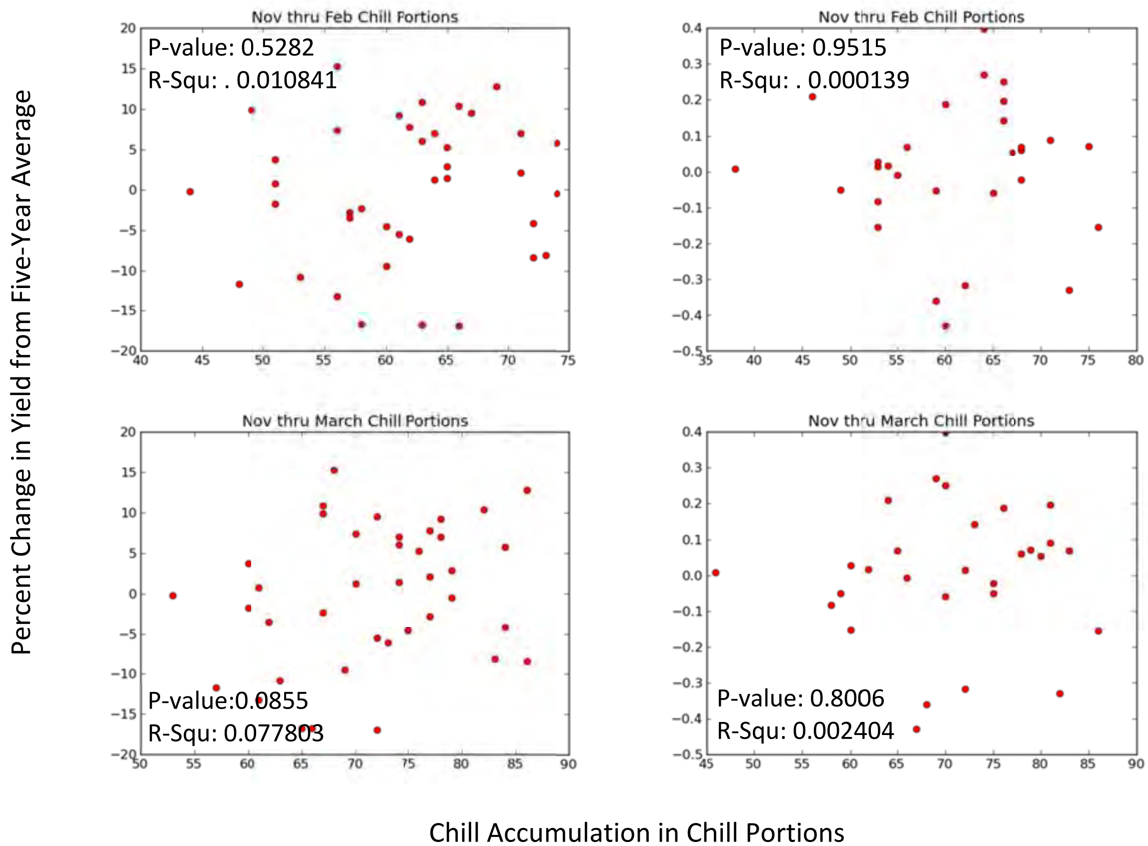


Figure 3. Walnut chill accumulation and percent change from five-year average yield with probability of simple linear regression model and associated R-squared value. State-wide (left) and Tulare County (right).



WESTERN GROWERS' CONSERVATION AND WILDLIFE QUESTIONNAIRE SUMMARY REPORT

DRAFT – NOT FOR RELEASE

This questionnaire was funded by a CDFA Specialty Crop Block Grant entitled, "Determining the Potential Impact of Vegetable Food Safety Regulations on Wildlife and the Environment"

November 14, 2011

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EXECUTIVE SUMMARY

Following the adoption of the leafy green commodity specific food safety guidelines developed in 2007, concerns were raised about the potential adverse impacts the implementation of the guidelines have on wildlife and the environment. To study the impacts of food safety guidelines on wildlife and the environment, Western Growers obtained a California Department of Food & Agriculture (CDFA) grant under the Specialty Crop Block Grant Program. Included in the grant was an objective of developing and fielding a wildlife and environmental assessment questionnaire designed to identify the practices growers use in dealing with potential wildlife-related contamination issues and whether those practices adversely impact the environment and/or wildlife. The questionnaire results will be used to address co-management challenges and to modify current best practices in the *Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens*.

To this purpose, several key findings from the questionnaire results that could be useful when considering how to address co-management challenges and the modification of current best practices are:

Wildlife environmental assessments – When growers were asked to describe the process they use to identify areas where their leafy green acreage may be at risk from wildlife concerns, the process and frequency varies greatly. Some growers cited the need for a pre-season assessment followed by observation with observations occurring daily or weekly. This is an area where there does not appear to be an agreed upon approach.

Animals of concern – Auditors, buyers and growers appear to be focused on different animals when considering the safety of leafy green produce. Auditors name domestic animals and rodents more frequently as animals of concern; growers name birds and deer as reasons for deciding not to harvest leafy green crops for food safety concerns. Buyers name frogs and wild pigs as the reason for rejecting crops. Based on these discrepancies, there does not appear to be an agreed upon approach to identify animals of concern.

Auditor/inspector practices – The questionnaire results indicate there are differences in terms of guidelines auditors/inspectors use to conduct the audit, how the audits are conducted and hence the rationale for making recommendations and decisions. Growers dealing with multiple auditors/inspectors would benefit from an industry group documenting these differences and providing reference material and training dealing with inconsistencies among auditing entities.

1.0 QUESTIONNAIRE OVERVIEW

The questionnaire was conducted using a web-based instrument designed to protect respondent confidentiality. Western Growers contracted with Intertox Decision Sciences, LLC (IDS) to collect the questionnaire responses and to remove any company or individual identifiers. Prior to launching the questionnaire, Western Growers provided a draft version for comment to several growers and recognized environmental and wildlife supporters. Once the questionnaire was finalized, an introductory letter and web link were sent from Western Growers to its leafy green growers and to other industry associations for distribution.

The questionnaire was designed to be an in-depth questionnaire of grower wildlife and environmental practices. The questionnaire included a total of 84 questions; however, the ability to skip questions not pertinent to a respondent's operations was incorporated into the study to minimize the time required for completion. Still, participation fallout was anticipated given the number of questions and estimated completion time.

1.1 Target Population

The target population for this questionnaire was the leafy green growers producing crops under third-party food safety guidelines such as the LGMA, GLOBALG.A.P, SQF or customer-specific programs. Determining the size of the target population and identifying participants, however, was difficult. The latest USDA Census of Agriculture (2007) indicated that in California there were approximately 414 ranches growing head lettuce, 520 ranches growing leaf lettuce, 174 ranches growing spinach and 177 ranches growing cabbage (USDA,2007). Since ranches may grow multiple leafy green crops, it is unclear from this data how many unique ranches are growing leafy greens. All growers producing and selling more than $1,000 of agricultural products are required to complete the census; therefore, the census results will contain a wide range of growers from the very small producers who plant 1 acre or less and sell to farmers' markets and are not subject to third-party food safety programs, to large growers selling to multiple buyers.

Beyond the USDA data, the county agricultural commissions collect information based on acres grown in each county. Again this is not data on the individual number of growers. An alternative to USDA data would be to use the county commissioners permit data to identify growers; however, this approach again has limitations since the permit application does not ask for information about the operation size or their food safety programs.

While the actual number of leafy green growers producing under third-party food safety guidelines is not known, the best estimate may be the number of leafy green growers participating in the LGMA. Based on available data from the California Leafy Green Products Handler Marketing Agreement (LGMA) entity, there are an estimated 197 leafy green growers supplying produce according to the food safety acceptable practices adopted by the LGMA.

1.1.1 Questionnaire distribution

Leafy green industry members were informed about the questionnaire through emails and newsletters from various industry groups, including Western Growers, the California Leafy Greens Products Handler Marketing Agreement, Imperial Valley Vegetable Growers Association, Grower-Shipper of Santa Barbara and San Luis Obispo, and the Grower-Shipper Association of Central California.

Efforts were made to reach as many leafy green growers as possible who are growing produce under food safety programs such as the LGMA. Questionnaires were made available to industry members for response between August 2010 and January 2011.

1.1.2 Questionnaire response collection

A total of 62 questionnaires were collected online between July 2010 and January 2011. Once the questionnaire was closed, IDS evaluated each response to ensure there were no duplicate or blank questionnaires. Partially completed questionnaires were included. During the validation process, IDS also checked to make sure respondents were a) leafy green growers and b) grew leafy greens in California. For responses that did not meet the above criteria, the questionnaires were retained and reviewed, but were not included in the results.

Responses from 53 questionnaires were used for this analysis.

1.1.3 Questionnaire response rates

Based on a sample population of 197 growers, the number of returned questionnaires resulted in a response rate of 26.9% of leafy green growers in California.

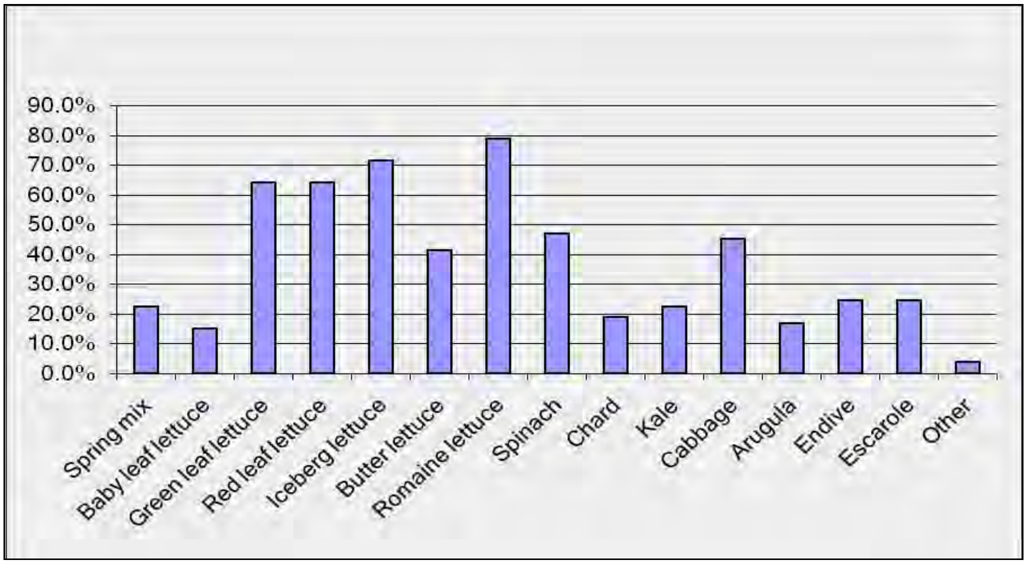
1.2 Demographic Findings

To understand the individual respondent's leafy green operations, questions were asked about the company's 2009 acreage including the types of crops grown, how they were grown (conventional or organic), where they were grown and the cost per acre. Responses to these questions are summarized in this section.

1.2.1 Leafy green crops grown

Questionnaire respondents indicated they are growing fifteen or more varieties of leafy greens (Figure 1). The most frequently grown lettuce crops are romaine (79.2%), iceberg (71.7%), green leaf (64.2%) and red leaf (64.2%). Other significant leafy green crops include spinach (47.2%) and cabbage (45.3%). On average, each respondent grows slightly more than five leafy green crop varieties.

Figure 1. Leafy green crops grown (% of respondents)



1.2.2 Ranch ownership, size and growing practices

Very few of the California growers own all of their leafy green acreage (11.8%). Most growers both own and rent their leafy green crop land (62.7%). The remainder of the growers (25.5%) rent their crop land.

In terms of grower size, the majority of respondents (77.4%) planted more than 500 total crop acres in 2009. Acreage planted includes all crops and not just leafy greens. When dividing those respondents who planted fewer than 500 total crop acres into three categories: 0-50 acres, 51-200 acres and 201-500 acres, the respondent numbers were the same in each category (7.4% of total responses). When considering only leafy green crop acreage, 47% of all growers grew leafy greens on more than half of their planted acreage in 2009.

Based on the above data and when applying the SBA's definition of a small business as those growers earning less than $750,000 per year (roughly estimated to be equivalent to 500 production acres), it appears as if three-quarters of the questionnaire respondents were large growers (77%) and the rest of the questionnaire population consisted of small- to medium-sized growing operations (23%).

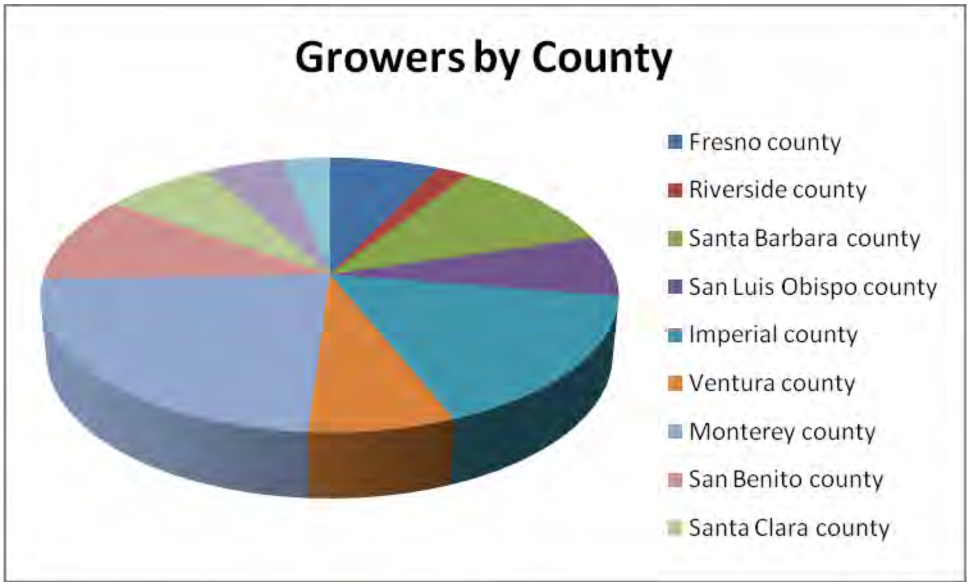
Most of the respondents indicated their crops were conventionally grown (67.3%) although some grew organic and conventional crops (28.8%). A small percentage of the respondents grew only organic crops (3.8%).

In addition to growing crops, nearly two-thirds of producers also harvested their crops. Slightly more than half were also involved in cooling and shipping of fresh produce.

1.2.3 Crop location

When asked about the county or counties where their leafy green crops are grown, the most frequent responses were: Monterey County (45.1%), Imperial (31.4%), Santa Barbara (21.6%) and San Benito (19.6%). In total respondents grow crops in 12 California counties. See Figure 2 below.

Figure 2. Growers by county (% of respondents)



Most growers grow crops in only one (62.7%) or two counties (19.6%). However, there are several growers with crops in three to eight counties.

1.3 Food Safety Programs

Growers were asked about their food safety programs including what programs, if any, are being applied. All of the growers responding to the questionnaire have a food safety program in place and many are following multiple food safety programs. The most frequently named food safety programs being used are shown in Table 1. As indicated, the California LGMA and PrimusLabs.com GAP Program are named more frequently than any other program. Additionally, growers are using buyer-specific food safety programs and other third-party programs such as SQF. Only 15.1% of the respondents are using the USDA GAP/GHP verification program. GLOBALG.A.P is cited by 20.8% of the respondents.

Table 1. Food safety programs currently in place (% of respondents)

California LGMA	88.7%
PrimusLabs.com GAP Program	62.3%
GLOBALG.A.P	20.8%
Buyer-specific program	18.9%
Arizona LGMA	17.0%
USDA-AMS GAP/GHP Audit Verification Program	15.1%
NSF Davis Fresh	9.4%
Other	5.7%
SQF	1.9%
None	0. 0%

Most growers receive specific details about the individual food safety programs from auditors (69.8%) as opposed to shippers (44.2%) or buyers (34.9%). If requirements are conflicting, growers manage the conflicts by applying the most stringent requirements to all operations as opposed to applying the individual requirements to specific acreage.

1.4 Leafy Green Customers

To understand the food safety requirements growers need to support, they were asked about their customers. More than half of all respondents sell to three or more customers and those customers include: brokers, processors, packer/shippers and wholesale distributors. Other customers included food service and institutions. None of the respondents sold to roadside markets or community supported agricultural programs.

1.5 Conservation Measures

To determine the impact the California LGMA food safety program has on conservation measures, growers were asked to not only name the conversation practices they are currently following but also to note how the California LGMA has impacted those practices.

More respondents (82.2%) have implemented conservation practices in their leafy green growing environments than in their overall growing environment (78.7%). The most frequently implemented conservation practices included: cover crops, fencing, irrigation water management and nutrient management. The adoption of LGMA did not result in the reduction or elimination of conservation measures for 82.6% of respondents who have implemented conservation practices in leafy green crops. In fact, some growers (23.4%) implemented conservation practices as a result of the LGMA guidelines. For these growers, the LGMA lead to the introduction of cover crops, critical planting areas, and hedgerows.

For those respondents who eliminated or decreased conservation practices because of the LGMA (17.4%), they described the changes made as follows: mowing grasses in filter strips, eliminating filter strips, scraping dirt to morph into bare roads along waterways therefore decreasing cropped acreage and beneficial habitat, removing vegetation around fields to reduce habitat for rodents, removing trees due to falling leaves, removing some water catchment basins, removing grass filter strips in some areas due to frog presence, removing trees to reduce the presence of birds and their droppings, and not reusing recovered tailwater because of possible contamination.

Several respondents participate in government-sponsored conservation programs from the USDA Natural Resources Conservation Service, the University of California Cooperative Extension and the USDA Farm Services.

1.6 Animal Presence

When asked about the types of animals growers observe and how frequently they are observed, it is not surprising that birds were named as being seen more frequently than other animals on a daily basis. While not seen as frequently, frogs, rodents, rabbits and dogs were sighted daily and monthly according to questionnaire responses. Deer and wild pig sightings occurred once or several times a month, and no respondent reported seeing cows in their leafy green fields.

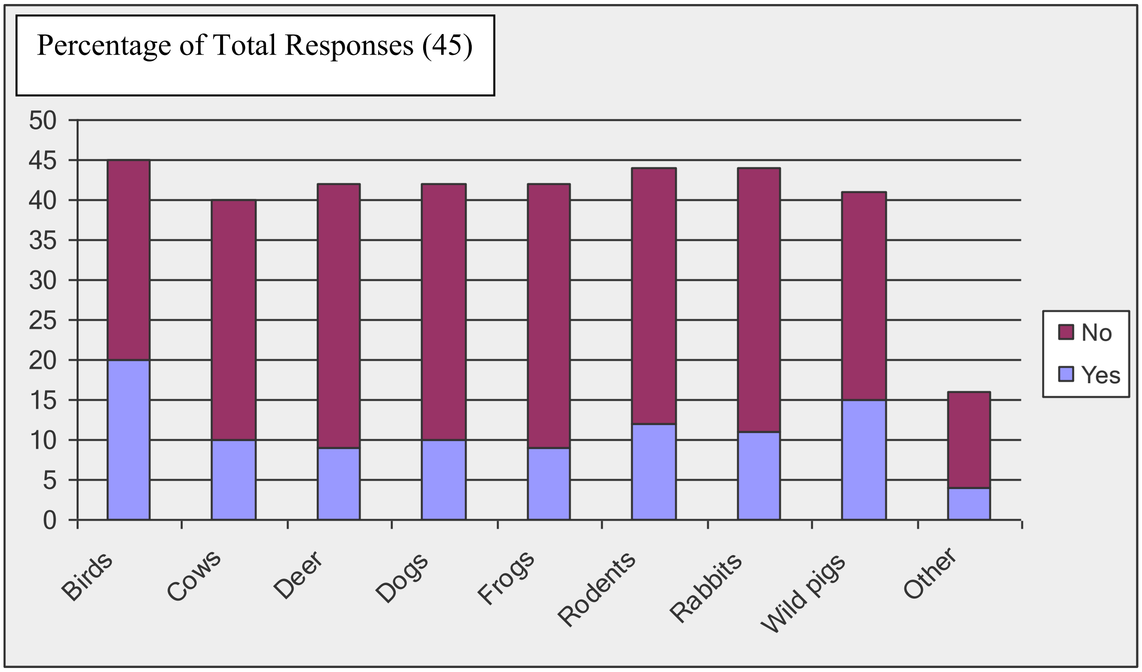
Table 2. Animal presence in leafy green fields (# of respondents)

Answer Options	Daily throughout the year	Daily during mating season	Daily during migration	Several times a month	Maybe once a month	Not at all
Birds	31	2	4	6	1	1
Cows	0	0	0	0	0	41
Deer	0	0	0	6	10	26
Dogs	2	0	0	6	20	14
Frogs	1	1	0	6	12	17
Rodents	9	3	0	20	11	2
Rabbits	9	2	0	14	13	6
Wild pigs	0	0	0	1	10	30
Other	4	0	0	5	2	7

1.7 Animals of Concern

While animals are frequently considered when discussing produce safety, more than half of the growers believe animals are not a threat to the safety of their leafy green crops. When asked about specific animals likely to be present in a grower's own leafy green production fields relating to food safety concerns, as shown in Figure 3, animals named included birds, cows, deer, dogs, frogs, rodents, rabbits, and wild pigs. Among those animals, birds were named more frequently and were perceived as the greatest wildlife risk to produce safety (44% of the growers observing birds in their leafy green fields). The second most frequently named animal as a potential food safety concern were wild pigs (36.6%) followed by rodents (27.3%).

Figure 3. Are animals observed on your land a threat to the safety of your leafy green crops?

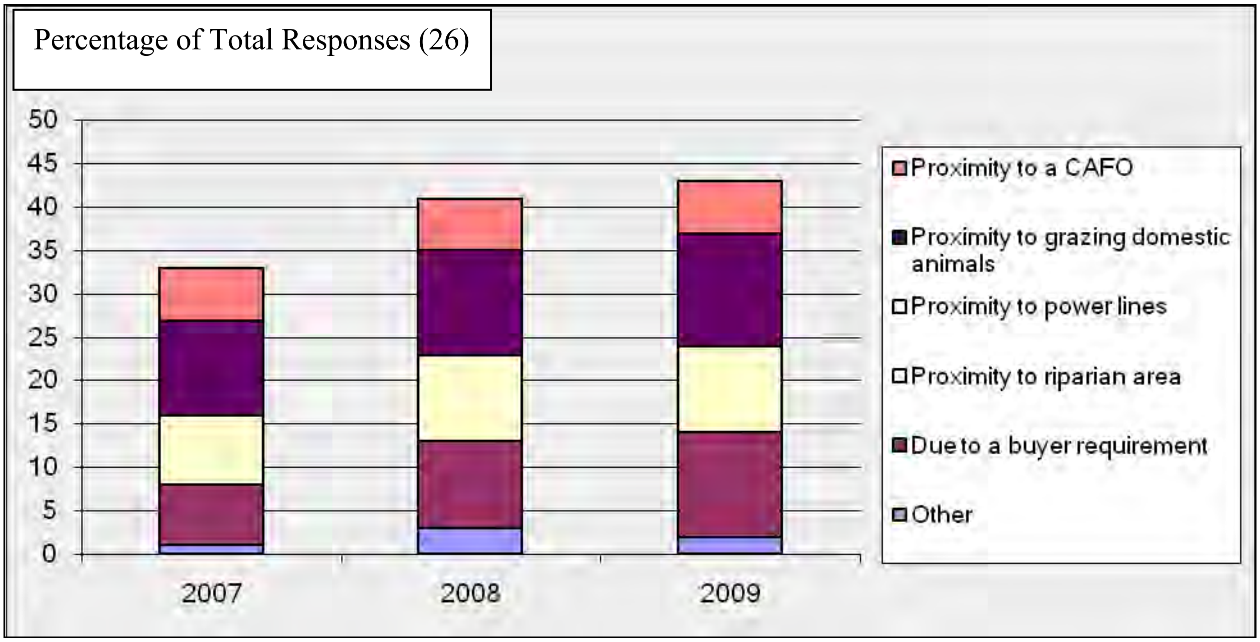


Growers were asked to describe the process they use to identify areas where their leafy green acreage may be at risk from wildlife concerns. While most growers responded that they look for signs of animal presence, the process and frequency of monitoring for animal activity varies. Some growers cited the need for a pre-season assessment followed by routine monitoring that may occur weekly or daily. This area does not appear to have an agreed upon approach to how the assessments are done, when they are done and how frequently routine monitoring occurs.

When asked how they jointly with their buyers identify areas where leafy green acreage may be at risk from wildlife concerns, the grower responses again varied greatly. The answers range from using common sense to pre-planting, pre-season assessment followed by regular monitoring.

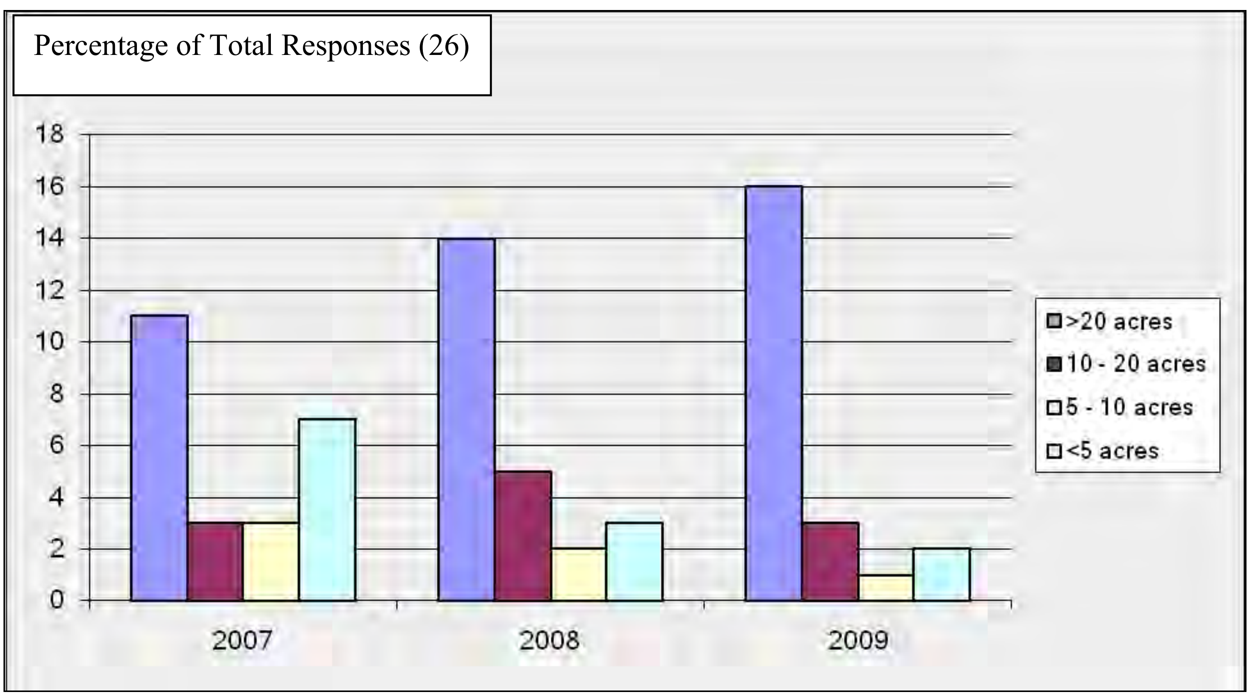
Regardless of how the risk is identified, nearly 64% of growers observing wildlife have not planted land because of wildlife concerns. Reasons for not planting include the proximity to grazing domestic animals, riparian areas, and CAFO's and buyer requirements (Figure 4).

Figure 4. Reasons for not planting relating to wildlife concerns



By not planting, growers estimated their lost acreage as seen below in Figure 5. For the 24 growers losing acreage in 2007, 11 lost more than 20 acres. In 2009, 16 growers lost more than 20 acres.

Figure 5. Acreage not planted due to concerns about wildlife



While less than 50% of respondents believe the presence of wildlife is a threat to food safety crops, a larger percentage (75.6%) of respondents have not harvested leafy green crops as a result of animal intrusion. The decision was made voluntarily and does not include instances where a buyer has rejected crops. The decision to not harvest was based on animal tracks and to a lesser extent animal feces and damaged or eaten plants. In these cases, the main animals of concern were birds (24%), deer (21%) and dogs (15%). Additionally 18 growers decided not to harvest leafy green crops even when no animal intrusion was observed.

Fewer than 25% of the respondents have ever had buyers reject crops because of animal intrusion events. When the crops were rejected by buyers, they were rejected mostly by handlers as opposed to other types of buyers. The rationale for rejecting the crops included: the presence of frogs in an adjacent pond (even though none were found in the field), the field was located within 500 feet of a residence, and tracks or scat in or around fields. In these latter cases, deer were the main animal of concern followed by frogs, rodents and wild pigs.

To address animal concerns, 23 out of 44 respondents (52.3%) use bait traps for monitoring and animal control purposes. The target species for the traps are rodents and to a lesser extent squirrels. Most traps are used seasonally. In addition, 72.7% of the respondents use fences to keep animals of concern including rabbits, deer, domestic animals, wild pigs, and rodents out of their leafy green fields. The type of fencing used is equally divided between temporary and permanent fencing materials. Approximately 25% of the fencing has been installed along streams and riparian areas. Fencing around leafy green field perimeters, around ponds and basins, and between fields and other habitat each occur in slightly less than 20% of total responses.

In addition to not planting/harvesting, some growers have taken other corrective actions such as establishing buffer zones and leaving acreage fallow near rivers and open land.

1.8 Food Safety Auditors and Animals of Concern

In addition to growers voluntarily deciding not to harvest crops as a result of animal intrusion, 48.8% of the respondents said audit companies have suggested or specified wildlife as a food safety hazard for growers' leafy green crops in the past year (Table 3).

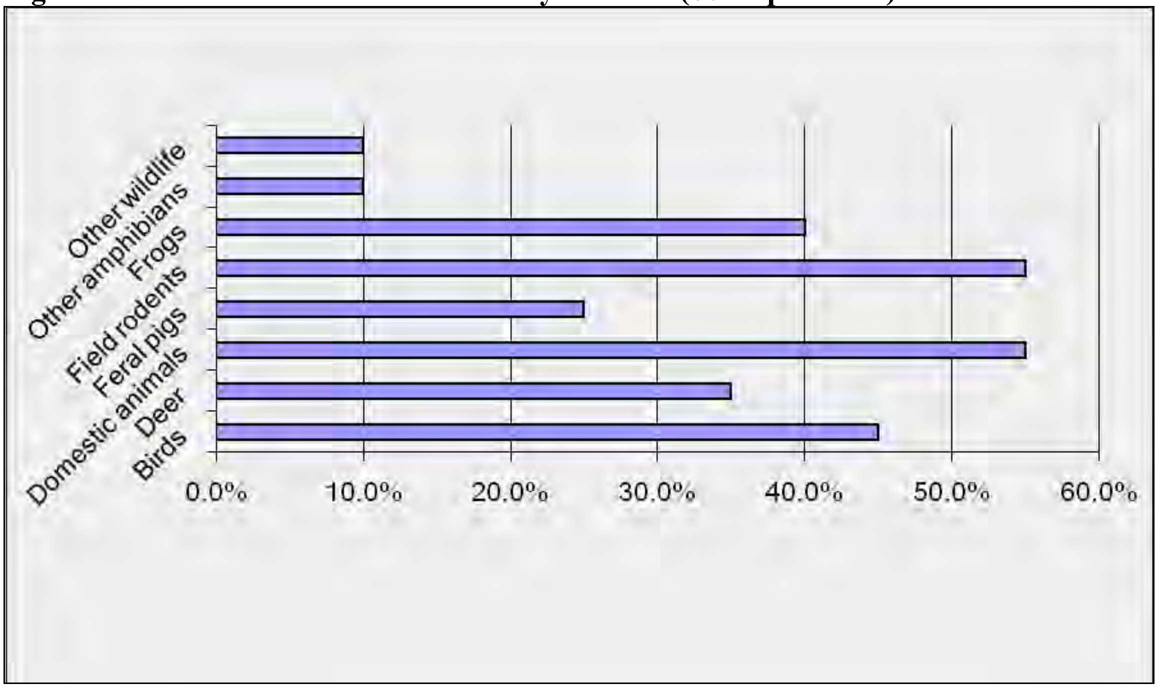
Table 3. Auditors specifying wildlife as food safety concerns (% respondents)

	Responses (21)
Primus auditor	61.9%
CDFA auditor for LGMA	42.9%
Handler	33.3%
Davis Fresh (NSF Int'l) auditor	28.6%
Food service operator	14.3%
GlobalGAP auditor	9.5%
Retailer	9.5%
SQF auditor	0.0%
Other	14.3%

Primus auditors were named more frequently for specifying wildlife as a concern followed by CDFA auditors for the LGMA, handlers and NSF international auditors. In examining whether a single auditor or multiple auditors specified wildlife as a concern for a particular grower, 38% of the time Primus was the only auditor identifying an issue. In every case where the CDFA auditors for the LGMA identified wildlife as a concern, other auditors were also named. For most growers reporting auditors' concerns about wildlife, this issue occurred more than once a year. More than half of the growers reported it happened three or more times in a year.

The two most animals most frequently identified by auditors were domestic animals and field rodents (Figure 6). This result differs from growers' concerns and with the animals named when growers voluntarily decided not to harvest crops. In both of those cases, birds and deer were the two animals named most frequently. Domestic animals, rodents and frogs were of lessor concern. Concerns about frogs and wild pigs and to a lessor extent rodents and deer were the reasons buyers rejected crops. Domestic animals were cited infrequently. In considering this data, it appears that growers, buyers and auditors may be focused on different animals when considering the safety of leafy green produce.

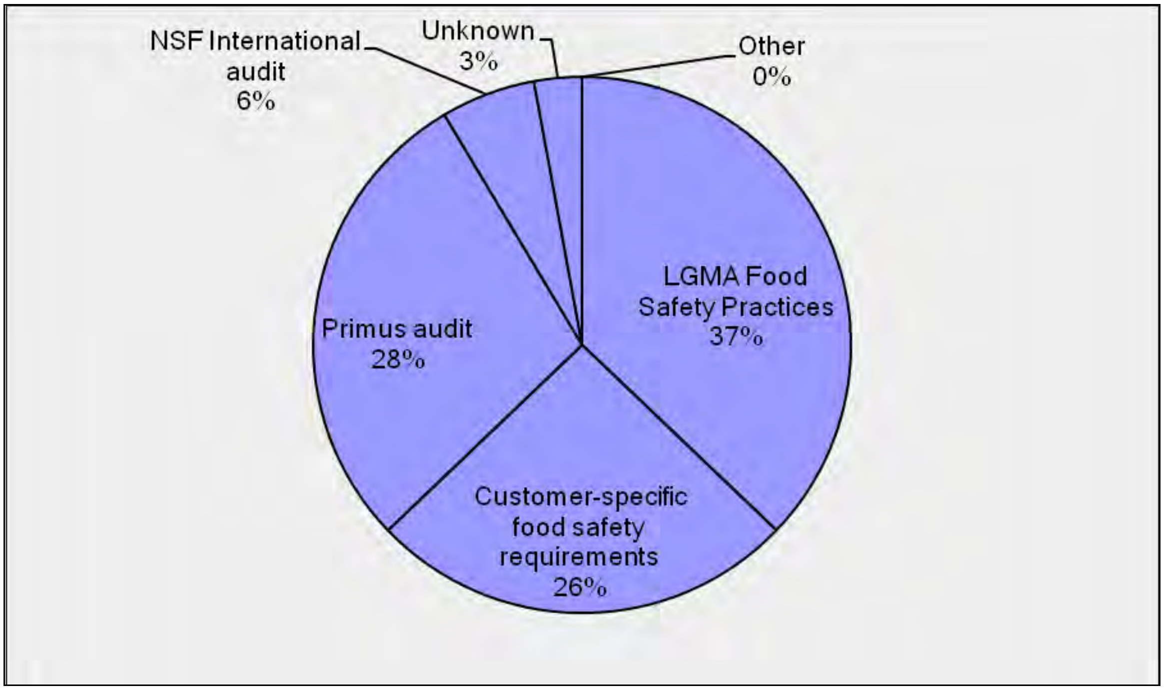
Figure 6. Animals of concern identified by auditors (% respondents)



When identifying animals of concern, auditors cited the LGMA food safety practices as the main guideline used and particularly in relation to frogs and other amphibians. In the 13 cases where the LGMA food safety practices were mentioned, five came from non-CDFA auditors. Those auditors were either handlers and/or Primus.

Based on their observations, the auditors recommended fencing, traps and habitat removal. When making recommendations, there was a strong correlation between frogs as the animal of concern and the recommended solutions. CDFA, Primus and handler auditors made similar recommendations for fencing and only had marginal variations in their recommendations for traps and habitat removal.

Figure 7. Guidelines cited for crop rejections by auditors (% of respondents)



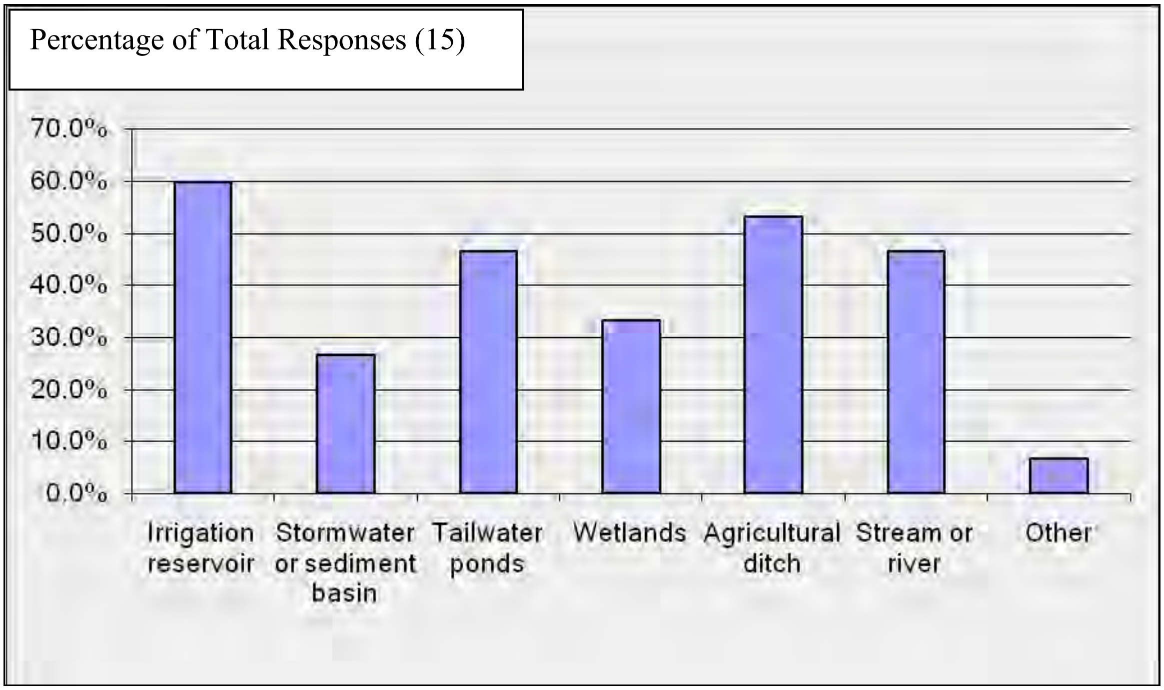
1.9 Land Modifications

The questionnaire also asked about land modifications growers may have made as a result of food safety concerns. Land modifications were described as removing a pond, reservoir, stormwater basin, or ditch. Slightly more than 68% of growers stated that they have not made any land modifications as a result of food safety concerns.

For those growers who modified their land after 2006, modifications were made on several occasions based on animal intrusion concerns, habitat concerns and water quality issues. In all cases where modifications were made, they were the result of auditors, customers or inspectors raising concerns. By far, handlers identified more concerns than any other group. Davis Fresh (NSF Intl) and Primus were a distant second followed by CDFA auditors for the LGMA in terms of concerns raised.

Waterbodies that were identified as a hazard or concern included irrigation reservoirs, agricultural ditches, streams and rivers and wetlands (Figure 8). When identifying these areas, most inspectors/auditors mentioned the LGMA guidelines as the rationale for their decision. Specifically, handlers, Davis Fresh (NSF Intl) and CDFA auditors for the LGMA were reported to have applied LGMA guidelines more than other guidelines. Handlers applied customer specific requirements as often as they applied LGMA guidelines.

Figure 8. Waterbodies auditors specified as a hazard or concern

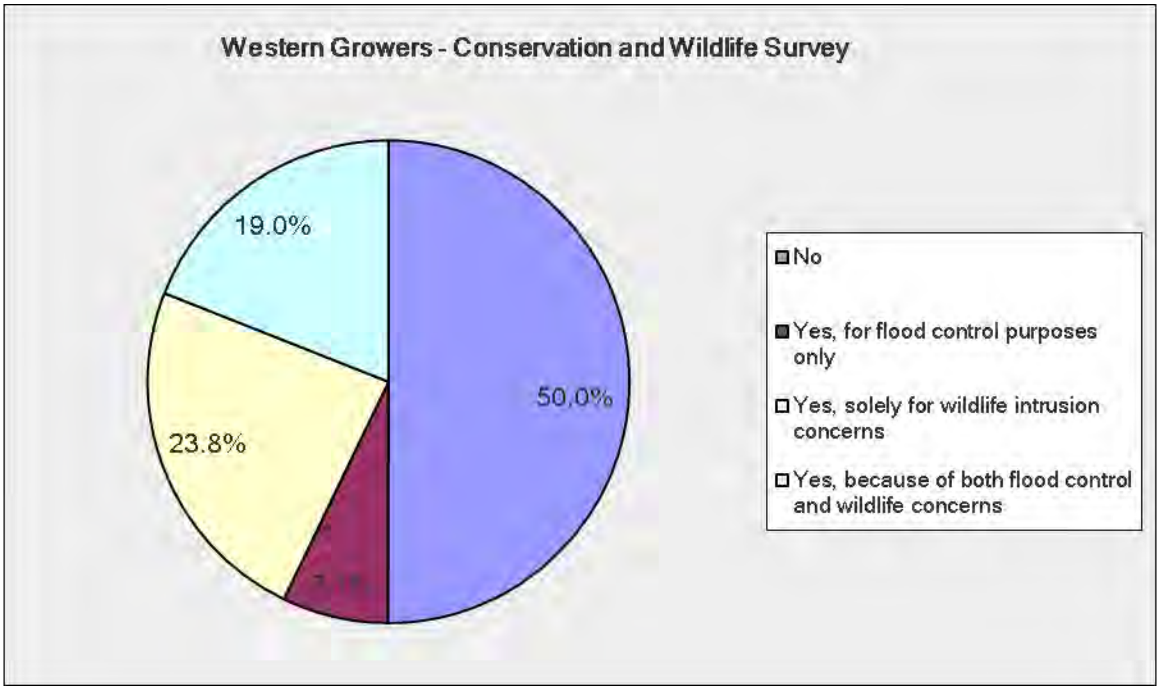


1.10 Vegetative Buffers and Riparian Areas

Many growers have vegetative buffers and riparian areas around their leafy green fields. Maintenance of the buffers is estimated to cost on average between $101 and $250 per acre. Approximately half of the respondents had removed non-crop vegetation as a result of concerns of flood control, wildlife intrusion or both (Figure 9). Wildlife intrusion was the main reason for removing non-crop vegetation. When removing vegetative areas, growers estimate they spend a similar amount per acre annually as they do to maintain vegetative buffers. The majority of growers, who removed vegetative areas, removed less than 0.5 acres if removal was solely for flood control and 0.5 – 5.0 acres if removed solely for wildlife intrusion concerns.

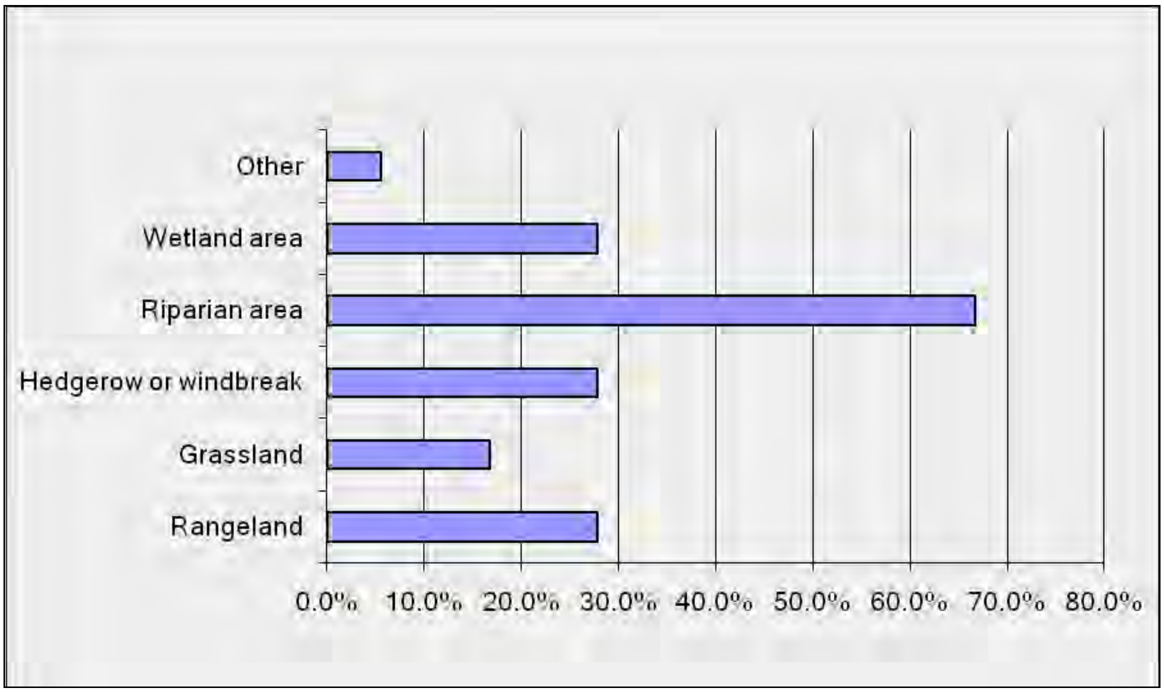
Fewer than 50% of growers said auditors/inspectors identified non-crop vegetation as a potential food safety hazard. Of these growers, half named handlers and CDFA auditors for the LGMA as the auditor/inspector making the identification.

Figure 9. Removal of non-crop vegetation (% of respondents)



When auditors/inspectors identified non-crop vegetation as a hazard or concern, the ones most frequently named were riparian areas (Figure 10). In identifying the areas of concern, most auditors/inspectors named the LGMA food safety practices and customer-specific food safety requirements as the rationale. Handlers who inspected areas identified areas of concern using LGMA food safety practices as frequently as customer-specific food safety requirements. Even when identified as an area of concern, fewer than 11% of the auditors and handlers recommended removing the non-crop vegetation.

Figure 10. Non-crop vegetative areas of concern (% of respondents)



Finally, when asking growers about any specific pratice or remedial action they would recommend as a solution to effectively address both food safety and conservation management, they provided the following suggestions:

Table 4. Grower recommendations for addressing food safety and conservation management

Build deer fencing around ranches.
Add buffers and traps to mitigate concerns
Conservation practices, such as vegetated waterways or sediment ponds have not impacted our food safety risk negatively. We have hedgerows/windbreaks as well, and although they provide habitat, their benefits outweigh this concern, especially in light of our pre-harvest inspections.
Complete use of drip tape. No standing water, minimize some added risks and animal concerns. Increased savings and management of water, higher yields, direct applications for crops.
Fences, placed alfalfa in key places to keep rabbits away from our fields
More portable toilets with better monitoring of cleanliness. Cleaning up debris, sanitation, removal of disease vectors, weed seed sources
Increased usage of grassed water ways as a way of reducing erosion and providing an un-inviting habitat for burrowing rodents.
Silt fences around ponds and along roads
Low profile fences, pre harvest inspection, training
Fencing

2.0 KEY FINDINGS

Based on a review of the questionnaire data, a few preliminary findings were made for further study. They are:

Wildlife environmental assessments – When growers were asked to describe the process they use to identify areas where their leafy green acreage may be at risk from wildlife concerns, the process and frequency varies greatly. Some growers cited the need for a pre-season assessment followed by observation with observations occurring daily or weekly. This is an area where there does not appear to be an agreed upon approach.

Animals of concern – Auditors, buyers and growers appear to be focused on different animals when considering the safety of leafy green produce. Auditors name domestic animals and rodents more frequently as animals of concern; growers name birds and deer as reasons for deciding not to harvest leafy green crops for food safety concerns. Buyers name frogs and wild pigs as the reason for rejecting crops. Based on these discrepancies, there does not appear to be an agreed upon approach to identify animals of concern.

Auditor/inspector practices – The questionnaire results indicate there are differences in terms of guidelines auditors/inspectors use to conduct the audit, how the audits are conducted and hence the rationale for making recommendations and decisions. Growers dealing with multiple auditors/inspectors would benefit from an industry group documenting these differences and providing reference material and training dealing with inconsistencies among auditing entities.

3.0 SUMMARY AND CONCLUSIONS

This report contains highlights of the questionnaire results for use in drafting recommended changes to the California LGMA best practices as part of the CDFA Specialty Crop Block Grant. Once the recommendations have been drafted and approved by a group of industry specialists, they will be published along with a more detailed statistical analysis of the questionnaire results.

APPENDIX A

REFERENCES

(USDA, 2007) USDA National Agricultural Statistics Service, "2007 Census of Agriculture,' United States Summary and State Data, Volume 1, Geographic Area Series, Part 51, Issued February 2009.

SUMMARIES AND ABSTRACTS OF RESEARCH RELEVANT TO CO-MANAGEMENT ISSUES RELATED TO LEAFY GREEN AGRICULTURAL FOOD SAFETY AND CONSERVATION PRACTICES

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1.0 INTRODUCTION

As part of California Department of Food and Agriculture's Specialty Crop Grant Program Grant Agreement #SCB09003, Western Growers and Intertox have prepared a summary of research reports and best management practices relevant to co-management issues between food safety and environmental conservation. This report is responsive to a portion of the revised work plan for that grant, calling for completion of this review and summary by March 31, 2010.

In order to complete this research summary, Intertox reviewed recent reports from conservation and food safety groups to determine where specific co-management issues existed, and then proceeded to search the scientific literature in those areas.[1] Over 120 articles, websites, and studies were reviewed for relevance and those important to understanding the scientific issues have been included. In general, review articles have not been included (although the studies cited in those review articles have been included if relevant); preference was given to peer-reviewed and other scientific journals. In some cases older studies have not been included if more recent, readily available, and relevant studies were found that covered the same issues. If an abstract was available for the study, it was used as the summary (as opposed to developing a new summary of the research results). If the available abstract did not capture the content relevant to this grant, footnotes were added to more fully characterize the research.

In addition to the research summaries, guidelines and agency recommendations for conservation practices were searched, and seven or more government agencies contacted to obtain information on these areas. Food safety best management practices have also been briefly summarized.

The purpose of this research and best management practice summary is two-fold: 1) to inform the development of a questionnaire for growers in California that may be experiencing these types of co-management issues, and 2) to provide background information for an expert panel that will provide recommendations for addressing these issues in the future. The expert panel will be provided this research summary, and the full text of any reference included herein will be available to them as needed.

2.0 RESEARCH AREAS

Research into co-management issues identified that there is one primary driver for co-management issues: the possibility that wildlife might contaminate crops with human pathogens. This possibility has led to two areas that must be addressed by co-management:

1. Co-managing excluding animals from fields with impacting animal migration routes and fragmenting habitats; and

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[1] Beretti, M., *Challenges to Co-Management of Food Safety and Environmental Protection: A Grower Survey*, Resource Conservation District of Monterey County, Salinas, 2009;
Resource conservation District of Monterey County, *A Grower Survey: Reconciling Food Safety and Environmental Protection*, Salinas, 2007;
Lowell, K., et al., *Safe and Sustainable: Co-Managing for Food Safety and Ecological Health in California's Central Coast Region*, San Francisco, Washington, D.C., 2009;
Starmer, E. and Kulick M., *Bridging the GAPs: Strategies to Improve Produce Safety, Preserve Farm Diversity and Strengthen Local Food Systems*, Institute for Agriculture and Trade Policy and Food & Water Watch, Minneapolis and Washington, D.C., 2009.

2. Co-managing riparian buffer strips that may improve water quality with their potential for harboring animals that could impact fields.

There are many different areas of research that must be understood if these types of situations are to be co-managed effectively. These include (but are not limited to) the occurrence rate of foodborne pathogens in wildlife, the possibility that feces may contain human pathogens that, in turn, are transferred to leafy greens, the persistence of pathogens in the environment, the benefits of riparian buffer strips and the removal of pathogens and improvement of water quality by these strips. In addition, it is necessary to understand the best practices involved in these various conservation and food safety measures and how they relate to growers.

2.1 Microbial Occurrence in Wildlife and Other Animals

2.1.1 General

Chapman, P. A., et al., A 1-Year Study of *Escherichia coli* O157 in Cattle, Sheep, Pigs and Poultry, *Epidemiology and Infection*, v. 119: 245-250, 1997.

Samples of rectal feces were collected immediately after slaughter from 400 cattle each month for a 1-year period and from 1000 each of sheep, pigs and poultry over the same period. Samples were examined for *Escherichia coli* O157 by enrichment culture. *E. coli* O157 was isolated from 752 (15.7%) of 4800 cattle, 22 (2.2%) of 1000 sheep and from 4 (0.4%) of 1000 pigs, but not from any of 1000 chickens. Of the cattle sampled, 1840 (38.4%) were prime beef animals, 1661 (34.6%) were dairy animals being culled and the status could not be determined for the other 1299 (27%) animals. *E. coli* O157 was found in 246 (13.4%) of the 1840 beef cattle and 268 (16.1%) of the 1661 dairy cattle. The monthly prevalence of *E. coli* O157 in cattle was 4.8-36.8% and was at its highest in spring and late summer. Seventeen of the 22 isolates from sheep were also made over the summer period. All *E. coli* O157 isolates from sheep and 749 (99.6%) of the 752 *E. coli* O157 isolates from cattle were verocytotoxigenic as determined by Vero cell assay and DNA hybridization, eaeA gene positive, contained a 92 kb plasmid and were thus typical of strains causing infections in man. In contrast isolates from pigs were non-toxigenic, eaeA gene negative and did not contain a 92 kb plasmid and would, therefore, be unlikely to be a source of infection for man.

Hancock, D. D., et al., Multiple Sources of *Escherichia coli* O157 in feedlots and dairy farms in the Northwestern USA, *Preventive Veterinary Medicine*, v. 35: 11-19, 1998.

Samples from cattle, other domestic and wild animals, flies, feeds, and water-troughs were collected from 12 cattle farms and tested for *Escherichia coli* O157. *E. coli* O157 was isolated from bovine fecal samples on all 12 farms with a within herd prevalence ranging from 1.1% to 6.1%. *E. coli* O157 was also found in 1 of 90 (1.1%) equine fecal samples, 2 of 65 (3.1%) canine fecal samples, 1 of 200 pooled bird samples (0.5%), 2 of 60 pooled fly samples (3.3%), and 10 of 320 (3.1%) water-trough sample sets (biofilm and water). No *E. coli* O157 were isolated from 300 rodents, 33 cats, 34 assorted wildlife, or 335 cattle feed samples. Indistinguishable pulsed-field gel electrophoresis patterns of XbaI digested chromosomal DNA and Shiga toxin types were observed for bovine and water-trough isolates from two farms and for one equine and two bovine isolates from one farm.

Jimenez, M., et al., Geographical and temporal dissemination of Salmonellae isolated from domestic animal hosts in the Culiacan Valley, Mexico, *Microbial Ecology*, v. 61, no. 4: 811-820, 2011.

The prevalence and diversity of salmonellae from domestic animal hosts were investigated in the Culiacan Valley, Mexico. A total of 240 farm animal feces (cows, chicken, and sheep) were evaluated for Salmonella spp. presence from July 2008 to June 2009. *Salmonella enterica* subsp. enterica strains were isolated from 76 samples (31.7%), and 20 serotypes were identified being *Salmonella* Oranienburg (25%), *Salmonella* Give (14%), *Salmonella* Saintpaul (12%), and *Salmonella* Minnesota (11%) the most frequent isolates. Twenty-four percent (18/76) of the isolates were resistant to ampicillin. *Salmonella* Oranienburg, *Salmonella* Minnesota, *Salmonella* Give, *Salmonella* Agona, *Salmonella* Weltevreden, and *Salmonella* Newport serotypes showed multiple pulsed-field electrophoresis patterns. *Salmonella* Oranienburg was the dominant serotype in the Culiacan Valley; however, no specific distribution patterns were detected in animal sources or sampling sites. The genetic diversity of salmonellae could be an evidence of the continuous animal exposition to the bacteria. Also, *Salmonella* adaptation in asymptomatic animals could be justified by the development of natural host immunity. This study provides novel information about *Salmonella* population distribution in domestic animals living at tropical areas. The presence of asymptomatic carriers may be critical to understand the routes of transmission of *Salmonella* in areas of high disease prevalence.

Gorski, L., et al., Prevalence, Distribution, and Diversity of *Salmonella enterica* in a Major Produce Region of California, *Applied and Environmental Microbiology*, v. 77, no. 8: 2734-2748, 2011.

A survey was initiated to determine the prevalence of *Salmonella enterica* in the environment in and around Monterey County, CA, a major agriculture region of the United States. Trypticase soy broth enrichment cultures of samples of soil/sediment (n = 617), water (n = 252), wildlife (n = 476), cattle feces (n = 795), and preharvest lettuce and spinach (n = 261) tested originally for the presence of pathogenic *Escherichia coli* were kept in frozen storage and later used to test for the presence of S. enterica. A multipathogen oligonucleotide microarray was employed to identify a subset of samples that might contain *Salmonella* a in order to test various culture methods to survey a larger number of samples. Fifty-five of 2,401 (2.3%) samples yielded *Salmonella*, representing samples obtained from 20 different locations in Monterey and San Benito Counties. Water had the highest percentage of positives (7.1%) among sample types. Wildlife yielded 20 positive samples, the highest number among sample types, with positive samples from birds (n = 105), coyotes (n = 40), deer (n = 104), elk (n = 39), wild pig (n = 41), and skunk (n = 13). Only 16 (2.6%) of the soil/sediment samples tested positive, and none of the produce samples had detectable *Salmonella*. Sixteen different serotypes were identified among the isolates, including *S. enterica* serotypes Give, Typhimurium, Montevideo, and Infantis. Fifty-four strains were sensitive to 12 tested antibiotics; one S. Montevideo strain was resistant to streptomycin and gentamicin. Pulsed-field gel electrophoresis (PFGE) analysis of the isolates revealed over 40 different pulsotypes. Several strains were isolated from water, wildlife, or soil over a period of several months, suggesting that they were persistent in this environment.

Sanchez, S., et al., Animal Issues Associated with *Escherichia coli* O157:H7, *Journal of the American Veterinary Medical Association*, v. 221, no. 8: 1122-1126, 2002.

Since *Escherichia coli* O157:H7 was first recognized in 1982 as a human pathogen, considerable progress has been made in elucidating principal vehicles of transmission. Cattle have been identified as a major source of *E. coli* O157:H7 infection of humans, with as many as 1 in 4 animals at slaughter shedding the pathogen in feces during the summer months.

Case control studies of sporadic cases of *E. coli* O157:H7 infection in the United States, Canada, and Europe have identified eating undercooked ground beef, visiting farms, and handling animals on the farm as principal risk factors for infection. Cattle manure, of which an estimated 1.2 billion tons are produced annually in the United States, appears to be a principal source of the *E. coli* O157:H7 problem. Animals, water, and food that contact cattle manure are potential vehicles of *E. coli* O157:H7. An effective control program to substantially reduce *E. coli* O157:H7 infections will require the implementation of intervention strategies throughout the food continuum, from farm to table. Promising intervention measures at the farm include competitive exclusion bacteria, bacteriophage, and targeted animal management practices addressing common points of contamination. Innovative intervention treatments are under development for use by food processors; however, most treatments have limitations that restrict their use to specific types of foods. For example, irradiation can create major off odors and flavors in foods that contain more than 10% fat. Consumers also have a role in implementing intervention controls in food handling and preparation. Unfortunately, many consumers eat high-risk foods, improperly handle and store foods, and ignore warnings regarding foods known to be unsafe. We all have a role in reducing the risk of foodborne illness, including *E. coli* O157:H7 infections, but clearly more needs to be done on the farm, including validating proposed and developing innovative on-farm control measures.

Scaife, H., Wild Rabbits as Potential Carriers of *E. coli* VTEC – Final Report, Health & Safety Laboratory, 2005.

Dairy and beef farms within a 30 mile radius of York were contacted. Those which had a resident rabbit population were invited to participate in the project. Of the sixteen farms initially visited, five were found to be positive for *E.coli* 0157 by both culture on selective agar and PCR and a further two farms were found to be positive by PCR alone. Rabbits were trapped from six farms, the rabbit population at the seventh farm being too small at the time of trapping. None of the 32 samples of rabbit faeces collected in late winter were found to be *E. coli* 0157 positive. Further sampling in summer revealed rabbits at both farms were excreting *E. coli* 0157 and two of the further four farms had *E. coli* 0157 positive rabbits. This suggests there may be a seasonal effect on the ability of rabbits to excrete *E. coli* 0157. Of the 97 samples collected in the summer, eight (8.25%) were positive for *E. coli* 0157 and twenty (20.6%) were positive for VTEC including non-0157 VTEC. All the positive samples were from female rabbits and although not statistically significant, the body condition index of infected rabbits were slightly lower than uninfected rabbits. It cannot be determined from this study whether rabbits become colonized by *E. coli* 0157, however the results have given an early indication that when rabbits are in contact with *E. coli* 0157 positive cattle, it is likely that their fecal pellets will contain *E. coli* 0157.

Shere, J.A., et al., Longitudinal Study of *Escherichia coli* O157:H7 Dissemination on Four Dairy Farms in Wisconsin, *Applied and Environmental Microbiology*, v. 64, no. 4: 1390-1399, 1998.

A 14-month longitudinal study was conducted on four dairy farms (C, H, R, and X) in Wisconsin to ascertain the source(s) and dissemination of *Escherichia coli* O157:H7. A cohort of 15 heifer calves from each farm was sampled weekly by digital rectal retrieval from birth to a minimum of 7 months of age (range, 7 to 13 months). Over the 14 months of the study, the cohort heifers and other randomly selected cattle from farms C and H tested negative. Farm R had two separate periods of *E. coli* O157:H7 shedding lasting 4 months (November 1995 to February 1996) and 1 month (July to August 1996), while farm X had at least one positive cohort animal for a 5-month period (May to October 1996). Heifers shed

O157:H7 strains in feces for 1 to 16 weeks at levels ranging from 2.0×10^2 to 8.7×10^4 CFU per g. *E. coli* O157:H7 was also isolated from other noncohort cattle, feed, flies, a pigeon, and water associated with the cohort heifers on farms R and/or X. When present in animal drinking water, *E. coli* O157:H7 disseminated through the cohort cattle and other cattle that used the water source. *E. coli* O157:H7 was found in water at <1 to 23 CFU/ml. Genomic subtyping by pulsed-field gel electrophoresis demonstrated that a single O157:H7 strain comprised a majority of the isolates from cohort and noncohort cattle, water, and other positive samples (i.e., from feed, flies, and a pigeon, etc.) on a farm. The isolates from farm R displayed two predominant XbaI restriction endonuclease digestion profiles (REDP), REDP 3 and REDP 7, during the first and second periods of shedding, respectively. Six additional REDP that were >89% similar to REDP 3 or REDP 7 were identified among the farm R isolates. Additionally, the REDP of an O157:H7 isolate from a heifer on farm R in 1994 was indistinguishable from REDP 3. Farm X had one O157:H7 strain that predominated (96% of positive samples had strains with REDP 9), and the REDP of an isolate from a heifer in 1994 was indistinguishable from REDP 9. These results suggest that *E. coli* O157:H7 is disseminated from a common source on farms and that strains can persist in a herd for a 2-year period.

Valcour, J.E., et al., Associations between Indicators of Livestock Farming Intensity and Incidence of Human Shiga Toxin-Producing *Escherichia coli* Infection, *Emerging Infectious Diseases*, v. 8, no. 3: 252-257, 2002.[2]

The impact of livestock farming on the incidence of human Shiga toxin-producing *Escherichia coli* (STEC) infection was assessed by using several livestock density indicators (LDI) that were generated in a systematic approach. A total of 80 LDI were considered suitable proxy measures for livestock density. Multivariate Poisson regression identified several LDI as having a significant spatial association with the incidence of human STEC infection. The strongest associations with human STEC infection were the ratio of beef cattle number to human population and the application of manure to the surface of agricultural land by a solid spreader and by a liquid spreader. This study demonstrates the value of using a systematic approach in identifying LDI and other spatial predictors of disease.

2.1.2 Deer

Cody, S. H., et al., An Outbreak of *Escherichia coli* O157:H7 from Unpasteurized Commercial Apple Juice, *Annals of Internal Medicine,* v. 130, no. 3: 202-209, 1999.

Escherichia coli O157:H7 infections have traditionally been associated with animal products, but outbreaks associated with produce have been reported with increasing frequency. In fall 1996, a small cluster of *E. coli* O157:H7 infections were epidemiologically linked to a particular brand (brand A) of unpasteurized apple juice. The objective of this study was to define the extent of the outbreak in the Western United States and British Columbia, Canada, confirm the source, and determine how the apple juice became contaminated using a descriptive epidemiologic study and trace back investigation. Seventy persons with *E. coli* O157:H7 infection and exposure to brand A unpasteurized apple juice were identified. Of these persons, 25 (36%) were hospitalized, 14 (20%) developed the hemolytic uremic syndrome, and 1 (1%) died. Recalled apple juice that was produced on 7 October 1996 grew *E. coli* O157:H7 with a pulsed-field gel electrophoresis pattern indistinguishable from that of

[2] This study has also been used as evidence of wildlife playing "a modest, or no role" in transmitting *E. coli*. As with Rangel et al. 2005, wildlife are not mentioned at all in this study.

case isolates. Apple juice produced on 7 October 1996 accounted for almost all of the cases, and the source of contamination was suspected to be incoming apples.

Three lots of apples could explain contamination of the juice: Two lots originated from an orchard frequented by deer that were subsequently shown to carry *E. coli* O157:H7, and one lot contained decayed apples that had been waxed. Standard procedures at a state-of-the-art plant that produced unpasteurized juices were inadequate to eliminate contamination with *E. coli* O157:H7. This outbreak demonstrated that unpasteurized juices must be considered a potentially hazardous food and led to widespread changes in the fresh juice industry.

Fischer, J. R., et al., Experimental and Field Studies of *Escherichia coli* O157:H7 in White-Tailed Deer, *Applied and Environmental Microbiology*, v. 67, no. 3: 1218-1224, 2001.

Studies were conducted to evaluate fecal shedding of *Escherichia coli* O157:H7 in a small group of inoculated deer, determine the prevalence of the bacterium in free-ranging white-tailed deer, and elucidate relationships between *E. coli* O157:H7 in wild deer and domestic cattle at the same site. Six young, white-tailed deer were orally administered 108 CFU of *E. coli* O157:H7. Inoculated deer were shedding *E. coli* O157:H7 by 1 day postinoculation (DPI) and continued to shed decreasing numbers of the bacteria throughout the 26-day trial. Horizontal transmission to an uninoculated deer was demonstrated. Although *E. coli* O157:H7 bacteria were recovered from the gastrointestinal tracts of deer necropsied from 4 to 26 DPI, attaching and effacing lesions were not apparent in any deer. Results are similar to those of inoculation studies in calves and sheep. In field studies, *E. coli* O157 was not detected in 310 fresh deer fecal samples collected from the ground. It was detected in feces, but not in meat, from 3 of 469 free-ranging deer in 1997. In 1998, *E. coli* O157 was not detected in 140 deer at the single positive site found in 1997; however, it was recovered from 13 of 305 dairy and beef cattle at the same location. Isolates of *E. coli* O157:H7 from deer and cattle at this site differed with respect to pulsed-field gel electrophoresis patterns and genes encoding Shiga toxins. The low overall prevalence of *E. coli* O157:H7 and the identification of only one site with positive deer suggest that wild deer are not a major reservoir of *E. coli* O157:H7 in the southeastern United States. However, there may be individual locations where deer sporadically harbor the bacterium, and venison should be handled with the same precautions recommended for beef, pork, and poultry.

Gilbreath, J. J., et al., Shiga Toxins, and the Genes Encoding Them, in Fecal Samples from Native Idaho Ungulates, *Applied and Environmental Microbiology*, v. 75, no. 3: 862-865, 2009.

Cattle are a known reservoir of Shiga toxin-producing Escherichia coli. The prevalence and stability of Shiga toxin and/or Shiga toxin genes among native wild ungulates (live mule deer and elk) in Idaho were investigated. The frequency of both Shiga genes and toxin was similar to that reported for Idaho cattle (~19%).

Keene, W. E., et al., An Outbreak of *Escherichia coli* O157:H7 Infections Traced to Jerky Made from Deer Meat, *Journal of the American Medical Association*, v. 277, no. 15: 1229-1231, 1997.

The objective of this study was to investigate a 1995 outbreak of *Escherichia coli* O157:H7 infections and to assess the safety of meat dehydration methods. A survey in the impacted Oregon community was conducted subsequent to a routine surveillance report and environmental investigation. The survey was used with members of extended households and their social contacts with confirmed or presumptive *E. coli* O157:H7 infections. A total of 6 confirmed and 5 presumptive cases were identified. Homemade venison jerky was implicated as the source of transmission. *E. coli* 0157:H7 with the same distinctive, pulsed-field gel electrophoresis pattern seen in the case isolates was recovered from leftover jerky, uncooked meat from the same deer, a saw used to dismember the carcass, and fragments of the deer hide. In a subsequent survey, *E. coli* O157:H7 was recovered from 3 (9%) of 32 deer fecal pellets collected in nearby forest land. In the laboratory, inoculated venison was dried at several time and temperature combinations, ranging up to 10 hours at 62.8º C. Viable organisms were recovered under all conditions tested. Deer can be colonized by *E. coli* O157:H7 and can be a source of human infections. Conditions necessary to ensure the safety of dried meat deserve further review. Game should be handled with the same caution indicated for commercially slaughtered meat.

Morse, H., Press Release: *Preliminary Research Results Find less than One Half of One Percent Occurrences of E. coli O157:H7 in Wildlife in California Central Coast Counties*, California Department of Fish and Game, April 7, 2009. www.dfg.ca.gov/news/news09/2009040702.asp. [3]

Preliminary results from a joint *E. coli* environmental study found less than one half of one percent of 866 wild animals tested positive for *Escherichia coli* O157:H7 in Central California. The study of water, soil, livestock and wildlife is being conducted by the University of California, Davis, the California Department of Fish and Game (DFG) and U.S. Department of Agriculture (USDA). It investigates the occurrence of the strain of *E. coli* that caused the disease outbreak in California agricultural fields in 2006.

From 2007 through 2008, the research team collected 866 wildlife samples, including 311 black-tailed deer, 184 wild pig, 73 birds, 61 rabbits, 58 tule elk, 52 ground squirrels, 51 coyotes, 24 mice, 19 raccoons, 17 opossums and 16 striped skunks. Of the 866 animals sampled, 862 tested negative. The four positive samples included: one wild pig, one coyote and two tule elk. These findings are preliminary and the research team will continue to collect and test a total of 2,400 wildlife samples from this region.

Sargeant, J.M., et al., Prevalence of *Escherichia coli* O157:H7 in White-Tailed Deer Sharing Rangeland with Cattle, *Journal of the American Veterinary Medical Association*, v. 215, no. 6: 792-794, 1999.

The objective of this survey study was to determine the prevalence of fecal shedding of *Escherichia coli* O157:H7 in white-tailed deer (*Odocoileus virginianus*) with access to cattle pastures. Fresh fecal samples (n=212) from free ranging white-tailed deer were collected on multiple pastures from 2 farms in north central Kansas between September 1997 and April 1998. *Escherichia coli* O157:H7 was identified by bacterial culture and DNA-based methods. *Escherichia coli* O157:H7 was identified in 2.4% (5/212) of fecal samples. There is considerable interest in the beef industry in on-farm control of *Escherichia coli* O157:H7 to reduce the risk of this pathogen entering the human food chain. Results of our study suggest that the design of programs for *Escherichia coli* O157:H7 control in domestic livestock on pasture will need to account for fecal shedding in free-ranging deer. In addition, the results have implications for hunters, people consuming venison, and deer-farming enterprises.

[3] The primary researcher was contacted to determine if additional details were available. At this time, the above press release is the only summary of this research.

2.1.3 Birds

Brittingham, M. C., et al., A Survey of the Prevalence of Selected Bacteria in Wild Birds, *Journal of Wildlife Diseases*, v. 24, no. 2: 299-307, 1988.

We determined the prevalence of six genera of bacteria from a sample of 387 cloacal swabs from 364 passerines and woodpeckers. The prevalence of bacteria were as follows: *Escherichia coli* (1%), Pseudomonas spp. (22%), Salmonella spp. (0%), Staphylococcus spp. (15%), Streptococcus spp. (18%), and *Yersinia* spp. (1%). The prevalence of Streptococcus spp. was higher in omnivorous species than in granivorous species (20% versus 8%). Individuals captured at feeders had a lower prevalence of both Streptococcus spp. (15% versus 33%) and *Escherichia coli* (0.5% versus 4%) than birds that did not have access to feeders. These differences are probably not due to the feeder per se, but instead to other site related differences. The prevalence of bacteria did not differ between male and female black-capped chickadees, *Parus atricapillus*. For 279 color marked black-capped chickadees, we calculated the cumulative mortality rate during 12 wk following swabbing. Although the cumulative mortality rates of infected birds were consistently higher than the rates of non-infected birds, none of these differences were significant. Infections may cause slight reductions in survival rates, but we were not able to confirm this with our data.

Carlson JC, Engeman RM, Hyatt DR, Gilliland RL, DeLiberto TJ, Clark L, Bodenchuk MJ, Linz GM. Efficacy of European starling control to reduce Salmonella enterica contamination in a concentrated animal feeding operation in the Texas panhandle. *BMC Veterinary Research*. 7:9. 2011 Feb

European starlings (Sturnus vulgaris) are an invasive bird species known to cause damage to plant and animal agriculture. New evidence suggests starlings may also contribute to the maintenance and spread of diseases within livestock facilities. Identifying and mitigating the risk pathways that contribute to disease in livestock is necessary to reduce production losses and contamination of human food products. To better understand the impact starlings have on disease transmission to cattle we assessed the efficacy of starling control as a tool to reduce Salmonella enterica within a concentrated animal feeding operation. We matched a large facility, slated for operational control using DRC-1339 (3-chloro-4-methylaniline hydrochloride, also 3-chloro p-toluidine hydrochloride, 3-chloro-4-methylaniline), with a comparable reference facility that was not controlling birds. In both facilities, we sampled cattle feed, cattle water and cattle feces for S. enterica before and after starling control operations.
RESULTS: Within the starling-controlled CAFO, detections of S. enterica contamination disappeared from feed bunks and substantially declined within water troughs following starling control operations. Within the reference facility, detections of S. enterica contamination increased substantially within feed bunks and water troughs. Starling control was not observed to reduce prevalence of S. enterica in the cattle herd. Following starling control operations, herd prevalence of S. enterica increased on the reference facility but herd prevalence of S. enterica on the starling-controlled CAFO stayed at pretreatment levels.
CONCLUSIONS: Within the starling-controlled facility detections of S. enterica disappeared from feed bunks and substantially declined within water troughs following control operations. Since cattle feed and water are obvious routes for the ingestion of S. enterica, starling control shows promise as a tool to help livestock producers manage disease. Yet, we do not believe starling control should be used as a stand alone tool to reduce S. enterica

infections. Rather starling control could be used as part of a comprehensive disease management plan for concentrated animal feeding operations.

Fenlon, D.R., Seagulls (Larus spp.) as vectors of salmonellae: An Investigation into the Range of Serotypes and Numbers of Salmonellae in Gull Faeces, *The Journal of Hygiene*, v. 86: 195, 1981.

Of 1242 samples of seagulls faeces examined, 12.9% were found to contain salmonellae. The number of positive samples was significantly higher (17-21%) near sewage outfalls. Twenty-seven serotypes were isolated, including a new serotype named Salmonella Grampian. The range and frequency of serotypes carried by gulls was similar to those in the human population, suggesting sewage as a possible source of gull infection.

The number of salmonellae found in positive samples was low (0.18-191 g^{-1} faeces). This was similar to the numbers found in sewage, 10-80 l^{-1}, suggesting gulls may only carry infected material without infecting themselves. Antibiotic resistance in the isolates was low, only 21 showing resistance to the antibiotics tested, although most of these were determined by resistance transfer plasmids.

Somarelli, J.A., et al., Wildlife Identified as Major Source of *Escherichia coli* in Agriculturally Dominated Watershed by BOX A1R-derived Genetic Fingerprints, *Journal of Environmental Management*, v. 82: 60-65, 2007.

The presence of *Escherichia coli* in recreational and potable waters is a major concern to the general public as elevated levels of *E. coli* suggest the presence of pathogenic bacteria and viruses. Unfortunately, traditional microbial techniques do not allow specific identification of the source of *E. coli*. This reduces the ability to target management practices that reduce bacterial contamination. In the Finger Lakes region of western New York, USA, wildlife resides in relatively high densities on watersheds dominated by people and dairy farms, and as a result, the sources of fecal degradation of potable and recreational waters are often unknown. In the Conesus Lake watershed, the sources of microbial contamination were assessed using Rep-PCR molecular tools, a method of amplifying repetitive DNA sequences found throughout the *E. coli* genome to produce distinct fingerprints for a given ecotype. Molecular fingerprints of *E. coli* isolated from regional populations of cattle, humans, geese and deer were compared to *E. coli* isolated from stream water samples. Canonical discriminant function analysis indicated that the DNA fingerprints of the original source group isolates were correctly predicted 90.2% of the time. Since land use in the sub-watersheds was dominated by dairy and cash crop farms, it was expected that the majority of *E. coli* isolated would be identified as cows; however, an unexpectedly high percentage of isolates were identified as wildlife (geese and deer). Geese were the dominant source of *E. coli* (44.7–73.7% of the total sources) in four sub-watersheds followed by cows (10.5–21.1%), deer (10.5–18.4%), humans (5.3–12.9%) and unidentifiable sources (0.0–11.8%). Management practices intended to decrease the number of cattle or the amount of manure spread in a sub-watershed were reflected in a decrease of *E. coli* ecotypes associated with dairy cows.

2.1.4 Domestic and Wild Pigs

Feder, I., et al., Isolation of *Escherichia coli* O157:H7 from Intact Colon Fecal Samples of Swine, *Emerging Infectious Diseases*, v. 9, no. 3: 380-383, 2003.

During the past two decades, disease caused by *Escherichia coli* O157:H7 has been increasing. Although cattle feces are the most important source of *E. coli* O157:H7, the need to evaluate the presence of *E. coli* O157:H7 in the feces of other animal species has been recognized. The presence of *E. coli* O157:H7 in swine feces has been reported in Japan, Norway, and Chile; however, to date, *E. coli* O157:H7 has not been reported in swine in the United States. Colon samples were collected at a cooperating swine slaughter facility from 305 swine carcasses during evisceration. Results from this study demonstrate that pigs in the United States can harbor *E. coli* O157:H7. The recovery rate of *E. coli* O157:H7 from colon fecal samples of pigs reported in this study was 2.0% (6/305). Previous attempts to isolate *E. coli* O157:H7 from swine feces in the United States have been unsuccessful (12,14). Use of more appropriate methods for sampling, processing, and culturing swine feces may have accounted for the ability to recover and isolate *E. coli* O157:H7 from swine feces in our study.

Jay, M. T., et al., *Escherichia coli* O157:H7 in Feral Swine Near Spinach Fields and Cattle, Central California Coast, *Emerging Infectious Diseases*, v. 13, no. 12: 1908-1911, 2007.

We investigated involvement of feral swine in contamination of agricultural fields and surface waterways with *Escherichia coli* O157:H7 after a nationwide outbreak traced to bagged spinach from California. Isolates from feral swine, cattle, surface water, sediment, and soil at 1 ranch were matched to the outbreak strain. Recent experimental and epidemiologic studies suggest that domestic pigs are biologically competent hosts and a potential reservoir of *Escherichia coli* O157:H7. Cattle are considered the primary reservoir of *E. coli* O157, but fecal shedding by other domestic livestock and wildlife has been described. *E. coli* O157 was isolated from a wild boar in Sweden, but there is limited information on its occurrence in feral swine in the United States.

Feral swine were live-captured in traps or hunted and humanely killed during October–November 2006 in the area near the ranch associated with the outbreak. Two feral swine corral traps were placed 1.4 km apart, and 1.7 km (trap 1) and 1.2 km (trap 2), respectively, from the implicated spinach field. Colonic fecal samples were collected from 40 feral swine (31 live-captured, 9 hunted); buccal swabs, rectal- anal swabs, and tonsils were analyzed from a subset of 8 animals. Additionally, feces from domestic animals (cattle, dog, goat, horse, sheep) and wildlife (bird, coyote, deer, feral swine), surface water and sediment, soil, and well/irrigation water were analyzed. We describe the first, to our knowledge, isolation of *E. coli* O157 from feral swine in the United States. The percentage of specimens positive for *E. coli* O157 among feral swine (14.9%) and cattle (33.8%) and the density (4.6 swine/km^2) were high compared with results of previous ecologic studies.

Atwill, E. R., et al., Prevalence of and Associated Risk Factors for Shedding Cryptosporidium parvum Oocysts and Giardia Cysts within Feral Pig Populations in California, *Applied and Environmental Microbiology*, v. 63, no. 10: 3946-3949, 1997.

Populations of feral pigs (*Sus scrofa)* may serve as an environmental reservoir of *Cryptosporidium parvum* oocysts and *Giardia* sp. cysts for source water. We conducted a cross-sectional study to determine the prevalence of and associated demographic and environmental risk factors for the shedding of *C. parvum* oocysts and *Giardia* sp. cysts. Feral pigs were either live-trapped or dispatched from 10 populations located along the coastal mountains of western California, and fecal samples were obtained for immunofluorescence detection of *C. parvum* oocysts and *Giardia* sp. cysts. We found that 12 (5.4%) and 17 (7.6%) of 221 feral pigs were shedding *C. parvum* oocysts and *Giardia* sp. cysts, respectively. The pig's sex and body condition and the presence of cattle were not associated with the probability of the shedding of *C. parvum* oocysts. However, younger pigs (<8 months) and pigs from high-density populations (>2.0 feral pigs/km2) were significantly more likely to shed oocysts compared to older pigs (>8 months) and pigs from low-density populations (<1.9 feral pigs/km^2). In contrast, none of these demographic and environmental variables were associated with the probability of the shedding of *Giardia* sp. cysts among feral pigs. These results suggest that given the propensity for feral pigs to focus their activity in riparian areas, feral pigs may serve as a source of protozoal contamination for surface water.

2.1.5 Insects

Talley, J. L., et al., Association of *Escherichia coli* O157:H7 with Filth Flies (Muscidae and Calliphoridae) Captured in Leafy Greens Fields and Experimental Transmission of *E. coli* O157:H7 to Spinach leaves by House Flies (Diptera: Muscidae), *Journal of Food Protection,* v. 72, no. 7: 1547-1552, 2009.

The recent outbreak of *Escherichia coli* O157:H7 infection associated with contaminated spinach led to an investigation of the role of insects, which frequent fields of leafy greens and neighboring rangeland habitats, in produce contamination. Four leafy greens fields adjacent to cattle-occupied rangeland habitats were sampled using sweep nets and sticky traps. Agromyzid flies, anthomyiid flies, and leafhoppers were caught consistently in both rangeland and leafy greens production fields at all sites. An unexpected number of flies (*n* _ 34) in the Muscidae and Calliphoridae families (known as filth flies because of their development in animal feces) were caught in one leafy greens field. A subset of these filth flies were positive (11 of 18 flies) for *E. coli* O157:H7 by PCR amplification using primers for the *E. coli* O157:H7–specific *eae* gene. Under laboratory conditions, house flies were confined on manure or agar medium containing *E. coli* O157:H7 tagged with green fluorescent protein (GFP) and then tested for their capacity to transfer the microbes to spinach plants. GFP-tagged bacteria were detected on surfaces of 50 to 100% of leaves examined by fluorescence microscopy and in 100% of samples tested by PCR. These results indicate that flies are capable of contaminating leafy greens under experimental conditions and confirm the importance of further investigation of the role of insects in contamination of fresh produce**.**

2.2 Mitigation Strategies for Animal Control

Belant, J. L., et al., Predator Urines as Chemical Barriers to White-tailed Deer, Proceedings of the 18th Vertebrate Pest Conference, 359-362, 1998.

The authors assessed whether bobcat (Lynx rufus) or coyote (Canis latrans) urine could reduce white-tailed deer (Odocoileus virginianus) use of established feeding areas or trails. A four-week experiment evaluating deer use of eight feeding stations, four each with coyote or bobcat urine was conducted at a 2,200 ha fenced facility in northern Ohio with high deer densities (38Ik1d). At this same facility, the authors also monitored deer use of four trails where coyote urine was applied. For both experiments, urine was placed in holders positioned at ground level within 2 m of the area being protected. The number of deer entering feeding stations after two weeks exposure to predator urines was 15 to 24% less (P <0.05) than the number of deer entering feeding stations during pretreatment. Deer use of trails did not decrease in response to presence of coyote urine. It was concluded that predator urines used as a chemical barrier were of limited effectiveness in deterring high concentrations of white-tailed deer from areas with established sources of food and ineffective in deterring deer from trails.

Jay, M. T., et al., Food Safety Risks and Mitigation Strategies for Feral Swine (*Sus scrofa*) near Agriculture Fields, Proceedings of the 23rd Vertebrate Pest Conference, 21-25, 2008.

Feral swine may harbor the causative agents of important foodborne diseases such as brucellosis, cryptosporidiosis, salmonellosis, and trichinosis. We described recently the isolation of *Escherichia coli* O157:H7 from feral swine in the central California coast during an investigation of a nationwide outbreak associated with consumption of contaminated fresh baby spinach. Additionally, the foodborne pathogen Campylobacter was found in tissues and feces from the same population of feral swine. Feral swine are the most abundant free-roaming ungulate in the United States, and their range in California continues to expand, with the highest numbers reported on the central coast. The expansion of feral swine in mainland California and concomitant damage to agriculture and public health underscore the need for mitigation strategies. A number of lethal and non-lethal methods for feral swine management have been described, including hunting, depredation, trapping, and exclusion such as fencing. This paper reviews current concerns relating to food safety and feral swine. The advantages and potential pitfalls of mitigation strategies to reduce the risk of contamination of raw vegetable commodities by free-roaming feral swine are discussed. A combination of hunting, trapping, and fencing are recommended as effective management strategies. Due to their mobility and large home range, habitat removal is not recommended as an effective control strategy for feral swine.

Nugent, B., et al., Managing Gulls to Reduce Fecal Coliform Bacteria in a Municipal Drinking Water Source, Proceedings of the 23rd Vertebrate Pest Conference, 26-30, 2008.

One of the major issues regarding uses of rodent control techniques including baits, traps, buffer strips and vegetation clearing in areas around leafy green production is that the target rodent species is generally unknown. Bare ground strips (buffer strips) are used to separate the leafy green crop from the rodents. While this is a recommended strategy for damage prevention, little is known about the size of strip needed to provide enough separation (Clark 1995). In most cases, bare strips are maintained around leafy green crops without knowing the target species. Without knowing the target animal and the strip size needed to provide separation, this approach may be creating signification vegetation-free areas that are having little impact on potential crop contamination. Bare ground strips (buffer strips) are used to separate the leafy green crop from the rodents. While this is a recommended strategy for damage prevention, little is known about the size of strip needed to provide enough separation (Clark 1995). In most cases, bare strips are maintained around leafy green crops without knowing the target species. Without knowing the target animal and the strip size needed to provide separation, this approach may be creating signification vegetation-free areas that are having little impact on potential crop contamination. Poison baits were the most commonly adopted wildlife mitigation measure (RCDMC 2007). While rodents are not listed as animals of significant risk, poison baits used must be targeted at them, since California allows use of poison bait for very few animals other than rodents. However, at a recent grower meeting, several indicated that baits were also being used to control birds, despite the fact that no bird poisons are registered for this use. In traveling through California's Central Coastal growing region, it is now (2008) common to see leafy green fields boarders lined with PVC bait stations. Presumably these bait stations contain first-generation anticoagulant materials, which are commonly used in agricultural settings. However, the target animals and overall bait usage is unknown. Indiscriminate and excessive use of anticoagulants can result in increased hazards to wildlife (Salmon 2007) and, while rare in field rodent situations, anticoagulant resistance (Salmon and Lawrence 2006a). The cost of baiting is also significant…while the benefit is largely unknown.

Salmon, T. P., Rodents, Rodent Control, and Food Safety, Proceedings of the 23rd Vertebrate Pest Conference, 16-19, 2008.
Large numbers of ring-billed gulls, herring gulls, and greater black-backed gulls roost each night on a municipal drinking water source in Maine and have been identified as the primary source of elevated fecal coliform bacteria levels. The lake has a resident gull population of approximately 800, while more than 3,000 gulls have been observed during seasonal migration. To alleviate this public health concern, the U.S. Department of Agriculture APHIS Wildlife Services program implemented an Integrated Wildlife Damage Management program in 2005. The program included the use of pyrotechnics and watercraft to harass gulls, as well as shooting to reinforce and enhance the effectiveness of non-lethal methods. Management activities were effective in keeping gulls off the drinking water source and lowering coliform bacteria levels to within EPA water quality standards. Additionally, the integrated program also involves an ongoing survey in areas surrounding the lake to identify feeding, loafing, and roosting areas that may affect gull movement. Information collected from the survey will result in more effective management practices and contribute to the long-term goal of reducing gull use on the lake.

2.3 Environmental Fate and Transfer

2.3.1 Water

Cooley, M., et al., Incidence and Tracking of *Escherichia coli* O157:H7 in a Major Produce Production Region in California, *PLoS ONE*, no. 11: 1-16, 2007.

Fresh vegetables have become associated with outbreaks caused by *Escherichia coli* O157:H7 (EcO157). Between 1995–2006, 22 produce outbreaks were documented in the United States, with nearly half traced to lettuce or spinach grown in California. Outbreaks between 2002 and 2006 induced investigations of possible sources of pre-harvest contamination on implicated farms in the Salinas and San Juan valleys of California, and a survey of the Salinas watershed. EcO157 was isolated at least once from 15 of 22 different watershed sites over a 19 month period. The incidence of EcO157 increased significantly when heavy rain caused an increased flow rate in the rivers. Approximately 1000 EcO157 isolates obtained from cultures of 100 individual samples were typed using Multi-Locus Variable-number-tandem-repeat Analysis (MLVA) to assist in identifying potential fate and transport of EcO157 in this region. A subset of these environmental isolates was typed by Pulse Field Gel Electrophoresis (PFGE) in order to make comparisons with human clinical isolates associated with outbreak and sporadic illness. Recurrence of identical and closely related EcO157 strains from specific locations in the Salinas and San Juan valleys suggests that transport of the pathogen is usually restricted. In a preliminary study, EcO157 was detected in water at multiple locations in a low-flow creek only within 135 meters of a point source. However, possible transport up to 32 km was detected during periods of higher water flow associated with flooding. During the 2006 baby spinach outbreak investigation, transport was also detected where water was unlikely to be involved. These results indicate that contamination of the environment is a dynamic process involving multiple sources and methods of transport. Intensive studies of the sources, incidence, fate and transport of EcO157 near produce production are required to determine the mechanisms of pre-harvest contamination and potential risks for human illness.

2.3.2 Leaf Uptake

Koike, S., et al., Examination of the survival and internalization of E. coli on spinach under field production environments, Final report for Center for Produce Safety, 2010. https://cps.ucdavis.edu/amass/documents/researchproject/106/Koike_CPS%202008_Final%20Report_4-1-10.pdf

In this field experiment, conducted twice, we applied controlled dose contamination to emerged and developing spinach leaves at First True Leaf (FTL), FTL + 7 days, and FTL + 14 days. For plants treated at FTL stage, recovery from collected leaves was possible only from 1 of 3 and 2 of 3 composite samples taken from the 576 and 57,600 MPN/100 ml doses in Trial 1 (September 2009) and none recovered in Trial 2 (October 2009). Within 2 weeks all applied bacteria were not detectable. For plants treated at FTL +7, only 1 of 3 samples yielded detectable populations from the 57,600 MPN/100 ml dose of generic E. coli in Trail 1 and 2. Lastly, for plants treated at FTL + 14 days, E. coli O157:H7rif strains were detected in 1 of 3 or 2 of 3 samples at the 235 and 576 or 57,600 MPN/100 ml dose, respectively in Trial 1 but were not detectable in Trial 2. At FTL+14, generic E. coli were not detectable in Trial 1 but recoverable in 3 of 3 and 1 of 3 samples from 5,760 and 57,600 MPN/100 ml doses, respectively.

Mitra, R., et al., Effect of Route of Introduction and Host Cultivar on the Colonization, Internalization, and Movement of the Human Pathogen *Escherichia coli* O157:H7 in Spinach, *Journal of Food Protection,* v. 72, no. 7: 1521-1530, 2009.

Human pathogens can contaminate leafy produce in the field by various routes. We hypothesized that interactions between *Escherichia coli* O157:H7 and spinach are influenced by the route of introduction and the leaf microenvironment. *E. coli* O157:H7 labeled with green fluorescent protein was dropped onto spinach leaf surfaces, simulating bacteria-laden raindrops or sprinkler irrigation, and survived on the phylloplane for at least 14 days, with increasing titers and areas of colonization over time. The same strains placed into the rhizosphere by soil infiltration remained detectable on very few plants and in low numbers (102 to 106 CFU/g fresh tissue) that decreased over time. Stem puncture inoculations, simulating natural wounding, rarely resulted in colonization or multiplication. Bacteria forced into the leaf interior survived for at least 14 days in intercellular spaces but did not translocate or multiply. Three spinach cultivars with different leaf surface morphologies were compared for colonization by *E. coli* O157:H7 introduced by leaf drop or soil drench. After 2 weeks, cv. Bordeaux hosted very few bacteria. More bacteria were seen on cv. Space and were dispersed over an area of up to 0.3 mm2. The highest bacterial numbers were observed on cv. Tyee but were dispersed only up to 0.15 mm2, suggesting that cv. Tyee may provide protected niches or more nutrients or may promote stronger bacterial adherence. These findings suggest that the spinach phylloplane is a supportive niche for *E. coli* O157:H7, but no conclusive evidence was found for natural entry into the plant interior. The results are relevant for interventions aimed at minimizing produce contamination by human pathogens.

Xicohtencatl-Cortes, J., et al., Interaction of *Escherichia coli* O157:H7 with Leafy Green

Produce, *Journal of Food Protection,* v. 72, no. 7: 1531-1537, 2009.

Enterohemorrhagic *Escherichia coli* (EHEC) is a foodborne pathogen responsible for human diarrheal disease. EHEC lives in the intestinal tract of cattle and other farm and wild animals, which may be the source of environmental contamination particularly of agricultural fields. Human infections are associated with consumption of tainted animal products and fresh produce. How the bacteria interact with the plant phyllosphere and withstand industrial decontamination remain to be elucidated. The goals of the present study were to investigate the environmental conditions and surface structures that influence the interaction of EHEC O157:H7 with baby spinach and lettuce leaves in vitro. Independently of the production of Shiga toxin, EHEC O157:H7 colonizes the leaf surface via flagella and the type 3 secretion system (T3SS). Ultrastructural analysis of EHEC-infected leafy greens revealed the presence of flagellated bacteria, and mutation of the *fliC* flagellin gene in EHEC EDL933 rendered the bacteria significantly less adherent, suggesting the involvement of flagella in the bacteria-leaf interaction. EDL933 mutated in the *escN* (ATPase) gene associated with the function of the T3SS but not in the *eae* (intimin adhesin) gene required for adherence to host intestinal cells had significantly reduced adherence compared with that of the parental strain. The data suggest a compelling role of flagella and the T3SS in colonization of leafy green produce. Colonization of salad leaves by EHEC strains may be a strategy that ensures survival of these bacteria in the environment and allows transmission to the human host.

Zhang, G., et al., Lack of Internalization of *Escherichia coli* O157:H7 in Lettuce (*Lactuca sativa L.)* after Leaf Surface and Soil Inoculation, *Journal of Food Protection,* v. 72, no. 7: 2028-2937, 2009.

Survival and internalization characteristics of Escherichia coli O157:H7 in iceberg, romaine, and leaf lettuce after inoculation of leaf surfaces and soil were determined. A five-strain mixture of *E. coli* O157:H7 in water and cow manure extract was used as an inoculum for abaxial and adaxial sides of leaves at populations of 6 to 7 log and 4 log CFU per plant. The five strains were individually inoculated into soil at populations of 3 and 6 log CFU/g. Soil, leaves, and roots were analyzed for the presence and population of *E. coli* O157:H7. Ten (4.7%) of 212 samples of leaves inoculated on the adaxial side were positive for *E. coli* O157:H7, whereas 38 (17.9%) of 212 samples inoculated on the abaxial side were positive. *E. coli* O157:H7 survived for at least 25 days on leaf surfaces, with survival greater on the abaxial side of the leaves than on the adaxial side. All 212 rhizosphere samples and 424 surface-sanitized leaf and root samples from plants with inoculated leaves were negative for *E. coli* O157:H7, regardless of plant age at the time of inoculation or the location on the leaf receiving the inoculum. The pathogen survived in soil for at least 60 days. Five hundred ninety-eight (99.7%) of 600 surface-sanitized leaf and root samples from plants grown in inoculated soil were negative for *E. coli* O157:H7. Internalization of *E. coli* O157:H7 in lettuce leaves and roots did not occur, regardless of the type of lettuce, age of plants, or strain of *E. coli* O157:H7.

2.3.3 Root Uptake

Koike, S., et al., Examination of the survival and internalization of E. coli on spinach under field production environments, Final report for Center for Produce Safety, 2010.
https://cps.ucdavis.edu/amass/documents/researchproject/106/Koike_CPS%202008_Final%20Report_4-1-10.pdf

When various *E. coli* strains were inoculated onto spinach roots by using a subsurface drip irrigation system, the above ground foliage did not test positive for the *E. coli* strains when using direct plating methods. Surface sterilizing plants with mercuric chloride followed by enrichment culture resulted in only one of 80 whole plants being positive for the rifampicin-resistant generic *E. coli*.

Sharma, M., et al., A Novel Approach to Investigate the Uptake and Internalization of *Escherichia coli* O157:H7 in Spinach Cultivated in Soil and Hydroponic Medium, *Journal of Food Protection,* v. 72, no. 7: 1513-1520, 2009.

Internalization of *Escherichia coli* O157:H7 into spinach plants through root uptake is a potential route of contamination. A Tn*7*-based plasmid vector was used to insert a green fluorescent protein gene into the *att*Tn*7* site in the *E. coli* chromosome. Three green fluorescent protein–labeled *E. coli* inocula were used: produce outbreak O157:H7 strains RM4407 and RM5279 (inoculum 1), ground beef outbreak O157:H7 strain 86-24h11 (inoculum 2), and commensal strain HS (inoculum 3). These strains were cultivated in fecal slurries and applied at ca. 103 or 107 CFU/g to pasteurized soils in which baby spinach seedlings were planted. No *E. coli* was recovered by spiral plating from surface-sanitized internal tissues of spinach plants on days 0, 7, 14, 21, and 28. Inoculum 1 survived at significantly higher populations (*P* _ 0.05) in the soil than did inoculum 3 after 14, 21, and 28 days, indicating that produce outbreak strains of *E. coli* O157:H7 may be less physiologically stressed in soils than are nonpathogenic *E. coli* isolates. Inoculum 2 applied at ca. 107 CFU/ml to hydroponic medium was consistently recovered by spiral plating from the shoot tissues of spinach plants after 14 days (3.73 log CFU per shoot) and 21 days (4.35 log CFU per shoot). Fluorescent *E. coli* cells were microscopically observed in root tissues in 23 (21%) of 108 spinach plants grown in inoculated soils. No internalized *E. coli* was microscopically observed in shoot tissue of plants grown in inoculated soil. These studies do not provide evidence for efficient uptake of *E. coli* O157:H7 from soil to internal plant tissue.

2.3.4 Environmental Persistence

Franz, E., et al., Modelling the Contamination of Lettuce with *Escherichia coli* O157:H7 from Manure-Amended Soil and the Effect of Intervention Strategies, *Journal of Applied Microbiology*, v. 105: 1569-1584, 2008.

In this study, the probability of lettuce contamination with *Escherichia coli* O157:H7 from manure-amended soil and the effect of intervention strategies was determined. Pathogen prevalence and densities were modeled probabilistically through the primary production chain of lettuce (manure, manure-amended soil and lettuce). The model estimated an average of 0.34 contaminated heads per hectare. A minimum manure storage time of 30 days and a minimum fertilization-to-planting interval of 60 days were most successful in reducing the risk. Some specific organic farming practices concerning manure and soil management were found to be risk reducing. Certain specific organic farming practices reduced the likelihood of contamination. This cannot be generalized to organic production as a whole. However, the conclusion is relevant for areas like the Netherlands where there is high use of manure in both organic and conventional vegetable production.

Islam, M., et al., Persistence of Enterohemorrhagic *Escherichia coli* O157:H7 in Soil and on Leaf Lettuce and Parsley Grown in Fields Treated with Contaminated Manure composts or Irrigation Water, *Journal of Food Protection*, v. 67, no. 7: 1365-1370, 2004.

Contaminated manure and polluted irrigation water are probable vehicles for *Escherichia coli*

O157:H7 in many outbreaks. In this study, the occurrence and persistence of *E. coli* O157:H7 in soil fertilized with contaminated poultry or bovine manure composts or treated with contaminated irrigation water and on lettuce and parsley grown on these soils under natural environmental conditions was determined. Twenty-five plots, each 1.8 by 4.6 m, were used for each crop, with five treatments (one without compost, three with each of the three composts, and one without compost out treated with contaminated water) and five replication plots for each treatment. Three different types of compost, PM-5 (poultry manure compost), 338 (dairy manure compost), and NVIRO-4 (alkaline-stabilized dairy manure compost), and irrigation water were inoculated with an avirulent strain of *E. coli* O157:H7. Pathogen concentrations were 107 CFU/g of compost and 105 CFU/ml of water. Contaminated compost was applied to soil in the field as a strip at 4.5 metric tons per hectare on the day before lettuce and parsley seedlings were transplanted in late October 2002. Contaminated irrigation water was applied only once on the plants as a treatment in five plots for each crop at the rate of 2 liters per plot 3 weeks after the seedlings were transplanted. *E. coli* O157:H7 persisted for 154 to 217 days in soils amended with contaminated composts and was detected on lettuce and parsley for up to 77 and 177 days, respectively, after seedlings were planted. Very little difference was observed in *E. coli* O157:H7 persistence based on compost type alone. *E. coli* O157:H7 persisted longer (by .60 days) in soil covered with parsley plants than in soil from lettuce plots, which were bare after lettuce was harvested. In all cases, *E. coli* O157:H7 in soil, regardless of source or crop type, persisted for .5 months after application of contaminated compost or irrigation water.

Johannessen, G. S., et al., Potential Uptake of *Escherichia coli* O157:H7 from Organic manure into Crisphead Lettuce, *Applied and Environmental Microbiology*, v. 71, no. 5: 2221-2225, 2005.

To investigate the potential transfer of *Escherichia coli* O157:H7 from contaminated manure to fresh produce, lettuce seedlings were transplanted into soil fertilized with bovine manure which had been inoculated with approximately 10^4 CFU g^{-1} *E. coli* O157:H7. The lettuce was grown for approximately 50 days in beds in climate-controlled rooms in a greenhouse. As the bacterium was not detected in the edible parts of the lettuce, the outer leaves of the lettuce, or the lettuce roots at harvest it was concluded that transmission of *E. coli* O157:H7 from contaminated soil to lettuce did not occur. The pathogen persisted in the soil for at least 8 weeks after fertilizing but was not detected after 12 weeks. Indigenous *E. coli* was detected only sporadically on the lettuce at harvest, and enterococci were not detected at all. The numbers of enterococci declined more rapidly than those of *E. coli* in the soil. *Pseudomonas fluorescens*, which inhibited growth of *E. coli* O157:H7 in vitro, was isolated from the rhizosphere.

Kim, J., et al., Factors Impacting the Regrowth of *Escherichia coli* O157:H7 in Dairy Manure Compost, *Journal of Food Protection*, v. 72, no. 7: 1576-1584, 2009.

The environmental variables affecting *Escherichia coli* O157:H7 regrowth in dairy manure compost were investigated. Factors evaluated were moisture content, strain variation, growth medium of inoculum, level of background microflora and inoculum, different days of composting, and acclimation at room temperature. A mathematical model was applied to describe *E. coli* O157 regrowth potential in compost. Repopulation occurred in autoclaved compost with a moisture content as low as 20% (water activity of 0.986) in the presence of background microflora of 2.3 to 3.9 log CFU/g. The population of all three *E. coli* O157 strains increased from ca. 1 to 4.85 log CFU/g in autoclaved compost, with the highest increase in the spinach outbreak strain. However, *E. coli* O157 regrowth was suppressed by background microflora at ca. 6.5 log CFU/g. By eliminating acclimation at room temperature and increasing the inoculum level to ca. 3 log CFU/g, *E. coli* O157:H7 could regrow in the presence of high levels of background microflora. *E. coli* O157:H7 regrowth in the autoclaved compost collected from the field study was evident at all sampling days, with the population increase ranging from 3.49 to 6.54 log CFU/g. The fate of *E. coli* O157:H7 in compost was well described by a Whiting and Cygnarowicz-Provost model, with *R*2 greater than 0.9. The level of background microflora was a significant factor for both growth and death parameters. Our results reveal that a small number of *E. coli* O157 cells can regrow in compost, and both background microflora and moisture content were major factors affecting *E. coli* O157:H7 growth.

Koike, S., et al., Examination of the survival and internalization of E. coli on spinach under field production environments, Final report for Center for Produce Safety, 2010. https://cps.ucdavis.edu/amass/documents/researchproject/106/Koike_CPS%202008_Final%20Report_4-1-10.pdf

Various E. coli strains (mixtures of either rifampicin-resistant generic E. coli or rifampicin-resistant attenuated O157:H7 E. coli) applied as water-based sprays or mixed with sand and placed in mesh bags to simulate point sources of contamination did not survive in soil for long periods of time under commercial growing conditions in the Salinas Valley. By one day after spray inoculation, all inoculated soil samples contained bacterial populations that were significantly lower than the original inoculum concentrations delivered to the soil surface. By 15 days after spray inoculation, recovery was below the detection limit by standard direct plating for both strains but the generic E. coli were still detectable following a centrifugation concentration enrichment. The attenuated O157:H7 strain declined at a faster rate compared to the generic strain. By three days after mesh bag inoculation, all inoculated soil samples contained bacterial populations that were significantly lower than the 1 dpi recovered concentrations. By 15 days after mesh bag inoculation, recovery at 0 cm distance was below the standard direct plating detection limit for both strains but the generic E. coli were still detectable following a centrifugation concentration enrichment. The generic and attenuated O157:H7 strains declined at comparable rates. However, when mature spinach plants were spray inoculated and immediately disked into the soil, inoculated bacteria were recovered from field plots for over 85 days.

2.4 Riparian Vegetation Buffers

Atwill E., et al., Transport of *Cryptosporidium parvum* Oocysts through Vegetated Buffer Strips and Estimated Filtration Efficiency, *Applied and Environmental Microbiology,*v. 68, no. 11: 5517-5527, 2002.

Vegetated buffer strips were evaluated for their ability to remove waterborne *Cryptosporidium parvum* from surface and shallow subsurface flow during simulated rainfall rates of 15 or 40 mm/h for 4 h. Log_{10} reductions for spiked *C. parvum* oocysts ranged from 1.0 to 3.1 per m of vegetated buffer, with buffers set at 5 to 20% slope, 85 to 99% fescue cover, soil textures of either silty clay (19:47:34 sand-silt-clay), loam (45:37:18), or sandy loam (70:25:5), and bulk densities of between 0.6 to 1.7 g/cm^3. Vegetated buffers constructed with sandy loam or higher soil bulk densities were less effective at removing waterborne *C.*

parvum (1- to 2-$\log_{10}$ reduction/m) compared to buffers constructed with silty clay or loam or at lower bulk densities (2- to 3-$\log_{10}$ reduction/m). The effect of slope on filtration efficiency was conditional on soil texture and soil bulk density. Based on these results, a vegetated buffer strip comprised of similar soils at a slope of <20% and a length of >3 m should function to remove >99.9% of *C. parvum* oocysts from agricultural runoff generated during events involving mild to moderate precipitation.

Collins, R., et al., Attenuation of effluent-derived fecal microbes in grass buffer strips, *New Zealand Journal of Agricultural Research,* v. 47, no. 4: 565-547, 2004.

A series of field experiments assessed the ability of sloping (8°) 5-m-long by 2-m-wide grass buffer strips to trap the fecal microbes *Escherichia coli* and *Campylobacter*. The microbes, applied within dairy-farm effluent, were washed into the strips by surface runoff generated at rates of 4-13 liters/min using a water sprinkler system. The effluent and surface and subsurface outflows at the lower end of each plot were sampled for microbial analysis. Flow rate influenced the timing of peak microbial concentration in outflow and the recovery of both microbes. Under high flow, recovery rates varied from 15-100%, and hence entrapment was often minimal. Under the slowest rate of water application, entrapment was much greater (95%), at least over the 40 min of water application. During large runoff events, and where preferential flow-paths occur, buffer strips need to exceed 5 m in length in order to markedly reduce the delivery of fecal microbes to waterways. Of those microbes trapped in the grass strips under fast flow rates, some were remobilized and washed out following a subsequent runoff event, 5 days later. On occasion, a considerable volume of flow was observed to bypass beneath the subsurface collecting troughs, probably reducing the effectiveness of the buffer strips.

Coyne, M., et. al. Soil and fecal coliform trapping by grass filter strips during simulated rain. *Journal of Soil and Water Conservation*, v. 50, no. 4: 405-408, 1995.

Poultry production is increasing in Kentucky. The wastes produced are typically added to soil but surface runoff from agricultural soils treated with poultry waste may exceed water quality standards for fecal indicator bacteria and contribute to agricultural nonpoint-source pollution. While soil erosion in surface runoff is frequently managed by grass filter strips, this management practice may not be an equally effective control for fecal bacteria. We measure soil and fecal coliform trapping in surface runoff from two poultry manure-amended plots in a simulated rain study. The simulation reflected a worst-case event in which poultry waste application was followed by high intensity rain. Grass filter strips, 9 meters long, trapped more than 99% of the soil in surface runoff but fecal coliform trapping was less effective. The efficiency of fecal coliform removal from surface runoff was 74% and 43% in the two plots studied. Fecal coliforms in surface runoff always exceeded primary contact water standards of 200 fecal coliforms/100 mL. These data indicated that grass filter strips which adequately controlled sediment runoff were inadequate to bring surface water contaminated with fecal bacteria into compliance with current primary water contact standards.

Entry, J., et al., The Influence of Vegetation in Riparian Filterstrips on Coliform Bacteria: I. Movement and Survival in Water, *Journal of Environmental Quality,* v. 29, no. 4: 1206-1214, 2000.

Swine (Sus scrofa) wastewater was applied to three separate 4 m wide x 30 m long riparian filterstrips consisting of 20 m grass and 10 m forest, 10 m grass and 20 m forest, and 10 m grass and 20 m maidencane (Panicum hemitomon Schult.) in Southern Georgia during each season. Total and fecal coliform numbers in the applied wastewater pulse did not decline as water moved downslope regardless of vegetation type or season. The pulse of applied wastewater did not move beyond 15 m in any treatment in autumn or summer (dry seasons) and only moved beyond 7.5 m in the 20 m grass-10 m forest treatment in the summer. Total and fecal coliform numbers in soil water and shallow ground water declined by approximately 10-fold every 7 d for the first 14 d regardless of vegetative treatment or season. Soil temperature and soil moisture correlated with total coliform bacteria in both 13 m wells (r2 = 0.89) and 2.0 m wells (r 2 = 0.89), and with fecal coliform bacteria in 1.5 (r2 = 0.82) and 2.0 m (r2 = 0.76) wells. Animal production operations may need to locate in warm–dry climates so animal waste can be applied to lands to help ensure enteric bacteria input to surface and ground water will not occur.

Entry, J., et al., The Influence of Vegetation in Riparian Filterstrips on Coliform Bacteria: II. Survival in Soils, *Journal of Environmental Quality,* v. 29, no. 4: 1215-1224, 2000.

Survival of total and fecal coliform bacteria was measured in the 0 to 5, 5 to 15, and 15 to 30 cm soil depths at 1, 3, 7, 14, and 90 to 120 days after swine (*Sus scrofa*) wastewater application to riparian filterstrips in southern Georgia during each season of the year. Vegetative treatments evaluated were: (i) 20 m grass-10 m forest, (ii) 10 m grass-20 m forest, and (iii) 10 m grass-20 m maidencane (*Panicum hemitomon* Schult.). During winter, spring, and summer vegetation type in riparian filterstrips did not affect survival of total and fecal coliform bacteria. Total and fecal coliform bacterial numbers were usually higher in the top 0 to 5 cm of soil than in the 5 to 15 and 15 to 30 cm soil depths in all treatments. Total and fecal coliform numbers in the 0 to 5, 5 to 15, and 15 to 30 cm depths declined approximately 10-fold every 7 to 14 d after waste application in all seasons of the year. At 90 to 120 d after waste application, total and fecal coliform numbers in the three soil depths did not differ from riparian filterstrips that did not have animal waste applied. Total coliform bacteria in the O to 5, 5 to 15, and 15 to 30 cm soil depths correlated with temperature and moisture in a curvilinear relationship (r2 = 0.80 , 0.77, and 0.64, respectively). Fecal coliform bacteria in 0 to 5, 6 to 15, and 16 to 30 cm of soil also correlated with temperature and moisture in a curvilinear relationship (r 2 = 0.56, 0.53, and 0.53, respectively).

Natural Resources Conservation Service, Herbaceous Wind Barriers, *Conservation Practice Standard Code 603*, 2003, ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/603.pdf

This standard describes the criteria for establishing herbaceous wind barriers for cropland to reduce soil erosion and protect growing crops from wind-borne sediment and sediment-borne contaminants as a resource management system using current approved wind erosion prediction technology.

Tate, K. W., et al., Significant *Escherichia coli* Attenuation by Vegetative Buffers on Annual Grasslands, *Journal of Environmental Quality*, v. 35: 795-805, 2006.

A study was conducted to estimate the retention efficiency of vegetative buffers for *Escherichia coli* deposited on grasslands in cattle fecal deposits and subject to natural rainfall-runoff conditions. The study was conducted on annual grasslands in California's northern Sierra Nevada foothills, a region with a distinct wet–dry season Mediterranean climate. We used 48, 2.0- by 3.0-m runoff plots to examine the efficacy of 0.1-, 1.1-, and 2.1-m buffers at three land slopes (5, 20, and 35%) and four dry vegetation matter levels (225, 560, 900, and 4500 kg/ha) across 27 rainfall-runoff events during two rainfall seasons. Buffer width treatments were implemented by placement of cattle fecal material containing known loads of *E. coli* 0.1, 1.1, or 2.1 m upslope of the plot runoff collector. Mean total runoff to total rainfall ratio per plot ranged from 0.014:1 to 0.019:1 and reflected the high infiltration capacity of these soils. Approximately 94.8 to 99.995% of total *E. coli* load applied to each plot appears to be either retained in the fecal pat and/or attenuated within 0.1 m downslope of the fecal pat, irrespective of the presence of a wider vegetated buffer. Relative to a 0.1-m buffer, we found 0.3 to 3.1 log10 reduction in *E. coli* discharge per additional meter of vegetative buffer across the range of residual dry vegetation matter levels, land slope, and rainfall and runoff conditions experienced during this project. Buffer efficiency was significantly reduced as runoff increased. These results support the assertion that grassland buffers are an effective method for reducing animal agricultural inputs of waterborne *E. coli* into surface waters.

Pannill, P. D., et al., *Riparian Forest Buffer Survival and Success in Maryland*, Maryland Dept. of Natural Resources Forest Service, Annapolis, 2001.

Riparian buffers are being planted in Maryland to improve water quality and prevent wind erosion and windborne contaminants. In order to determine the survival and success of planted riparian forest buffers in Maryland 130 randomly selected sites, 1 to 3 yrs. of age, were measured. Data were collected using 1/100th acre plots with a random-start systematic line-plot cruise at an overall average 3.3% sample intensity. Average stocking was 488 trees per acre, and the median stocking level was 434 trees per acre. Acceptable stocking (≥200 trees/acre) was found on 82% of sites. Preferred stocking levels (≥400 trees/acre) were found on 52% of sites. Natural regeneration made a significant contribution to stocking, in many cases augmenting planted stock sufficiently to achieve acceptable or preferred stocking levels. The overall average degree of vegetative competition provided by weeds, grasses, and brush was rated as moderate, and there was an inverse relationship between the degree of competition and the survival of planted trees, but correlations were not close ($r^2 < 0.1$). Problems that affected survival and growth were identified at almost all sites (95%), with the principal problem being weed competition. Drought, deer, vines, machinery, and insects were lesser but still significant problems.

2.5 Water Protection and Quality

Bellows, B., Protecting Water Quality on Organic Farms, *ATTRA's Organic Matter Series*, Davis, CA, 2002.

Organic farming involves many practices that protect against nutrient leaching, water runoff, and soil erosion. Water quality protection is greatest when organic practices are implemented using a “systems approach” rather than simply following a general list of approved practices. By understanding the biological, chemical, and climatic processes occurring in each field, organic farmers can implement practices that both enhance production and protect water quality. When organic practices are implemented in a more piecemeal and less sustainable manner, they can cause environmental impacts similar to those found on conventional farms. Environmental problems most commonly found on organic farms result from mismanaging manure applications or soil incorporation of green-manure crops, and from improper storage of manure or compost. This publication discusses practices that protect and practices that fail to protect water quality. Farmers can use the guidelines provided here to modify management to suit their soil, climate, and farming conditions.

Cahn, M., et al., Vegetated Treatment Ditches: Ineffective in Reducing Nutrient, Sediment, and *E. coli* Bacteria Concentrations in Irrigation Run-off on the Central Coast., *Crop Notes*, Cooperative Extension, Monterey County, Nov/Dec., 2010.

Research reports from other regions of the United States suggest that vegetation in these ditches could reduce bacterial loads in run-off, thereby reducing the risk of microbial contamination to downstream fields as well as reducing loads of nutrients and sediments. Polymers are another management tool that can improve farm water quality. Our past studies have shown that adding polyacrylamide (PAM) to irrigation water at concentrations of 5 ppm significantly reduced concentrations of sediment and associated nutrients in tail water run-off. However, we have not examined the effect of PAM on bacterial loads in irrigation run-off. Because of lack of information on the efficacy of vegetation and polymers to reduce bacterial loads in run-off under central coast conditions, we undertook a 2 year field study that simulated E. coli contamination in a lettuce field. The field trials evaluated the effectiveness of vegetated treatment ditches, polyacrylamide polymer, and the combination of these two practices to reduce bacteria, sediment, and nutrient concentrations in irrigation run-off.

The lack of effectiveness of the vegetated treatment to reduce the concentration of suspended sediment and nutrients in run-off may be explained by a combination of factors. Flow rates of the run-off were high relative to the length of the vegetated ditch such that the residence time was less than 45 min. A majority of the biomass of the wild rye that was planted on the bottom of the ditches was 6 inches above the soil surface and would have been unlikely to interact with the run-off fl owing in the ditches. Finally, the concentration of suspended sediment in the run-off was significantly higher than concentrations found in run-off of other vegetative ditch studies due to the use of impact sprinklers and that the trial was conducted on a highly erodible soil. Despite these limitations we expected to measure at least a small reduction in sediment concentration between the inflowing and out-fl owing run-off from the vegetated ditch. These results suggest that it may be challenging to design vegetated treatment systems that are effective for run-off with high volumes and high sediment loads. The addition of polyacrylamide polymer to irrigation water at concentrations of 5 ppm and less reduced suspended sediments in sprinkler run-off by an average of 90% and total N and P by approximately 70% for both years of the trials. Because PAM presumably flocculated suspended sediment in run-off water, insoluble forms of N and P associated with the sediments would have also been retained in the field rather than carried in the run-off. More surprising was the result that the addition of PAM significantly, albeit modestly, reduced the concentration of soluble P and NO3-N in run-off during the 2008 trial. The reduction in soluble P and NO_3-N concentration of about 30% under the PAM treatment was relatively small compared to the effect of PAM on total nutrient and sediment concentration; and therefore it was not surprising that no significant reduction in these soluble nutrients was measured for the PAM treatment during the 2007 trial. None of the management practices evaluated reduced *E. coli* and coliform bacteria concentrations less than the concentrations measured in the bare control treatment. This result might be expected for the vegetated treatment since vegetation was ineffective in reducing sediment concentration. Despite consistently reducing sediment concentration in the runoff, PAM was ineffective in reducing bacteria concentration. The results of these trials suggested that the majority of the *E. coli* and coliform bacteria resided in the water and were not associated with suspended sediments. Other studies that have reported that vegetation reduced the load of *E. coli* in irrigation run-off may have lessened the volume of runoff or dropped out bacteria associated with suspended fecal particles. For example, the vegetated buffers in the study of Tate et al. (2006) minimized the bacterial load by enhancing infiltration into the soil and minimizing the movement of cattle feces. In our study, soil was inoculated with *E. coli* from a point source (satchels of *E. coli*) and was allowed to migrate in the run-off along the length of the furrows. Because we removed the source of *E. coli* after the first irrigation event, all bacterial collected during subsequent irrigations would have persisted in the soil, presumably in a state that could be readily transported in run-off during irrigation events. Another difference from previous studies was that the reaction time of the vegetated treatment was limited to less than 45 min, which is probably an insufficient time for potential degradation processes to affect bacterial populations. Studies of large constructed wetlands have shown a degradation of *E. coli* populations during the course of several days. Unfortunately, large vegetated treatment systems designed to handle large run-off volumes associated with overhead sprinklers would be an impractical solution for most of the high valued vegetable production areas on the Central Coast.

Greenway, M., The Role of Constructed Wetlands in Secondary Effluent Treatment and Water Reuse in Subtropical and Arid Australia, *Ecological Engineering*, v. 25: 501-509, 2005.

Water reclamation and reuse is being actively promoted in Australia. In Queensland, surface-flow constructed wetlands with a diversity of macrophyte types offer the greatest potential for effluent polishing. Constructed wetlands in subtropical climates in coastal regions and arid climates in inland western regions are conducive to high macrophyte growth rates and nutrient removal, in particular nitrogen, producing an effluent suitable for irrigation, restoration of wetlands and/or release into natural waterways. Faecal-coliform removal is also high, producing effluent with <1000 cfu/100mL and as low as 100 cfu/100 mL, acceptable for agricultural irrigation. Constructed wetlands can be designed to maximise the removal of both nutrients and pathogens by enhancing macrophyte diversity and natural disinfection processes by incorporating lagoons, shallow-water wetlands and subsurface-flow wetlands into the treatment train. Surface-flow wetlands can also be designed to minimize mosquito breeding by increasing macro-invertebrate predators, thereby alleviating community concerns about potential health risks. This paper addresses the role of constructed wetlands in nutrient and pathogen removal in Queensland's wetlands, and presents three case studies with respect to effluent reuse.

Hench, K. R., et al., Fate of Physical, Chemical, and Microbial Contaminants in Domestic Wastewater Following Treatment by Small Constructed Wetlands, *Water Research,* v. 37: 921-927, 2003.

In order to evaluate the efficacy of constructed wetlands for treatment of domestic wastewater for small communities located in rural areas, small-scale wetland mesocosms (400L each) containing two treatment designs (a mixture of Typha, Scirpus, and Juncus species; control without vegetation) were planted into two depths (45 or 60 cm) with pea gravel. Each mesocosm received 19 L/day of primary-treated domestic sewage. Mesocosms were monitored (inflow and outflow samples) on a monthly basis over a 2-year period for pH, total suspended solids (TSS), 5-day biochemical oxygen demand (BOD5), total Kjeldahl nitrogen (TKN), dissolved oxygen (DO), and conductivity. Microbiological analyses included enumeration of fecal coliforms, enterococci, *Salmonella, Shigella, Yersinia,* and coliphage. Significant differences between influent and effluent water quality for the vegetated wetlands (po0:05) were observed in TSS, BOD5, and TKN. Increased DO and reduction in fecal coliform, enterococcus, *Salmonella, Shigella, Yersinia,* and coliphage populations also were observed in vegetated wetlands. Greatest microbial reductions were observed in the planted mesocosms compared to those lacking vegetation. Despite marked reduction of several contaminants, wetland treated effluents did not consistently meet final discharge limits for receiving bodies of water. Removal efficiencies for bacteria and several chemical parameters were more apparent during the initial year compared to the second year of operation, suggesting concern for long-term efficiency and stability of such wetlands.

Hunt J., et al., Use of toxicity identification evaluations to determine the pesticide mitigation effectiveness of on-farm vegetated treatment systems. *Environmental Pollution*, v. 156: 348-358, 2008.

Evidence of ecological impacts from pesticide runoff has prompted installation of vegetated treatment systems (VTS) along the central coast of California, USA. During five surveys of two on-farm VTS ponds, 88% of inlet and outlet water samples were toxic to Ceriodaphnia dubia. Toxicity identification evaluations (TIEs) indicated water toxicity was caused by diazinon at VTS-1, and chlorpyrifos at VTS-2. Diazinon levels in VTS-1 were variable, but high pulse inflow concentrations were reduced through dilution. At VTS-2, chlorpyrifos concentrations averaged 52% lower at the VTS outlet than at the inlet. Water concentrations of most other pesticides averaged 20e90% lower at VTS outlets. All VTS sediment samples were toxic to amphipods (Hyalella azteca). Sediment TIEs indicated toxicity was caused by cypermethrin and lambdacyhalothrin at VTS-1, and chlorpyrifos and permethrin at VTS-2. As with water, sediment concentrations were lower at VTS outlets, indicating substantial reductions in farm runoff pesticide concentrations.

Monterey Bay National Marine Sanctuary, *Action Plan IV: Agriculture and Rural Lands – Management Practices for Agricultural Nonpoint Sources*, Monterey, 1999

Many "best management practices" (BMPs) have been incorporated into modern American agriculture, including management practices for agricultural nonpoint sources including berms, water bars, sediment basins, drainage ditches, field drains and sumps, contour plowing, vegetative buffers, windbreaks and minimum stubble heights. Most management practices can be implemented by individual growers or in combination with grower neighbors. Water moving away from the crops often carries with it eroded soil, nutrients and pesticides, which then become pollutants. Although farmers are under pressure to show "insect free" unblemished produce to their purchasers, overuse of pesticides is not common, as they are expensive and remain in the soil for extensive periods of time. Irrigation scheduling guidelines can be managed by using the California Irrigation Management Information System (CIMIS) and using such technologies as drip or micro-irrigation, timers, and moisture sensors. Wildlife's use of rangeland often adds bacterial contaminants to local water. This is called grazing management and may include adding vegetative buffers, fencing, barns and corrals to promote a diversity of plants, protect waterways and reduce erosion. Many government agencies are now involved including the State Water Resources Control Board who endorses the California Rangeland Water Quality Management Plan, and county cattlemen associations and farm bureaus.

Moore M.T., et al., Mitigation assessment of vegetated drainage ditches for collecting irrigation runoff in California. *Journal of Environmental Quality*, v. 37, no. 2: 486-493, 2008.

Widespread contamination of California water bodies by the organophosphate insecticides diazinon and chlorpyrifos is well documented. While their usage has decreased over the last few years, a concomitant increase in pyrethroid usage (e.g., permethrin) (replacement insecticides) has occurred. Vegetated agricultural drainage ditches (VADD) have been proposed as a potential economical and environmentally efficient management practice to mitigate the effects of pesticides in irrigation and storm runoff. Three ditches were constructed in Yolo County, California for a field trial. A U-shaped vegetated ditch, a V-shaped vegetated ditch, and a V-shaped unvegetated ditch were each amended for 8 h with a mixture of diazinon, permethrin, and suspended sediment simulating an irrigation runoff event. Water, sediment, and plant samples were collected spatially and temporally and analyzed for diazinon and permethrin concentrations. Pesticide half-lives were similar between ditches and pesticides, ranging from 2.4 to 6.4 h. Differences in half-distances (distance required to reduce initial pesticide concentration by 50%) among pesticides and ditches were present, indicating importance of vegetation in mitigation. Cis-permethrin half-distances in V ditches ranged from 22 m (V-vegetated) to 50 m (V-unvegetated). Half-distances for trans-permethrin were similar, ranging from 21 m (V-vegetated) to 55 m (V-unvegetated). Diazinon half-distances demonstrated the greatest differences (55 m for V-vegetated and 158 m for V-unvegetated). Such economical and environmentally successful management practices will offer farmers, ranchers, and landowners a viable alternative to more conventional (and sometimes expensive) practices.

Moore M.T., et al., Mitigation of chloropyrifos runoff using constructed wetlands. *Chemospher,* v. 46: 827-835, 2002.
Constructed wetlands have been proposed as a potential best management practice (BMP) to mitigate effects of pesticide-associated agricultural runoff. Wetland mesocosms (14 m x 59–73 m) were amended with chlorpyrifos to simulate a storm runoff event at concentrations of 73, 147 and 733 ug/l. Water, sediment and plant samples collected weekly for 12 weeks indicated that chlorpyrifos rapidly sorbed to sediment and plant material, with approximately 47–65% of measured chlorpyrifos mass retained within the first 30–36 m of wetland mesocosms. Of the measured mass, approximately 55% and 25% were retained by sediments and plants, respectively. A field-scale evaluation of a constructed wetland's mitigation capability was performed in the Lourens River watershed of Cape Town, South Africa. Results indicate that the wetland was able to retain and considerably decrease the concentration (and hence toxicity) of chlorpyrifos and suspended sediment entering the receiving waterbody (Lourens River). This research provides fundamental answers concerning constructed wetland capabilities that are necessary for constructing field-scale systems within agricultural watersheds.

Nokes, R. L., et al., Microbial Water Quality Improvement by Small Scale On-Site Subsurface Wetland Treatment, *Journal of Environmental Science and Health*, v. A38, no. 9: 1849-1855, 2003.

It has been demonstrated that large constructed wetlands used for domestic wastewater treatment are useful in the reduction of enteric microorganisms. This study evaluated the ability of three small-scale, on-site subsurface wetlands with different vegetation densities to remove total coliforms, fecal coliforms, coliphage, *Giardia* and *Cryptosporidium*. These wetlands were found to be equally efficient in the removal of enteric bacteria and coliphage as larger constructed wetlands. *Giardia* and *Cryptosporidium* were usually undetectable after passage of the wastewater through the subsurface wetlands. Coliphage removal increased with increasing vegetation density.

Stuart, D., Coastal Ecosystems and Agricultural Land Use: New Challenges on California's Central Coast, *Coastal Management*, v. 38: 42-64, 2010.

This article uses the Central Coast region of California as a case study to examine the challenges of protecting coastal ecosystems near areas of intensive agricultural production. Coastal water quality and biodiversity are greatly impacted by regional land use. Agricultural land use can have significant impacts on water quality through erosion and the runoff of agricultural chemicals. While the Central Coast region of California is a center for intensive agricultural production, it is also home to the largest marine sanctuary in the United States. This combination has resulted in intensive efforts from government agencies and conservation organizations to reduce pollution associated with agriculture. Efforts have focused on education and incentives, but are recently facing increasing challenges stemming from new standards created by the produce industry in response to food safety concerns. Personal interviews with crop growers were used to explore these challenges and to better understand the range of possible environmental impacts resulting from new food safety standards. Results indicate that substantial management changes are taking place that are likely to impact regional water quality and wildlife. This case study also explores the role of policy networks in shaping management decisions and illustrates how certain approaches to addressing agricultural pollution may be vulnerable to external policy changes.

2.6 California Guidelines, Codes, Rules

Amended Clean Water Act, 1987, Section 319, The Nonpoint Source Management Program.

Administered by the State Water Resources Control Board and 9 Regional Water Quality Control Boards encourages the use of filter strips, vegetative barriers, contour buffer strips, grassed waterways and constructed wetlands, which remove metals, pesticides, nutrients, fertilizers and animal wastes.

U.S. Department of Agriculture, Natural Resources Conservation Service, 2006-2009.

The following are conservation practice standards recommended by the NRCS. These standards were specifically set up for Monterey County, California:

1. Conservation Cover, Standard 327: establishing and maintaining permanent vegetative cover to accomplish the following:
    - Reduce soil erosion and sedimentation
    - Improve water quality
    - Improve air quality
    - Enhance wildlife habitat
    - Improve soil quality
    - Manage plant pests
2. Cover Crop, Standard 340: crops including grasses, legumes and forbs for seasonal cover and other conservation purposes to accomplish the following:
    - Reduce erosion from wind and water
    - Increase soil organic matter content
    - Capture and recycle or redistribute nutrients in the soil profile
    - Promote biological nitrogen fixation
    - Increase biodiversity
    - Weed suppression
    - Provide supplemental forage
    - Soil moisture management
    - Reduce particulate emissions into the atmosphere

- Minimize and reduce soil compaction

3. Fence, Standard 382: a constructed barrier to animals or people to facilitate the application of conservation practices by providing a means to control movement of animals, including wildlife, and people.
4. Field Border, Standard 386: a strip of permanent vegetation established at the edge or around the perimeter of a field to accomplish the following:
   - Reduce erosion from wind and water
   - Protect soil and water quality
   - Manage pest populations
   - Provide wildlife food and cover
   - Increase carbon storage
   - Improve air quality
5. Filter Strip, Standard 393: a strip or area of herbaceous vegetation situated between cropland, grazing land or disturbed land (including forestland) and environmentally sensitive areas to:
   - Reduce sediment, particulate organics and sediment adsorbed contaminant loadings in runoff and surface irrigation tailwater
   - Reduce dissolved contaminant loadings in runoff
   - To serve as Zone 3 of a Riparian Forrest Buffer, Practice Standard 391
   - To restore, create or enhance herbaceous habitat for wildlife and beneficial insects
   - To maintain or enhance watershed functions and values
6. Hedgerow Planting, Standard 422: establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose, providing at least one of the following conservation functions:
   - Food, cover and corridors for terrestrial wildlife
   - Food and cover for aquatic organisms that live in watercourses with bank-full width less than 5 feet
   - To intercept airborne particulate matter
   - To reduce chemical drift and odor movement
   - To increase carbon storage in biomass and soils
   - Living fences
   - Boundary delineation
   - Contour guidelines
   - Screens and barriers to noise and dust
   - Improvement of landscape appearance
7. Riparian Herbaceous Cover, Standard 390: grasses, grass-like plants and forbs that are tolerant of intermittent flooding or saturated soils and that are established or managed in the transitional zone between terrestrial and aquatic habitats to:
   - Provision of food, shelter, shading substrate, access to adjacent habitats, nursery habitat and pathways for movement by resident and nonresident aquatic, semi-aquatic and terrestrial organisms

- Improve and protect water quality by reducing the amount of sediment and other pollutants, such as pesticides, organic materials, and nutrients in surface runoff as well as nutrients and chemicals in shallow ground water flow
- Help stabilize stream banks and shorelines
- Increase net carbon storage in the biomass and soil

8. Vegetative Barrier, Standard 601: permanent strips of stiff, dense vegetation along the general contour of slopes or across concentrated flow areas to:

    - Reduce sheet and rill erosion
    - Reduce ephemeral gully erosion
    - Manage water flow
    - Stabilize steep slopes
    - Trap sediment

MINIMIZING POTENTIAL LEAFY GREEN MICROBIOLOGICAL RISKS WHILE PROTECTING WILDLIFE AND THE ENVIRONMENT- A CO-MANAGEMENT CHALLENGE

DRAFT

HANK GICLAS, WESTERN GROWERS

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ABSTRACT

The fall 2006 *Escherichia coli* 0157:H7 outbreak associated with bagged spinach resulted in 205 illnesses and three deaths. When spinach purchases resumed, purchases were significantly below historical levels – a result of diminished consumer confidence in the safety of U.S. leafy greens. In response the leafy green industry along with buyers, food service companies, academia and representatives from the U.S. Food and Drug Association and the California Department of Health Services collaborated on the development of the "Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens." Today, "approximately 99% of the volume of leafy green production in California and roughly 75% of leafy green production in the U.S" (LGMA 2010) are grown based on these guidelines.

With the guidelines and their implementation, environmental organizations became concerned that some growers' practices focused on food safety and ignored potential adverse impacts on wildlife and the environment. To address these concerns, this study examines wildlife related food safety risks, determines how the guidelines address the risks, identifies areas where adverse impacts might exist, and while supporting food safety as the number one objective, recommends changes to the guidelines to reduce or eliminate conflicts. The research involved fielding a grower survey, reviewing available scientific studies and assembling an expert panel representing leafy green industry members, academics, wildlife NGOs and representatives from government agencies. The recommended changes were submitted to the California Leafy Green Products Handler Marketing Agreement Technical Committee for review and adoption and are the subject of the October 2012 meeting.

1.0 INTRODUCTION

The final FDA report on the 2006 *Escherichia coli* 0157:H7 outbreak identified several environmental risk factors that may have resulted in the outbreak. “Potential environmental risk factors for *E.coli* O157:H7 contamination at or near the field included the presence of wild pigs, the proximity of irrigation wells used to grow produce for ready-to-eat packaging, and surface waterways exposed to feces from cattle and wildlife” (FDA 2006). The California Leafy Green Products Handler Marketing Agreement (LGMA) adoption of the *Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens* (CSGLLG) in 2007 was focused on addressing those environmental risks. Membership in the LGMA is voluntary and open to all leafy green handlers; however, members of the LGMA must grow according to the guidelines. Conformance is verified through audits conducted by USDA auditors.

Based on the FDA report, the CSGLLG document provides guidelines for reducing potential crop contamination associated with environmental risks, including ones associated with wildlife. The LGMA audit checklist contains 13 questions relating to wildlife out of total of 42 main questions (main questions are always asked as opposed to “follow-on” questions that are only asked based on the response to a prior question.

In implementing the guidelines, several environmental organizations raised concerns about the impact of these practices on wildlife habitat and water quality (Wild Farm Alliance, 2008; RCD Monterey Bay, 2009). One concern was some species might have migration routes affected by fencing or endangered species could be killed by indiscriminate trapping. Another concern was that buffer strips could have an adverse impact on stream or wetland quality.

This research addressed these concerns by determining which leafy greens practices actually do pose wildlife and environmental concerns and by providing solutions based on current science subject to a review by food safety and environmental experts. California vegetable growers will benefit by having more effective and efficient practices identified and unnecessary practices eliminated from food safety guidelines.

The results of this project are recommended updates to best practices for managing these conflicting priorities that assist lettuce and leafy green producers in implementing cost-effective GAPs that both meet food safety guidelines and decrease impacts to environmental quality, and provide valuable information to environmental regulators and industry experts that influence food safety guidelines.

2.0 Materials and Methods

The focus of this research is to help clarify, reduce and/or eliminate any potential impacts to the environment as the result of implementing best practices aimed at improving leafy green food safety. The methods used consist of a grower survey to determine current growing practices and their impact on wildlife and the environment followed by a review of the scientific literature addressing food safety concerns relating to wildlife and environmental risks. Then, a food safety and environmental expert panel was convened to develop recommended changes to the CSGLLG.

2.1 Grower Survey

The survey was designed to identify current California leafy green co-management practices associated with food safety guidelines and whether those practices adversely affect wildlife and/or the environment. (The Resource Conservation District of Monterey conducted an environmental practices survey in 2007 for row crops (RCMD 2007) and this leafy green survey was structured based on the RCD work.) The in-depth survey instrument consisted of 84 questions and employed skip logic. Prior to roll-out it was reviewed with industry members and conservation experts.

2.1.1 Survey Distribution

Between July 2010 and January 2011, the survey was open and accessible via the Internet for completion. Intertox Decision Sciences, a third party database company, managed the survey distribution and response evaluations. Leafy green industry members were informed about the survey through emails and newsletters from various industry groups, including the California Leafy Greens Products Handler Marketing Agreement, the Grower-Shipper Association of Central California, the Grower-Shipper of Santa Barbara and San Luis Obispo, the Imperial Valley Vegetable Growers Association, and Western Growers. Efforts were made to reach as many leafy green producers growing under food safety programs such as the LGMA as possible.

2.1.2 Data Collection and Analysis

A total of 62 questionnaires were collected by January 2011. After the questionnaire was closed, survey responses were reviewed and duplicate and blank questionnaires were removed from the database. Responses were checked to ensure they were from companies that a) grow leafy greens and b) grow in California. For responses that did not meet this criteria, the questionnaires were retained and reviewed, but were not included in the results. Responses from 53 questionnaires were used for the research results. Based on a sample population of 197 LGMA growers, the number of returned questionnaires represented 26.9% of leafy green growers in California. Once the database was validated, a statistical analysis of the survey results was performed using Microsoft Excel.

2.2 Review of existing scientifically-based literature

For the scientific-based literature review, over 120 articles, websites, and studies relating to co-management issues associated with leafy green food safety and conservation practices were studied for relevance. Preference was given to peer-reviewed and other scientific journals. In addition to the research summaries, guidelines and agency recommendations for conservation practices were searched, and several government agencies were contacted to obtain further information on these areas. The purpose of this research was two-fold: 1) to inform the development of a questionnaire for growers that may be experiencing these types of co-management issues, and 2) to provide background information for an expert panel.

2.3 Expert Panel Review

Eight expert panel members were selected to represent small, medium, and large growers, wildlife NGOs, wildlife academics, shippers, processors and food safety academics. Government representatives from the USDA and the FDA participated as observers. After a review of the survey responses, the scientific literature research, and based on their professional opinions, expert panel members focused on reviewing and, if supported by food safety considerations, developing recommended alternatives to current CSGLLG practices. Expert panel members met twelve times between August 2011 and March 2012.

3.0 RESULTS

3.1.1 Food Safety Programs

In the survey, growers were asked about the food safety programs they use. All of the growers responding to the questionnaire have a food safety program in place and many are following multiple food safety programs. The most frequently named food safety programs being used are shown in Table 1. As indicated, the California LGMA and the PrimusLabs.com GAP Program are named more frequently than any other program. Additionally, growers are using buyer-specific food safety programs and other third-party programs such as SQF. Only 15.1% of the respondents are using the USDA GAP/GHP verification program. GLOBALG.A.P is cited by 20.8% of the respondents.

3.1.2 Conservation Practices

To determine the impact the California LGMA food safety program has had on conservation measures, growers were asked to not only name the conversation practices they are currently following but also to note how the California LGMA has impacted those practices. More respondents (82.2%) have implemented conservation practices in their leafy green growing environments than in their overall growing environment (78.7%). The most frequently implemented conservation practices included: cover crops, fencing, irrigation water management and nutrient management. The adoption of LGMA did not result in the reduction or elimination of conservation measures for 82.6% of respondents who have implemented conservation practices in leafy green crops. In fact, some growers (23.4%) implemented conservation practices as a result of the LGMA guidelines. For these growers, the LGMA lead to the introduction of cover crops, critical planting areas, and hedgerows.

For those respondents who eliminated or decreased conservation practices because of the LGMA (17.4%), they described the changes made as follows: mowing grasses in filter strips, eliminating filter strips, scraping dirt to morph into bare roads along waterways therefore decreasing cropped acreage and beneficial habitat, removing vegetation around fields to reduce habitat for rodents, removing trees due to falling leaves, removing some water catchment basins, removing grass filter strips in some areas due to frog presence, removing trees to reduce the presence of birds and their droppings, and not reusing recovered tailwater because of possible contamination.

Several respondents participate in government-sponsored conservation programs from the USDA Natural Resources Conservation Service, the University of California Cooperative Extension and the USDA Farm Services.

4.0 DISCUSSION

Using the survey results, analysis of relevant scientific literature and input from the peer review, several changes were recommended to the CSGLLG. The main recommendations include:

4.1 Animals of significant risk

The first recommended change is to remove the “animals of significant risk” list from the document. The animal list, consisting of cattle, sheep, goats, pigs (domestic and wild) and deer, was developed for the 2007 CSGLLG based on Centers for Disease Control and Prevention (CDC) publications identifying animals posing the greatest risk. The focus of the 2007 list was on *E. coli* O157:H7 as the human pathogen of concern. Since that time, numerous studies have demonstrated the need to include other potential human pathogens such as *Salmonella* monocytogenes and Listeria. As the list of human pathogens has expanded, so has the number of animals identified as potential pathogen vectors (Fenlon, 1985, Gorski, 2011, Jay, 2007, Keene, 1997, LeJeune, 2008, Perz, 2001).

Based on the research and the survey results, the expert panel felt updating or adding to the existing list of animals of significant risk would be counter-productive. Research since 2006 demonstrates the current list is inadequate from a food safety perspective and the panel felt a new list would be too long. Therefore, the recommendation was made to remove the list of animals.

Furthermore, it is apparent from the survey responses that growers perceive animals other than the animals on the “animals of significant risk” list are threats to produce safety and they have been acting accordingly. When asked about the types of animals growers observe and how frequently they are observed, it is not surprising that birds were named as being seen more frequently than other animals on a daily basis (Table 2). While not seen as frequently, frogs, rodents, rabbits and dogs were sighted daily and monthly according to questionnaire responses. Deer and wild pig sightings occurred once or several times a month, and no respondent reported seeing cows in their leafy green fields.

Among those animals, birds were named more frequently and were perceived as the greatest wildlife risk to produce safety (44% of the growers observing birds in their leafy green fields). The second most frequently named animal as a potential food safety concern were wild pigs (36.6%) followed by rodents (27.3%). In many cases growers did not plant crops because of animal concerns.

Similarly, auditors have indicated animal concerns as well (Table 3). Birds and domestic animals were noted as animals of concern by several audit companies. Based on grower feedback and the scientific literature research, removing the list of “animals of significant risk” strengthens food safety by addressing other potential animal concerns. While environmentalists may express concerns that this modification has the potential to increase focus on all animals, the next recommendation ensures this will not be the case.

4.2 Animal intrusion

The second recommended change is to replace "intrusion by animal of significant risk that might impact produce safety" with "with any fecal contamination that may present a risk to the production block or crop." This expert panel recommendation was made based on the current scientific literature, co-management concerns, and taking into account current grower and USDA/FDA practices. The concern, from a food safety perspective, is that based on the literature, a list of potential animal vectors would include much of the animal kingdom - yet the real issue is not with animal intrusion but with feces and potential for fecal contamination. From a wildlife perspective, any list is perceived as targeting species on the list and potentially endangering the animals and their habitats. By removing "animal intrusion" and focusing on feces or crop damage as a potential indicator of the presence of feces, the panel felt it would protect animals (not focus on which animals are present but if they are present are they damaging crops) and at the same time support current practices used by the USDA and FDA auditors (regardless of the origin of feces, if any are found crops will need to be destroyed).

4.3 Adjacent land

The third recommended change is to delete the wording, "Locate production blocks to minimize potential access by animals of significant risk and maximize distances to possible sources of microbial contamination. For example, consider the proximity to water (i.e., riparian areas), animal of significant risk harborage, open range lands, non-contiguous blocks, urban centers, etc. Periodically monitor these factors and assess during preseason and pre-harvest assessments."

The new wording would read: "The designated food safety professional or other trained personnel should evaluate the potential for microbial contamination from adjacent areas. A risk assessment shall be performed to determine the risk level as well as to evaluate potential strategies to control or reduce the introduction of human pathogens. Periodically monitor these factors and assess during the preseason and pre-harvest assessments…." The change acknowledges differences between ranches in what can and cannot be done as well as a consideration of local fish and game and water quality initiatives. Instead of prescribing solutions that that do not fit the majority of users, the modification recognizes the role of the designated food safety professional and points to supporting resources the food safety professional can use.

Adjacent land concerns do result in growers not planting in certain locations (Figure 2). From a food safety perspective, risk assessments conducted prior to planting to assess adjacent land hazards, and if deemed necessary, risk mitigation efforts, can provide data for making more informed planting decisions when faced with adjacent land concerns.

4.4 Crop Damage

The fourth recommended change is to include a definition of crop damage as: “any damage to the crop that renders the crop adulterated and thus unfit for harvest and/or consumption by humans. Adulteration can include but is not limited to: 1. Animal induced damage through eating, trampling, or any other noticeable physical damage to the crop. 2. Contamination from animal feces, urine, body fluids, or animal parts and/or matter due to acts such as molting or shedding.

The addition of the crop damage definition was made to reduce any confusion that may arise when food safety personnel, handlers, buyers and auditors are considering whether crop damage has occurred. While there was support for adding language suggesting “incidental contact” should also be considered as crop damage, the expert panel felt the scientific literature did not support this addition, nor is it actionable from an audit perspective.

4.5 Summary

The recommendations were submitted to the California Technical Subcommittee in an effort to strengthen the LGMA metrics in terms of food safety. Many of the recommendations are reflective of what the industry is already doing according to our survey results. While strengthening food safety, the changes should reduce pressure on wildlife and wildlife habitat in leafy greens production areas throughout California. In essence, the changes shift the focus from concerns over discrete lists of animals and animal intrusion to an emphasis on fecal matter in the field. They are strong, science-based, auditable changes to metrics that have support from industry leaders, wildlife experts, food safety scientists and have been vetted with both the USDA and the FDA.

In April 2012 and in June 2012, presentations to the LGMA Technical Committee were made on the expert panel recommendations. A final vote will be held at the October 2012 Technical Committee meeting on the recommended changes.

5.0 ACKNOWLEDGEMENTS

We would like to thank the members of the expert panel – Mary Bianchi, Chris Fischer, Sharan Lanini, Afreen Malik, Brendan Miele, Laura Mills, Michele Jay-Russell, and Ken Stearns. We are also grateful to Cecilia Crowley and Michael Mahovic from the FDA, Gregory McNair, and the auditors who reviewed the proposed changes from the USDA, Karen Lowell, and Vicki Scott from the Arizona LGMA. This study was supported by funding received from the California Department of Food & Agriculture, grant #SCB09003, as part of the USDA's Specialty Crop Block Grant program.

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Table 1. Food safety programs currently in place (% of respondents)

California LGMA	88.7%
PrimusLabs.com GAP Program	62.3%
GLOBALG.A.P	20.8%
Buyer-specific program	18.9%
Arizona LGMA	17.0%
USDA-AMS GAP/GHP Audit Verification Program	15.1%
NSF Davis Fresh	9.4%
Other	5.7%
SQF	1.9%
None	0. 0%

Table 2. Animal presence in leafy green fields (# of respondents)

Answer Options	Daily throughout the year	Daily during mating season	Daily during migration	Several times a month	Maybe once a month	Not at all
Birds	31	2	4	6	1	1
Cows	0	0	0	0	0	41
Deer	0	0	0	6	10	26
Dogs	2	0	0	6	20	14
Frogs	1	1	0	6	12	17
Rodents	9	3	0	20	11	2
Rabbits	9	2	0	14	13	6
Wild pigs	0	0	0	1	10	30
Other	4	0	0	5	2	7

Table 3. Auditors specifying wildlife as a food safety concern

Please provide the name of the auditing company, inspector or customer who suggested or specified wildlife as a food safety hazard or concern for your leaf green crop operations. Please check all that apply.	Which animals were suggested or specified as being a hazard/concern? Please check all that apply.						
Answer Options	Birds	Deer	Domestic animals	Feral pigs	Field rodents	Response Percent	Response Count
CDFA auditor for LGMA	6	3	8	1	5	50.0%	9
Primus auditor	5	4	7	2	7	66.7%	12
Davis Fresh (NSF Int'l) auditor	4	2	3	1	2	27.8%	5
GlobalGAP auditor	1	0	0	0	0	5.6%	1
SQF auditor	0	0	0	0	0	0.0%	0
Retailer (please provide name in space below)	0	2	2	2	1	11.1%	2
Handler (please provide name in space below)	6	2	4	2	6	38.9%	7
Food service operator (please provide name in space be	1	1	2	1	2	11.1%	2
Other please provide name in space below)	0	1	1	0	1	5.6%	1
Name of company							27

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FIGURE 1. ARE ANIMALS OBSERVED ON YOUR LAND A THREAT TO THE SAFETY OF YOUR LEAFY GREEN CROPS?

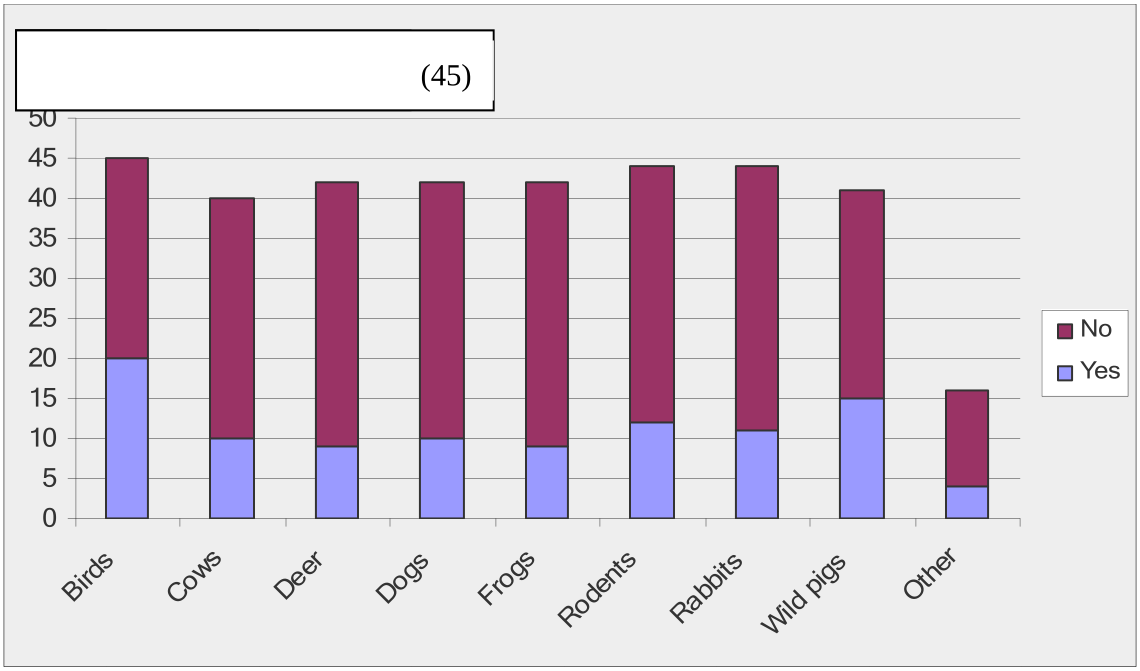
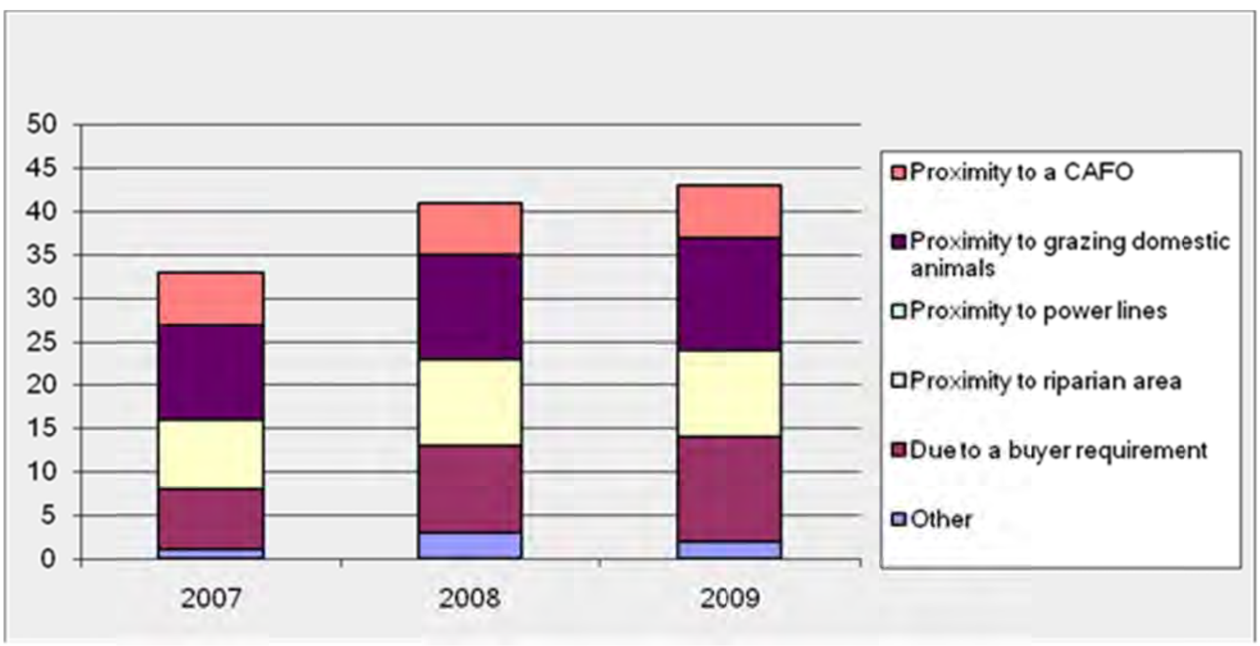


Figure 2. Reasons for not planting relating to wildlife concerns



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The Impacts of Changes in Agricultural Transportation Sector on the Competitiveness of the California Specialty Crop Industry

August 2012

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I. Introduction

The U.S transportation system moves agricultural commodities and products thorough a vast network of food system handlers, processors and distributors to domestic consumers and coastal ports for export to international markets. An agricultural transportation system that provides reliable, safe, and cost efficient service is critical to the current and future successful marketing of U.S. food products.

The USDA reports that the agricultural sector is the largest user of freight transportation services in this country.[1] By aggregating the movements of raw agricultural commodities with the movements of processed products and agricultural inputs, agriculture accounted for 31% of all ton-miles transported in the U.S. in 2007.

This observation is reinforced by a previous U.S. Department of Transportation (USDOT) study[2] that used input-output methods to determine the extent to which transportation is incorporated into the output of various sectors. Their study shows $0.15 of transport service is required for each $1 increase in final demand for agricultural products, which is the highest transport requirement of any sector. It follows that transportation costs embodied in agricultural product prices are comparatively large implying the potential importance of transportation costs and investments on product price, regional and international competitiveness, and agricultural producers and affiliated industries profitability.

Transportation is especially important for California agriculture because of the dynamic link between California's specialty crop[3] production to California markets and markets in the other 49 U.S states. Across the nation, U.S. consumers regularly purchase many crop commodities where California leads the nation in production and in some crop commodities is virtually the sole producer

Table 1.1 shows the crops and livestock in which California leads the nation in production. California leads the nation in the production of 77 different crops and livestock, i.e. it is the top producer in terms of dollar value of the commodity. There are 14 commodities (highlighted in black in table 1.1) where California produces over 99% of the production for the U.S.

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[1] U.S. Department of Agriculture, Transportation Services Division, Agricultural Marketing Service. *Study of Rural Transportation Issues.* April, 2010.

[2] U.S. Department of Transportation (USDOT).Transportation Satellite Accounts: A New Way of Measuring Transportation Services in America. Bureau of Transportation Statistics, BTS99-R01. Washington. DC. 1999.

[3] Fresh fruit, nuts, and vegetables are three of the crop categories included in the USDA definition of specialty crops. The other categories include dried fruit, nursery and floriculture products.

Table 1.1. Crops and Livestock Commodities in which California Leads the Nation[4]

Almonds	Escarole/Endive	Limes	Pigeons and Squabs
Apricots	**Figs**	Mandarins & Mandarin Hybrids 2/	**Pistachios**
Artichokes	Flowers, Bulbs	Melons, Cantaloupe	Plums
Asparagus	Flowers, Cut	Melons, Honeydew	**Plums, Dried**
Avocados	Flowers, Potted Plants	Milk	Pluots
Beans, Dry Lima	Garlic	Milk Goats	**Pomegranates**
Bedding/Garden Plants	**Grapes, Raisins**	Nectarines	Raspberries
Broccoli	Grapes, Table	Nursery, Bedding Plants	**Rice, Sweet**
Brussels Sprouts	Grapes, Wine	Nursery Crops	Safflower
Cabbage, Chinese	Greens, Mustard	**Olives**	Seed, Alfalfa
Cabbage, F.M.	Hay, Alfalfa	Onions, Dry	Seed, Bermuda Grass
Carrots	Herbs	Onions, Green	**Seed, Ladino Clover**
Cauliflower	Kale	Parsley	Seed, Vegetable and Flower
Celery	**Kiwifruit**	**Peaches, Clingstone**	Spinach
Chicory	Kumquats	Peaches, Freestone	Strawberries
Cotton, American Pima	Lemons	Pears, Bartlett	Tomatoes, Processing
Daikon	Lettuce, Head	Peppers, Chile	Vegetables, Greenhouse
Dates	Lettuce, Leaf	Peppers, Bell	Vegetables, Oriental
Eggplant	Lettuce, Romaine	Persimmons	**Walnuts**
			Wild Rice

Additionally, foreign markets have become relatively more important in the past six years for California exports of specialty crops. California agricultural exports reach nearly 150 countries in any given year. The 2010 export value of California's principal commodities was $39,952 million dollars. Specialty crop exports were $11,454 million or 29% of that $39,952 million dollars.[5] For a number of California specialty crops the export market is the largest market as measured by the ratio of quantity exported to quantity produced. Examples would include almonds (67%), blueberries (50%), dried plums (59%), oranges (43%), and walnuts (56%).

For California specialty crop producers to continue to benefit from increasing overseas demand, exporters must be able to deliver their products to customers thousands of miles away with no substantial loss in freshness and quality. Moreover, the cost of transporting perishable products, in many cases, is substantially more than for bulk commodities: 5 to 10 percent of the free on board (fob) value of grain versus over 30 percent for important horticultural products such as lettuce and citrus. Increasingly major challenges facing California specialty crop producers in the future will be related to issues of maintaining an efficient, timely, and competitive agricultural transportation system.

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[4] California Agricultural Statistics, Crop Year 2010 (October 28, 2011). USDA, National Agricultural Statistic Service California Field Office.

[5] California Agricultural Exports 2010 report. Agricultural Issues Center University of California. http://www.aic.ucdavis.edu/publications/exportstable2012.pdf. The California specialty crop export figure has been adjusted by removing the wine export value.

The movement of these California fruits, vegetables, and nuts to distant domestic and international markets requires movement by a multimodal system of truck, rail cars, intermodal rail, ocean ports and air transport. The services provided, the prices charged, and the competitive/complementary interactions among modes, directly affects the competitive success of California specialty crop shippers in reaching and serving these markets.

Increasingly a major future challenge facing California specialty crop producers, affiliated firms, and California public officials will be related to issues of maintaining a logistically efficient, and competitive California agricultural transportation system.

Study Problem Statement and Objectives

The basic problem addressed by this study was the lack of information and analysis available to assess how changes in the agricultural transportation technology, infrastructure, and transportation cost might impact the regional and international competitiveness of California specialty crop industries.

The specific objectives associated with answering the basic problem included:

- Gather primary and secondary data on the various modes of transportation. This data would include product market and transportation market information by region and specialty crop sector.
- Identifying those transportation modes (truck, rail, air, ports) where the California specialty crop grower, shippers, and transportation industry firms are experiencing or may experience changes in their regional and international competitiveness due to logistical and cost issues associated with current and projected changes in transportation technology, infrastructure, and agricultural transportation markets. The importance will be identified by specialty crop category and California region.
- Evaluate the impact that changes in agricultural transport technology, infrastructure, and agricultural transportation markets will have on the future competitiveness of California specialty crop producers in the regional and international marketplace.
- Provide policy makers and others stakeholders involved with agricultural transportation issues suggestions on maintaining or improving the regional and international competitiveness of California specialty crop industries through changes and improvements in existing transportation mode services.

Overview of the Report and Study Limitations

The primary limitation for this study as it progressed was the availability of secondary data. As noted in the overview of demand for transportation services, there is limited information available for total shipments of fresh fruit and vegetables into specific cities/markets and from designated locations. The United States Department of Agricultural, Agricultural Marketing

Service last produced an annual report of Fresh Fruit and Vegetable Arrival Totals for 20 Cities in 1998. The report is no longer prepared due to budget limitations. A possible other data limitation is that shipment data is based on information obtained from various shipping points.

The shipment information used in this analysis fails to captures the total shipments to various domestic market destinations (e.g. Chicago). Many California fruits and vegetables have historically been sold through terminal market and shipping point transactions with buyers and sellers developing stable and on-going relationships. These relationships have, over the last number of years, become formalized through the increased use of production and market contracts between produce buyers and seller. These contracts take a myriad of forms from a payment for so much per pound (or box) of production to complex cost and revenues sharing agreements. Calvin[6] provides a discussion of the recent changes that have occurred in produce marketing. The data that represent the changes do not appear to exist in the public domain. Furthermore, data for air, rail, and boat transportation appears to be limited in a usable form.

Additional data limitations that are specific to the remaining sections of the report will be discussed in those sections. Although having a more robust data set would have strengthened the analysis done in this study, the general observations and conclusions do provide insight to the objectives of the study.

The rest of the report is broken into seven sections. The next section provides an overview of the demand for transportation services. It develops an estimate of the quantities of selected California fruits and vegetables that must be moved each year to domestic and international markets. The third section discusses characteristics of refrigerated truck transportation services. This discussion is based on two surveys regarding the issue. The first survey covered examined transportation issues from the standpoint of specialty crop refrigerated truck shippers while the second survey examined transportation issues from the specialty crop refrigerated truckers' perspective.

The forth section is an overview of the rail and air transportation services and the fifth discusses ocean port specialty crop transportation issues. The sixth section provides the results of multiple modeling efforts. The first effort is a discussion of the overlap in production capabilities for selected fresh fruit and vegetables. The second is a spatial analysis of transporting fresh fruit and vegetables with no production capability constraints. Third, a model of regional competitiveness constrained by states' production capabilities and transportation costs, and an analysis of the impact of greenhouse gas emissions on California specialty crop refrigerated truck movement. The final section of the report provides a summary of the study and some suggestions on addressing the major specialty crop transportation issues that are brought out in study.

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[6] Linda Calvin and Roberta Cook (coordinators); Mark Denbaly, Carolyn Dimitri, Lewrene Glaser, Charles Handy, Mark Jekanowski, Phil Kaufman, Barry Krissoff, Gary Thompson, and Suzanne Thornsbury. U.S. Fresh Fruit and Vegetable Marketing: Emerging Trade Practices, Trends, and Issues. Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 795. May 2001

II. Demand for Transportation Services

California agricultural production encompasses a wide variety of products; the California Department of Food and Agriculture reports that 400 different commodities are grown within the state.[7] California production of specialty crops abounds, with nearly half of the fruits, nuts and vegetables produced in the United States grown in California. While per capita consumption of specialty crops by California's 37 million plus population is estimated to be above the national average the vast majority of production is exported either to other states in the United States or into the global marketplace.[8]

To better understand the overall magnitude of the demand for transportation services it was necessary to develop an estimate of the quantities of California's fruits and vegetables that must be moved each year. To accomplish this we begin with a review of the annual production tonnages of the major fruit and vegetable crops obtained from the California Department Food and Agriculture statistics. To estimate a "usual" crop, an annual average of the production of the crops for 2008, 2009 and 2010 was used.

Table 2.1 provides information regarding the production of a select set of fruits produced in California. It shows that approximately half of the commodities have an upward trend, while the rest are trending lower. Grapes and oranges are the two largest produced commodities in terms of short tons in the table. Thirteen of the commodities are ranked first in production in comparison to the rest of the United States. The fruits presented in the table in total represent production that occurs throughout the year.

Information in Table 2.2 shows the amount of short tons of a select group of vegetables that were produced in California in 2008, 2009, and 2010. Head lettuce, carrots, and onions have the largest volume of production occurring in this time period. As with the fruits in Table 2.1, the vegetables in totality are grown across the whole year. In the case of vegetables, there are more commodities that are produced on a continuous basis in comparison to fruits. California ranks first in the production of 17 of the crops presented. A little more than half of the crops in the table have production trends that are increasing. This average is used to represent the annual tonnage production of 20 fruit crops and 22 vegetable crops (Tables 2.1 and 2.2).

To provide some understanding of the seasonal nature of the demand for transportation services, the usual harvest periods and each crop's production are also provided. To give insight regarding where the overall level of demand may be headed production trends of each crop based on 10-year production data for the indicated crops were calculated. Lastly the importance of export markets for selected California fresh fruits and vegetables expressed as the percent of production

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[7] California Department of Food and Agriculture. "California Agricultural Highlights, 2010", www.cdfa.ca.gov/statistics

[8] Robert Wood Johnson Foundation. " F as in Fat: How Obesity Threatens America's Future, 2010", www.healthyamericans.org , page 21.

being exported, which have implications for international transportation service demand, are presented in Table 2.3.

Table 2.1. California Fresh Fruit Production

	Volume in 1,000 Short Tons						
Commodity	2008	2009	2010	3 Year Average	Harvest Season	Leading Counties	Trend
Apples	180	133	140	151	July 15-Oct. 30	San Joaquin, Kern, El Dorado, Fresno, Stanislaus	Decrease
Apricots	77	60	59	65	May 1-July 15	Stanislaus, Fresno, Kings, Kern, San Joaquin	Decrease
Avocados	165	88	275	176	Continuous	San Diego, Santa Barbara, Ventura, Riverside, San Luis Obispo	Increase
Boysenberries	0			0	June 1-Oct. 31	Santa Cruz, Ventura, Monterey, Los Angeles, San Bernardino	Decrease
Cherries, Sweet	86	78	97	87	May 20-June 25	San Joaquin, Fresno, Stanislaus, Tulare, Kern	Increase
Grapefruit, All	174	161	151	162	Nov. 1-July 31	Riverside, San Diego, Tulare, Kern, Kings	Decrease
Grapes, Raisin Type	2,520	1,927	2,079	2,175	May 15-Nov. 15	Fresno, Madera, Tulare, Kern, Kings	Decrease
Grapes, Table Type	973	874	1,008	952	May 25-Dec. 15	Kern, Tulare, Fresno, Riverside, Madera	Increase
Kiwifruit	23	26	33	27	Oct. 1-May 31	Tulare, Butte, Yuba, Fresno, Sutter	Decrease
Lemons	562	798	798	719	Aug. 1-July 31	Ventura, Riverside, Kern, Tulare, San Diego	Increase
Nectarines	295	210	225	243	June 10-Sept. 5	Fresno, Tulare, Kings, Kern, Madera	Increase
Olives	67	46	195	103	Sept. 25-Mar. 15	Glenn, Tehama, San Joaquin, Tulare, Butte	Decrease
Oranges, Navel & Misc.	1,688	1,294	1,594	1,525	Nov. 1-Aug 31	Tulare, Fresno, Kern, Riverside, San Bernardino	Increase
Oranges, Valencia	638	450	563	550	Nov. 1-June 15	Tulare, Kern, Fresno, Ventura, San Diego	Increase
Peaches, Clingstone	426	469	432	442	July 15-Sept. 15	Stanislaus, Sutter, Yuba, Merced, Butte	Decrease
Peaches, Freestone	433	350	385	389	May 10-Sept. 15	Fresno, Tulare, Kings, Stanislaus, Merced	Increase
Pears, All	243	255	220	239	Aug. 5-Oct. 5	Sacramento, Fresno, Lake, Mendocino, Yuba	Decrease
Plums	160	112	141	138	May 25-Aug. 20	Fresno, Tulare, Kings, Madera, Yuba	Decrease
Raspberries	27	51	41	40	June 1-Oct. 31	Ventura, Santa Cruz, Monterey	Increase
Strawberries, Fresh Market	930	1,002	1,041	991	--	Monterey, Ventura, Santa Barbara, San Luis Obispo, Sacramento	Increase
Tangerines, Mandarins, Tangelos & Tangors	251	251	371	291	Nov. 1-May 15	Kern, Tulare, Madera, Riverside, San Diego	Increase
Source: California Agricultural Statistice, various crop years. NASS , California Field Office, USDA							
Note: Trend is based on the estimated slope of the commodity for the period of 1990-2010							

Table 2.2. California Fresh Vegetable Production

	Volume in 1,000 Short Tons						
Commodity	2008	2009	2010	3 Year Average	Harvest Season	Leading Counties	Trend
Artichokes	57	56	45	53	Continuous	Monterey, Riverside, Imperial, San Mateo, San Benito	Increase
Asparagus	21	20	20	20	Jan. 1 Nov. 30	San Joaquin, Monterey, Fresno, San Benito, Imperisl	Decrease
Beans, Snap	30	35	53	39	June 1-Dec. 31	Stanislaus, Riverside, Fresno, San Diego, Santa Clara	Increase
Broccoli	928	920	859	902	Continuous	Monterey, Santa Barbara, Imperial, San Lui Obispo, Fresno	Increase
Cabbage	267	247	234	249	Continuous	Monterey, Ventura, San Luis Obispo, Imperial, Santa Barbara	Increase
Carrots	1,068	994	987	1,016	Continuous	Imperial, Monterey, Fresno, Riverside, Los Angeles	Decrease
Cauliflower	291	290	275	285	Jan. 20-Dec. 15	Monterey, Santa Barbara, Imperial, San Luis Obispo, Riverside	Increase
Celery	954	932	964	950	Continuous	Monterey, Ventura, Santa Barbara, San Luis Obispo, Imperial	Increase
Corn, Fresh Market Sweet	199	224	244	223	May 1-Dec. 1	Imperial, Fresno, San Joaquin, Contra Costa, Riverside	Increase
Cucumbers, Fresh Market	27	23	42	31	Apr. 1-Nov. 30	Ventura, San Diego, San Joaquin, Tulare, Fresno	Decrease
Garlic	196	187	181	188	Apr. 1 Sept. 15	Fresno, Kern, Santa Clara, San Benito, Mono	Decrease
Lettuce, Head	2,059	2,109	1,943	2,037	Jan. 1 Nov. 30	Monterey, Imperial, Fresno, Santa Barbara, San Lui Obispo	Decrease
Lettuce, Leaf	531	476	474	494	Continuous	Monterey, Imperial, Fresno, Santa Barbara, San Lui Obispo	Increase
Lettuce, Romaine	885	1,024	461	790	Continuous	Monterey, San Benito, Riverside, Ventura	Increase
Melons, Cantaloupe	585	586	546	572	June 1 Dec. 15	Fresno, Imperial, Merced, Stanislaus, Kern	Decrease
Melons, Honeydew	134	134	118	129	June 1-Dec. 15	Fresno, Sutter, Imperial, Riverside, Stanislaus	Decrease
Melons, Watermelon	328	347	314	329	June 1 Oct. 25	Fresno, Riverside, San Joaquin, Kern, Imperial	Decrease
Mushrooms, Agaricus	59	62	56	59	Continuous	Monterey, Santa Clara, Ventura, San Diego, Fresno	Decrease
Onions	1,507	1,010	941	1,153	May 1 Oct. 31	Fresno, Imperial, Kern, Los Angeles, San Joaquin	Increase
Peppers, Bell	403	380	387	390	Apr. 1-Oct. 31	Riverside, Ventura, Kern, San Joaquin, San Benito	Increase
Spinach, Fresh Market	206	221	217	215	Continuous	Monterey	Increase
Tomatoes, Fresh	583	522	599	568	May 15 Jan. 31	Fresno, San Diego, San Joaquin, Merced, Stanislaus	Increase
Source: California Agricultural Statistice, various crop years, NASS , California Field Office, USDA							
Note: Trend is based on the estimated slope of the commodity for the period of 1990-2010							

Table 2.3. Percent of Fresh Fruits and Vegetables Going to Export, California: 2010

FRUITS	Export %	VEGETABLES	Export %2
Apples	24.7%	Artichokes	6.2%
Apricots	10.1%	Asparagus	1.2%
Avocados	14.2%	Broccoli	16.8%
Cherries, Sweet	35.9%	Cabbage	2.6%
Grapefruit	29.0%	Carrots	11.0%
Grapes All	28.0%	Cauliflower	36.0%
Grapes, Table Type	35.3%	Celery	11.7%
Kiwifruit	27.0%	Corn, Sweet	5.2%
Lemons	12.9%	Garlic	14.8%
Peaches and Nectarines	10.2%	Lettuce	8.0%
Peaches, Fresh Market	14.0%	Lettuce, Head	4.9%
Pears, All	10.0%	Melons	11.4%
Plums	41.0%	Onions	19.5%
Raspberries and blackberries	61.5%	Peppers, Bell and Chili	4.3%
Strawberries	10.7%	Spinach, Fresh Market	9.4%
Tangerines, Mandarins,	4.3%	Tomatoes, Fresh	5.7%
		Watermelon	7.6%

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Demand for international transportation services are generated by the large percentage of California fresh fruits and vegetables going to the export market (Table 2.3). For example in 2010 over sixty percent of raspberries and blackberries were exported. Exports markets account for smaller, but important outlets for California fresh vegetables. For example 36 percent of cauliflower production flows to international markets.

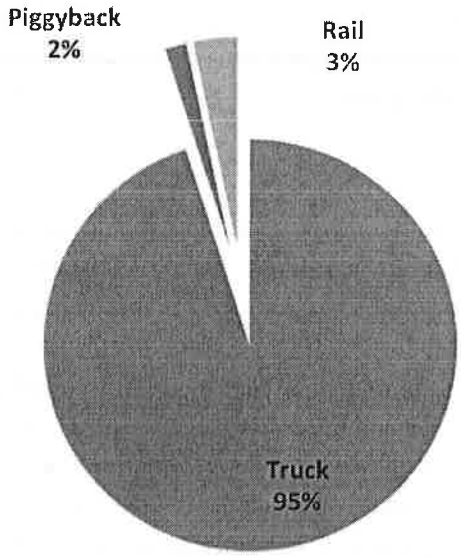
Shipments by Mode: Land-based Services

Information regarding the movement of specialty crops by alternative land-based modes is limited. For many years the USDA, Agricultural Marketing Service (AMS) has provided a summary of shipments by mode by calendar year.[9] Data provided in these reports is admittedly not representative of the complete movements for any given commodity. However, the information provided allows for a useful approximation of the role of individual carrier modes in the shipment of California fruits and vegetables and the role California plays in the utilization of each mode and total volume usage for product deliveries. The information reported here represents movements both within California and throughout the United States. The distributions of these inter and intrastate movements among various market destinations will be discussed in the following section.

Trucks dominate as a mode of surface transportation for the United States fruits and vegetables. According to the most recent AMS movement report, shipments by truck account for 95 percent of all domestic movements, while rail accounts for the remaining 5 percent split between refrigerated railcar and the multi-modal function of container on flatcar (Piggyback) as illustrated in Figure 2.1.

[9] USDA, AMS. *Fresh Fruit and Vegetable Shipments: By Commodities, States, and Months,* FVAS-4 Calendar Year 2010.

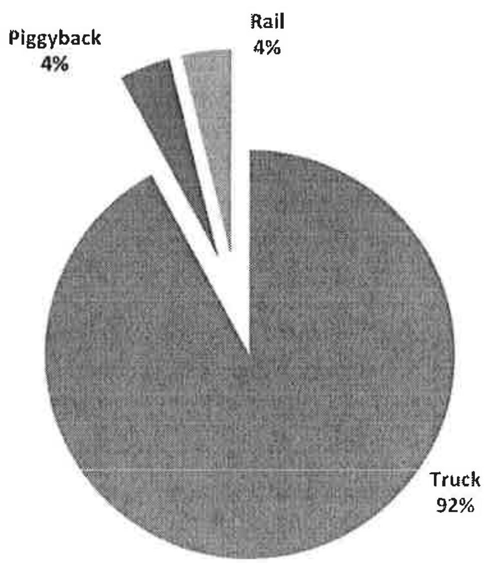
Figure 2.1. U.S. Fresh Fruit and Vegetable Shipments by Mode: 2010



Source: USDA, AMS, FVAS-4, Callendar Year 2010

Shipments of fresh fruit and vegetables from California reflect the U.S. experience with truck transport accounting for 92 percent of surface movements, with rail accounting for the remaining 8 percent evenly split between piggyback and railcar (Figure 2.2).

Figure 2.2. California Fresh Fruit and Vegetable Shipments by Mode: 2010

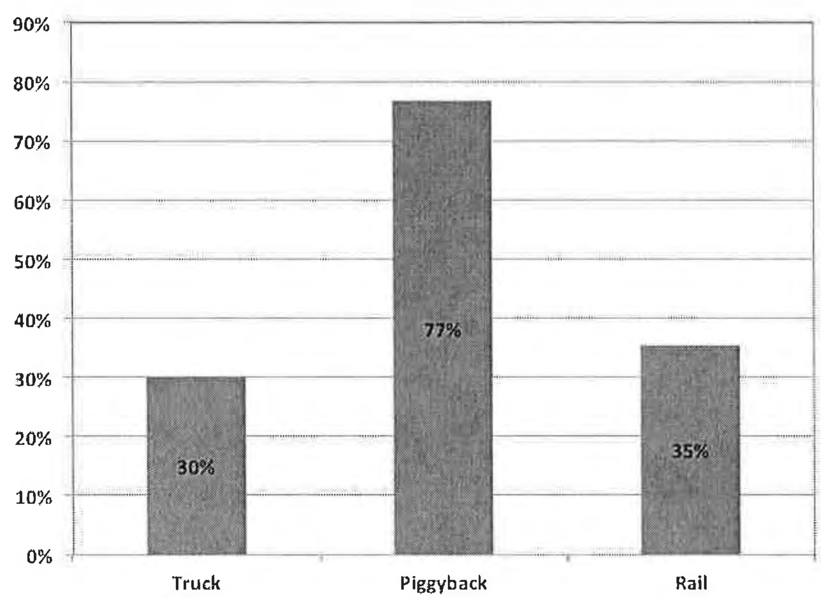


Source: USDA, AMS, FVAS-4

Figure 2.3 provides information on what percentage of the U.S. total shipments of fruits and vegetables are shipped from California producers by mode. While piggyback shipments comprise a small portion of total state shipments of fruits and vegetables, California shipments take up the lion's share of total piggyback rail shipments accounting for seventy-seven percent of all recorded U.S. movements of fruits and vegetables using the piggyback mode of transportation. Out of all the fruits and vegetable shipments across the country by truck transport, California accounted for thirty percent of total recorded truck shipments. Thirty-five percent of all rail deliveries of fresh fruits and vegetables originate from California.

On a commodity specific basis the choice of surface transportation mode appears to be linked with relative perishability. Hence, more perishable crops with higher values would utilize air transport, while less perishable low value crops might be more likely to move by rail. However for all California commodities trucks remain the dominant transportation as described in Appendix A.

Figure 2.3. California Share of U.S. Fruit and Vegetable Shipments by Mode, 2010



Shipments to Selected Markets

Domestic shipments of California specialty crops are directed toward markets throughout the United States. In the existing supply chain, shipments from California travel to major regional distribution centers for subsequent repackaging, storage and additional handling and/or transit to other markets for delivery to their final destination. As mentioned earlier, data on fresh produce shipments are limited and those reported here include movements for export, for California markets along with product destined for markets outside of California in other western and eastern states. To develop a better approximation of actual domestic shipments outside of the state of California a subset of commodities produced in the state was examined in greater detail. In addition to the subset of commodities an effort was made to describe market destinations based on historical information to aid in understanding where the demand for enhanced transportation services may most likely be present.

The commodities selected for this study were chosen to represent a mix of specialty crops that reflect the overall variation in perishability and the broad category of the many commodities produced in California. These include root crops (celery), stone fruit (cherries), vine crops (table grapes), leafy green (head lettuce), stone fruit (peaches), berries (strawberries), common vegetables (sweet corn, fresh tomatoes), and melons (watermelon). The refined shipment volume estimates by mode are presented in Table 2.4.

Limited information is available for total shipments of fresh fruit and vegetables into specific cities/markets and from designated locations. However, the United States Department of Agricultural, Agricultural Marketing Service, has historically produced an annual report of Fresh Fruit and Vegetable Arrival Totals for 20 Cities, but has ceased production of this report due to budget limitations. The last year this report was available is for the calendar year 1998, and it is utilized here to provide general information regarding key markets for California fresh fruit and vegetables.

Table 2.4. California Fresh Fruit and Vegetable Shipments by Month: 2010

California Fruits (100,000 LBS)													
Commodity	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**
TRUCK													
Cherries, Sweet					476.59	444.62							**921.21**
Grapes, Table	50.76				100.80	583.07	938.42	1,974.75	2,372.16	2,139.37	1,989.25	836.17	**10,984.77**
Peaches, Fresh Market					123.87	663.54	907.82	869.71	585.58	269.40	0.87		**3,420.79**
Strawberries	218.55	402.60	1,458.54	2,279.84	2,737.65	2,646.78	2,073.94	1,698.95	1,457.39	889.16	422.15	169.09	**16,454.64**
Sub Total	**269.32**	**402.60**	**1,458.54**	**2,279.84**	**3,438.91**	**4,338.00**	**3,920.18**	**4,543.41**	**4,415.14**	**3,297.93**	**2,412.27**	**1,005.26**	**31,781.40**
PIGGYBACK													
Grapes, Table							5.80	13.05	41.34	14.50	10.15	3.63	**88.48**
Peaches, Fresh Market					2.60	8.66	14.73	14.73	9.53	2.60			**52.84**
Sub Total					**2.60**	**8.66**	**20.53**	**27.78**	**50.87**	**17.10**	**10.15**	**3.63**	**141.32**
RAIL													
Grapes, Table						11.60	7.25	31.18	118.93	88.48	39.16	18.13	**314.74**
Peaches, Fresh Market					0.87					2.60			**3.46**
Sub Total					**0.87**	**11.60**	**7.25**	**31.18**	**118.93**	**91.07**	**39.16**	**18.13**	**318.21**
TOTAL													
Cherries, Sweet					476.59	444.62							**921.21**
Grapes, Table	50.76				100.80	594.67	951.48	2,018.99	2,532.44	2,242.35	2,038.57	857.92	**11,387.99**
Peaches, Fresh Market					127.34	672.20	922.55	884.43	595.11	274.60	0.87		**3,477.09**
Strawberries	218.55	402.60	1,458.54	2,279.84	2,737.65	2,646.78	2,073.94	1,698.95	1,457.39	889.16	422.15	169.09	**16,454.64**
Sub Total	**269.32**	**402.60**	**1,458.54**	**2,279.84**	**3,442.38**	**4,358.27**	**3,947.96**	**4,602.37**	**4,584.94**	**3,406.11**	**2,461.58**	**1,027.01**	**32,240.93**

California Vegetables (100,000 LBS)													
Commodity	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**
TRUCK													
Celery	927.58	889.76	1,091.45	1,036.83	1,166.04	1,187.05	872.95	926.53	924.43	1,148.18	1,797.38	1,194.40	13,162.57
Corn, Sweet				135.51	356.88	200.72	238.40	209.78	132.25	64.85	72.10	11.96	1,422.45
Lettuce, Head	1,181.29	1,025.52	1,376.01	3,063.57	3,154.44	3,141.46	2,894.81	2,920.78	2,907.80	3,362.14	2,206.81	1,077.44	28,312.06
Melons, Watermelon					54.31	184.72	271.01	309.61	153.01	30.60			1,003.26
Tomatoes						86.31	1,159.29	1,282.91	1,562.82	1,508.01	459.52	8.16	6,067.02
Sub Total	**2,108.87**	**1,915.28**	**2,467.46**	**4,235.90**	**4,731.67**	**4,800.25**	**5,436.47**	**5,649.61**	**5,680.30**	**6,113.78**	**4,535.81**	**2,291.96**	**49,967.36**
PIGGYBACK													
Celery	93.49	79.84	97.70	125.01	114.50	104.00	80.89	73.53	73.53	65.13	94.54	99.80	1,101.96
Lettuce, Head				155.77	129.81	116.83	90.87	90.87	90.87	103.85	51.92		830.80
Melons, Watermelon						2.21	7.17	5.79	5.79	0.83			21.78
Tomatoes						4.67	36.15	36.15	38.49	48.98	19.83		184.27
Sub Total	**93.49**	**79.84**	**97.70**	**280.78**	**244.32**	**227.70**	**215.08**	**206.35**	**208.68**	**218.79**	**166.30**	**99.80**	**2,138.81**
RAIL													
Celery	28.36	39.92	30.46	33.62	69.33	66.18	45.17	25.21	22.06	31.51	95.59	79.84	567.26
Tomatoes						4.67	17.49	14.00	15.16	19.83			71.14
Sub Total	**28.36**	**39.92**	**30.46**	**33.62**	**69.33**	**70.85**	**62.67**	**39.21**	**37.22**	**51.34**	**95.59**	**79.84**	**638.40**
TOTAL													
Celery	1,049.43	1,009.52	1,219.61	1,195.45	1,349.87	1,357.23	999.01	1,025.27	1,020.02	1,244.82	1,987.52	1,374.03	14,831.79
Corn, Sweet				135.51	356.88	200.72	238.40	209.78	132.25	64.85	72.10	11.96	1,422.45
Lettuce, Head	1,181.29	1,025.52	1,376.01	3,219.35	3,284.25	3,258.29	2,985.68	3,011.65	2,998.66	3,465.99	2,258.73	1,077.44	29,142.86
Melons, Watermelon					54.31	186.92	278.18	315.40	158.80	31.43			1,025.04
Tomatoes						95.64	1,212.94	1,333.06	1,616.47	1,576.82	479.34	8.16	6,322.43
Sub Total	**2,230.73**	**2,035.03**	**2,595.62**	**4,550.30**	**5,045.32**	**5,098.79**	**5,714.21**	**5,895.16**	**5,926.20**	**6,383.91**	**4,797.69**	**2,471.60**	**52,744.57**

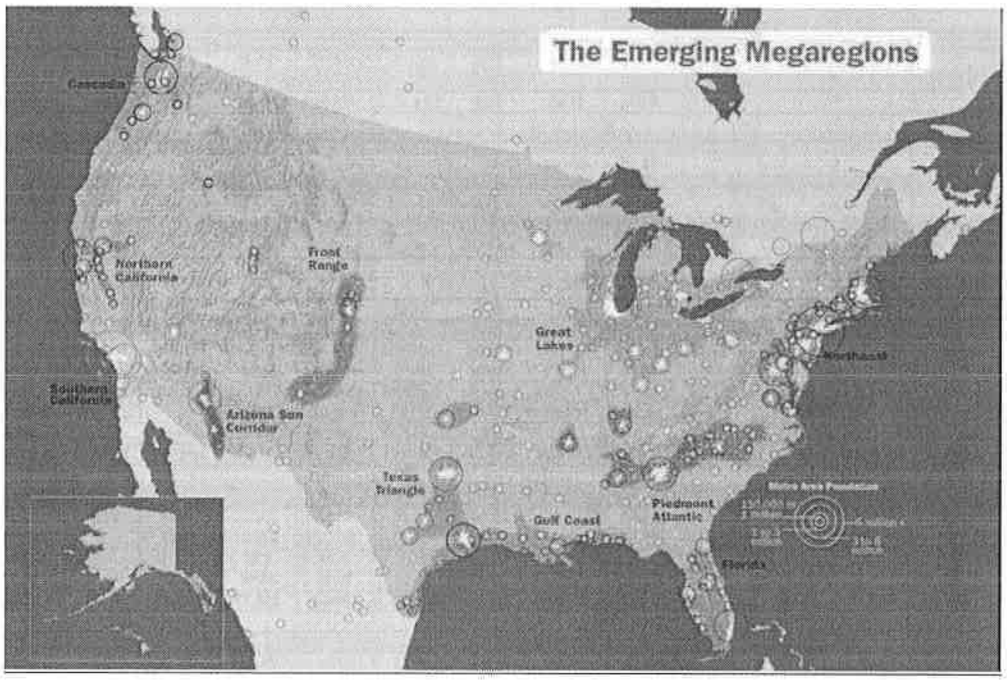
Source: Distribution is taken from: Fresh Fruit and Vegetable Shipments by Commodities, States, and Months, Agricultural Marketing Service, Fruit and Vegetable Programs, USDA, FVAS-4 Calendar Year 2010, Issued February 2011. Production data: NASS, USDA; Consumption: ERS, USDA

The data provided from this report do not capture all shipments from California, since there are likely many cities, not included in this report, that receive smaller volumes individually but comprise a significant portion collectively. More recent studies suggest that while regional groupings may have expanded to include larger service areas, the destinations remain similar in-terms of the major city hub market that defines each region (Figure 2.4).[10]

[10] Witzke, Erika, Cambridge Systematics, Inc.

The amount of shipments (as measured in 100,000 lbs. units) to each of the selected cities for California divided by modal choice is provided in Table 2.5 (truck and rail + piggyback). In this case the volumes presented include all recorded shipments to account for sizeable intra-state movements. The California production origins and the commodity movement volumes and destinations are additionally illustrated geographically in Figures 2.5 a/b - 2.12 a/b. Those products where rail movements are notable are illustrated in Figures 2.13 – 2.16.

Figure 2.4. Regional Distribution/Consumption Centers



Source: Erika Witzke, PE; Cambridge Systematics, Inc.

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Table 2.5. Selected Commodity Shipments by Destination

California Commodity Shipments*	Atlanta	Baltimore	Boston	Chicago	Columbus	Dallas	Detroit	Los Angeles
CELERY-RAIL		47	296	471				
CELERY-TRUCK	522	889	540	1782	39	773	1126	1867
CHERRIES-TRUCK		103	69	207			69	516
CORN, SWEET-TRUCK	4		7	11		262	4	1770
GRAPES-TABLE-RAIL			88	215				
GRAPES-TABLE-TRUCK	819	1345	789	1527	66	854	1178	2674
LETTUCE, ICEBERG- RAIL		29	222	381				
LETTUCE, ICEBERG - TRUCK	1685	1382	1604	2404	251	808	1187	2780
PEACHES-RAIL			16	16				
PEACHES-TRUCK	84	181	141	490	0	313	313	865
STRAWBERRIES-TRUCK	748	1078	1147	1515	25	991	1097	3085
TOMATOES-RAIL			46	59				
TOMATOES-TRUCK	217	140	79	704	54	842	439	1394
TOMATOES, CHERRY-TRUCK	2	2	5	11	1	11	8	3
WATERMELONS-TRUCK	10		6	8		2	29	2227

California Commodity Shipments*	Miami	New York	Philadelphia	Pittsburgh	St Louis	San Francisco	Seattle	Total
CELERY-RAIL		531	244					1589
CELERY-TRUCK	431	1285	607	565	491	942	671	12530
CHERRIES-TRUCK	34					241		1239
CORN, SWEET-TRUCK	4				101	1327	435	3926
GRAPES-TABLE-RAIL		174	79					556
GRAPES-TABLE-TRUCK	425	1244	597	455	748	1613	814	15147
LETTUCE, ICEBERG- RAIL		419	188	9				1246
LETTUCE, ICEBERG - TRUCK	438	1340	684	746	709	852	455	17324
PEACHES-RAIL		23	11					65
PEACHES-TRUCK	115	84	75	106	229	847	106	3949
STRAWBERRIES-TRUCK	193	823	436	623	636	1172	736	14305
TOMATOES-RAIL		73	41					219
TOMATOES-TRUCK	43	310	50	88	168	512	163	5202
TOMATOES, CHERRY-TRUCK	0	1	2			6	2	53
WATERMELONS-TRUCK	2		14		4	1090	247	3639

*Shipments in 100,000 lbs units, 2010 California shipments volume from USDA/AMS/FVAS-4 2010 is allocated based on destinations from Historic shipment patterns from USDA/AMS/FVAS-3, 1998

Figure 2.5 a/b California Celery Production and Distribution

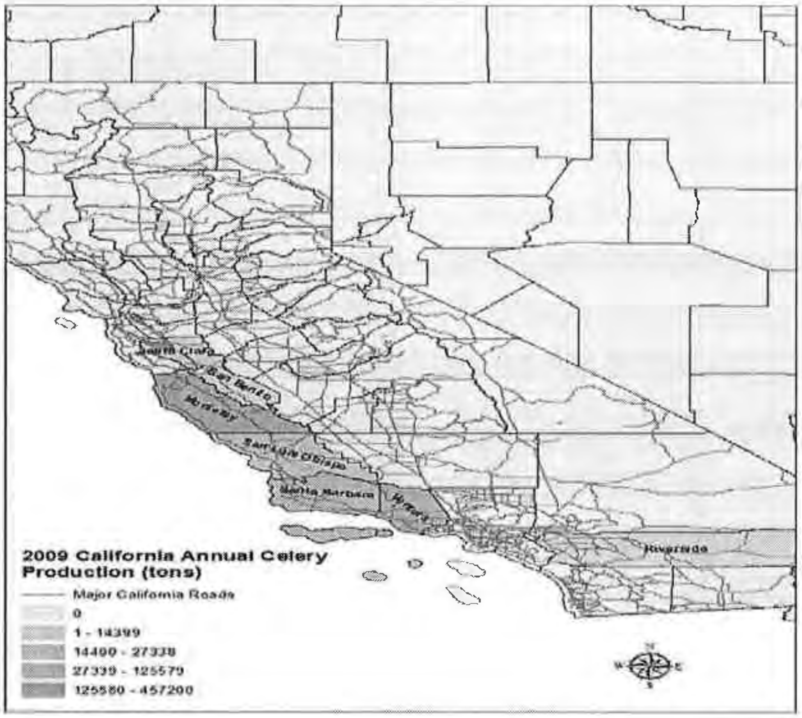

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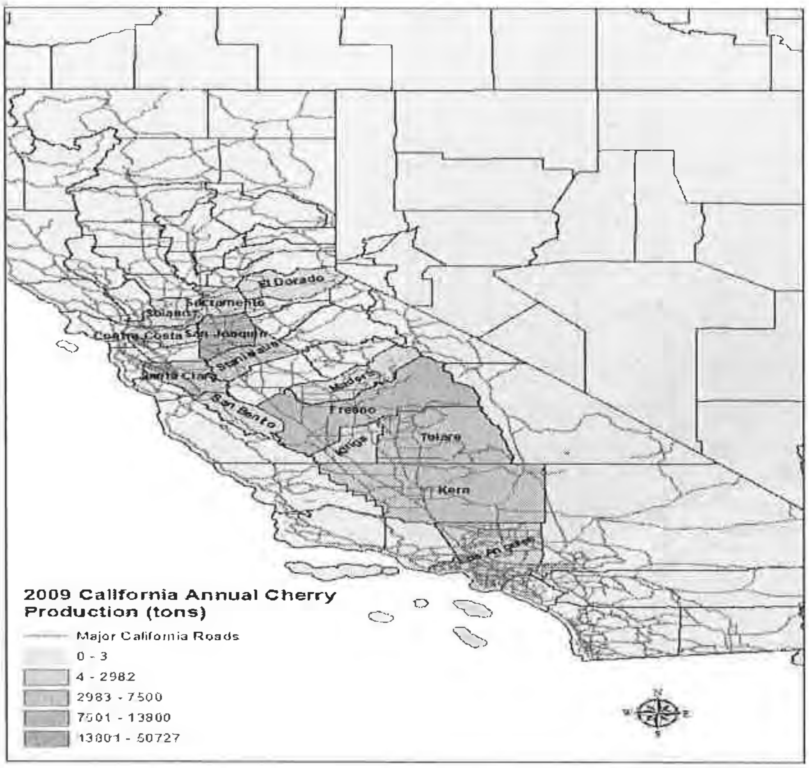
Figure 2.6 a/b California Cherry Production and Distribution



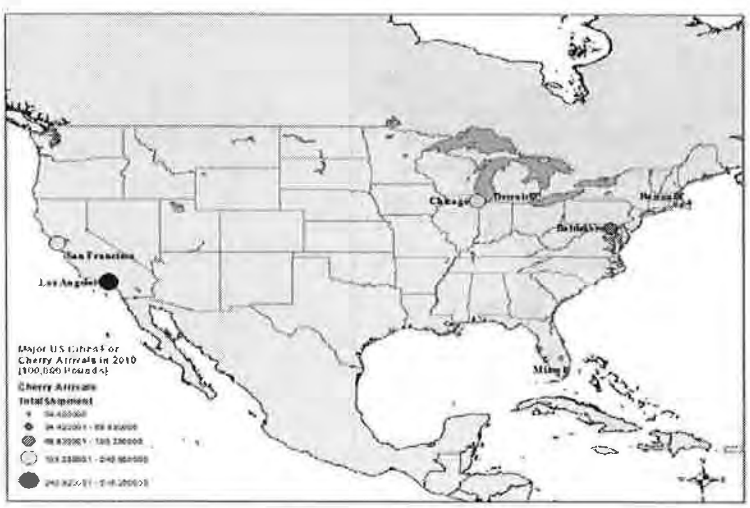


Figure 2.7 a/b California Table Grape Production and Distribution

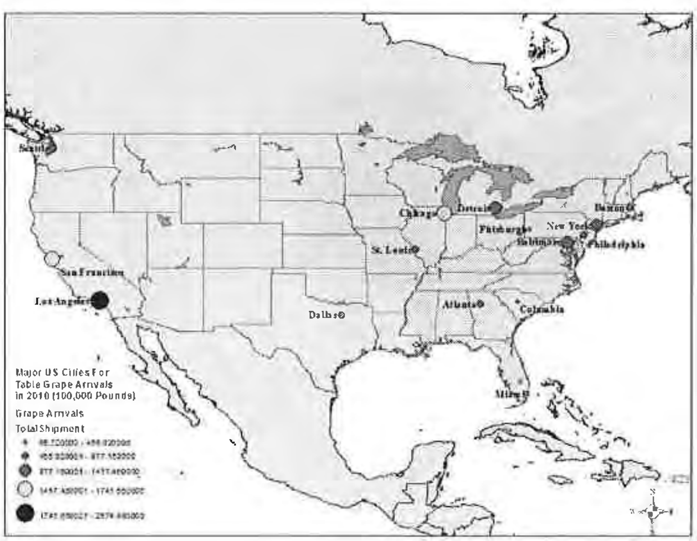


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Figure 2.8 a/b California Lettuce Production and Distribution

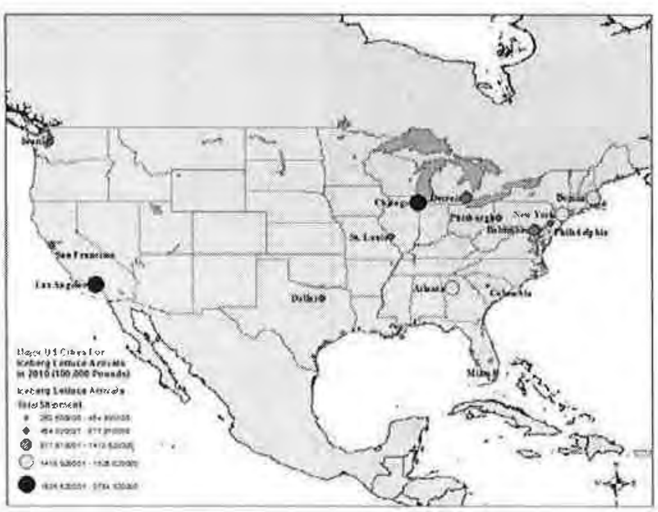

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Figure 2.9 a/b California Strawberry Production and Distribution

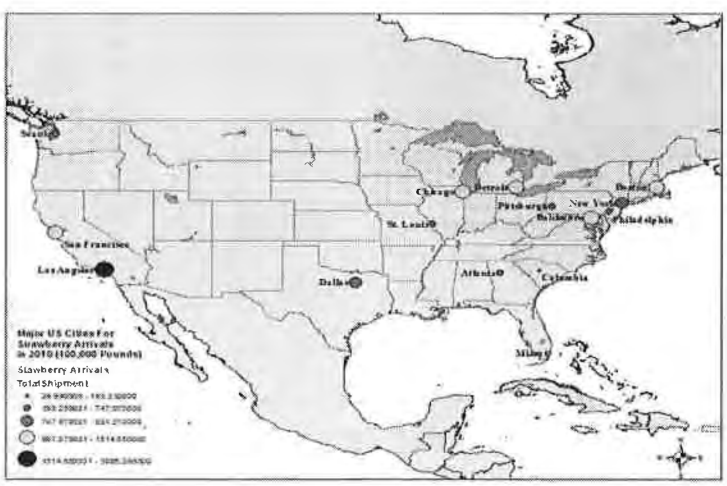


Figure 2.10 a/b California Sweet Corn Production and Distribution

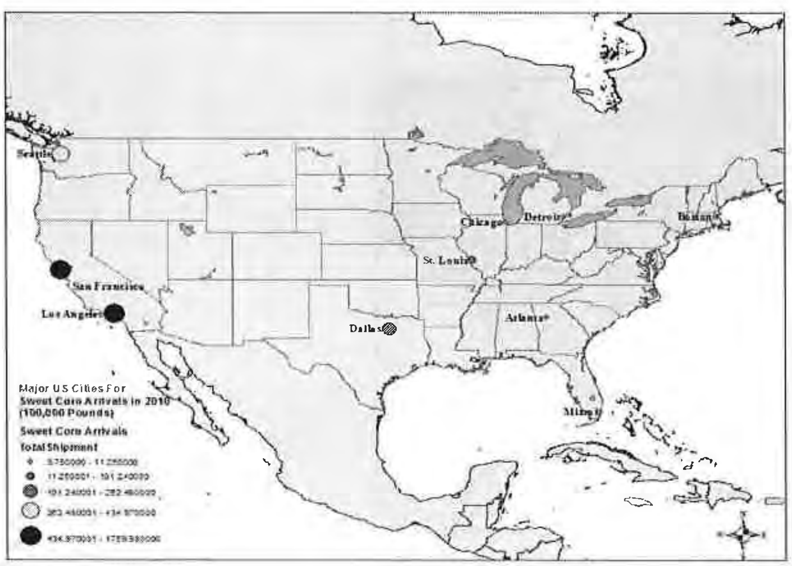
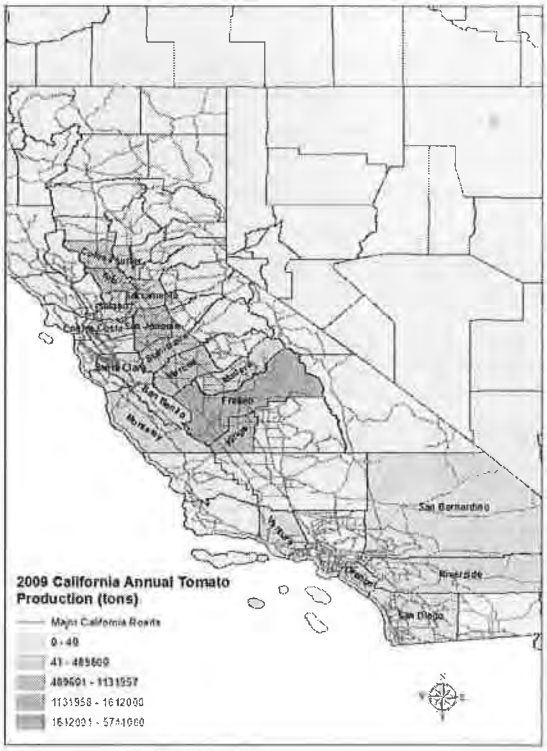


Figure 2.11 a/b California Fresh Tomato Production and Distribution



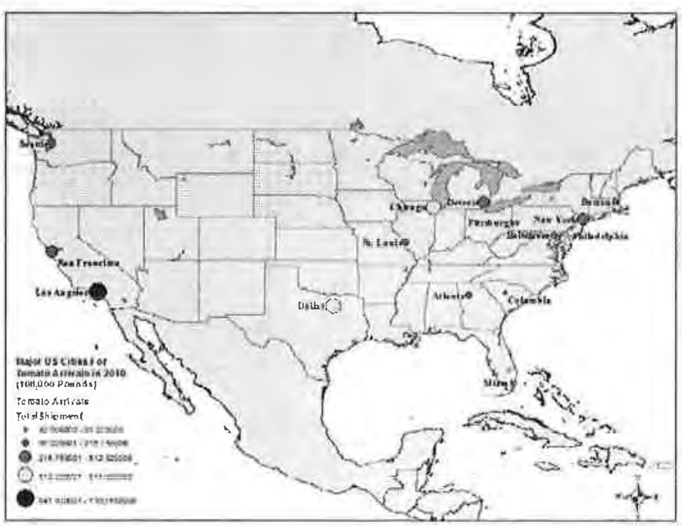


Figure 2.12 a/b California Watermelon Production and Distribution

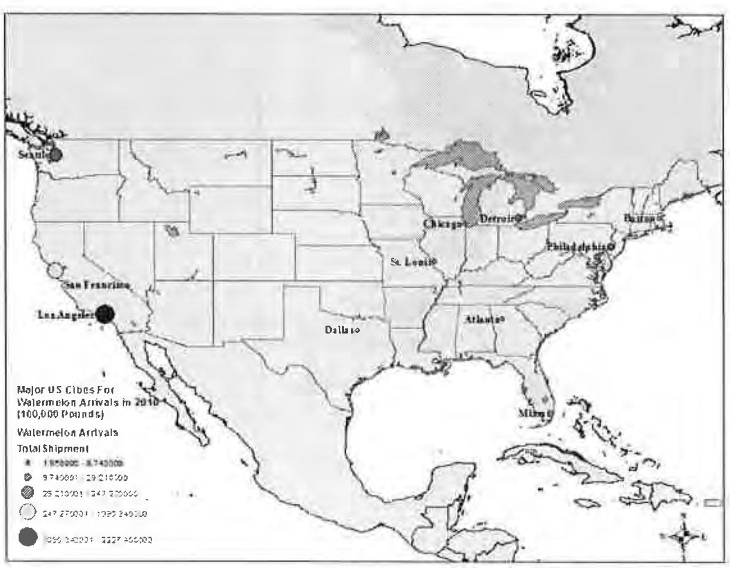


Figure 2.13 Celery Shipments by Mode, 2010

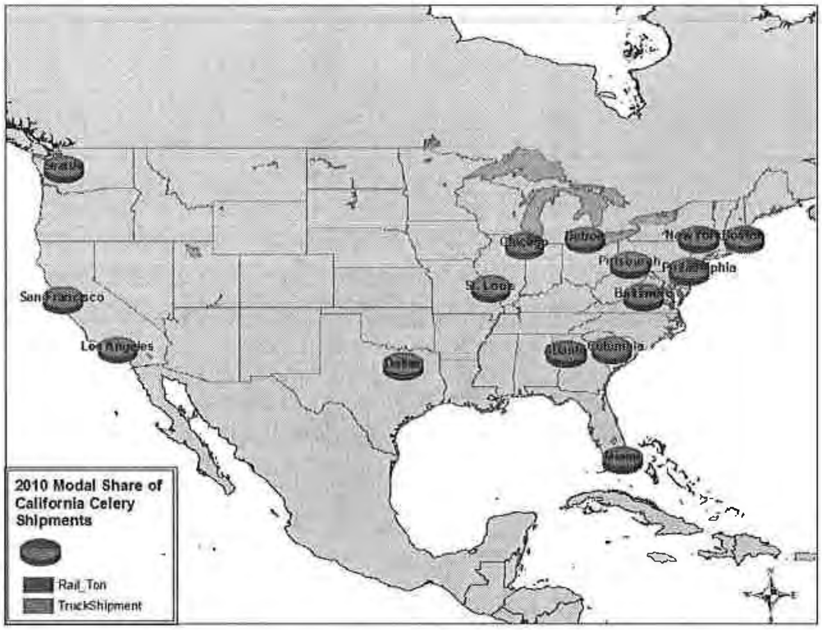


Figure 2.14 Table Grape Shipments by Mode, 2010

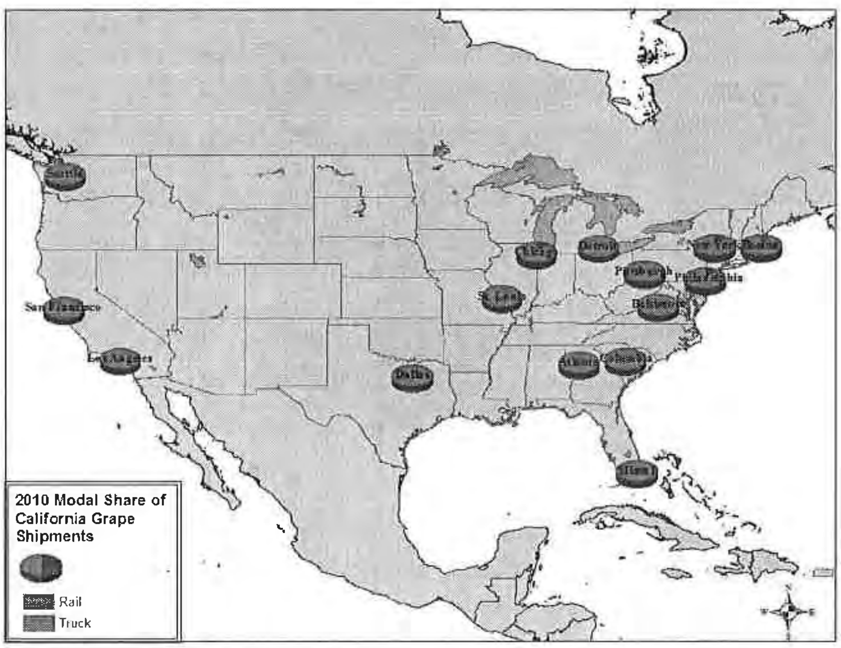


Figure 2.15 Lettuce Shipments by Mode, 2010

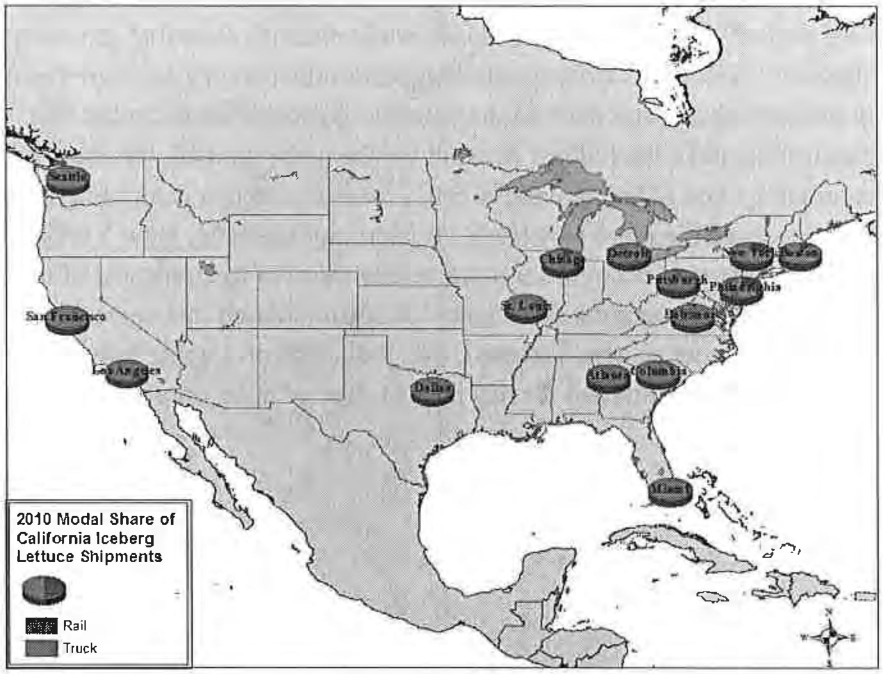
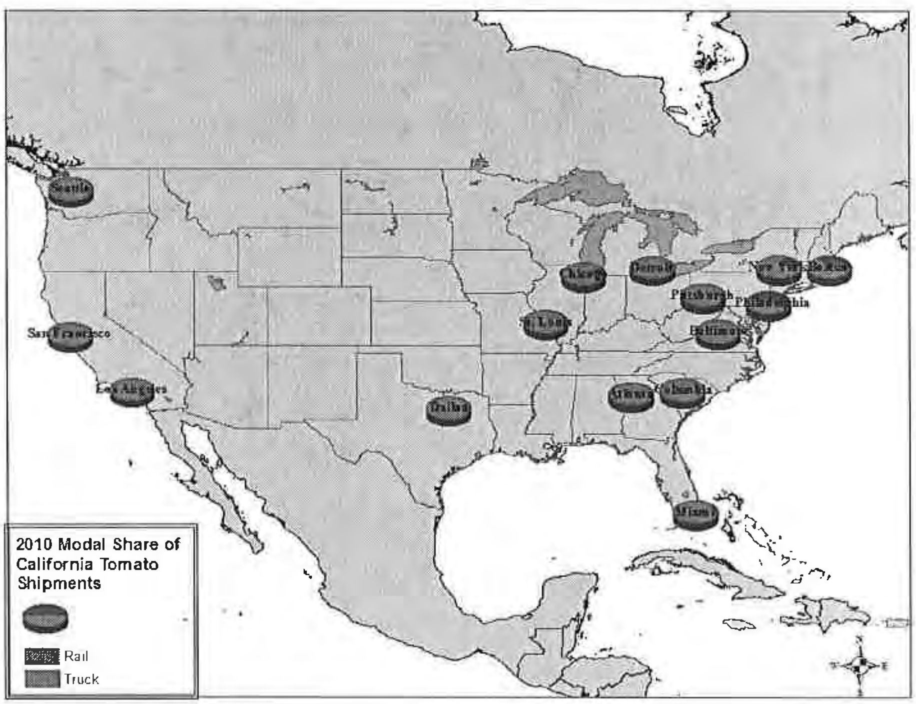


Figure 2.16 Tomato Shipments by Mode, 2010



Upon reviewing Figures 2.5 through 2.16, there are several key points that can be highlighted. Production of each of the crops examined is distributed differently across the state. For example, strawberries and lettuce are primarily produced on the coast, while cherries and table grapes are produced in the inner valleys of California. Different markets across the country have greater or lesser demand for certain products than other parts of the country. As would be expected San Francisco and Los Angeles usually have the highest demand for the crops studied, but there are times when other regions surpass some of the demand in San Francisco. When examining modal distributions, most of the products studied move by truck. It is not until Boston, New York, and Philadelphia are reached that rail starts to account for a noticeable share of the transport of the crops studied. The exception to this observation is Chicago. It is conjectured that since Chicago is along the major rail route to the upper eastern seaboard, that it does receive some rail shipments. Out of the 11 crops that were studied for this project, five of them only utilize trucks and did not ship by rail.[11]

[11] It should be noted that only four out of the 11 crops studied are represented in the modal figures presented. This is because they represent the most noticeable usage of rail transport.

III. Characteristics of Transportation Services: Truck

As indicated by the reported data, the mode of choice for the movement of California fresh fruit and vegetables is truck. Accordingly it is important to better understand the relationship between those who utilize these services and those that provide them. In order to formulate alternatives for improvements in the efficiency of goods movements, an understanding of stakeholder views on the current state of operations and important issues of concern are critical. With a view toward obtaining such insight a detailed survey of carriers and shippers were conducted. The results of these surveys are provided in the following sections. A copy of the survey instruments can be obtained from the authors upon request.

Description/Summary of Carrier Survey

Transportation issues can have an effect on both shippers and truckers. In the produce industry, where perishability requires the timely transport of products, transportation is a key factor in California maintaining a competitive edge over its rivals. Unfortunately, there is little information about the issues that are affecting the transportation of California fresh produce. In order to understand these issues, a survey was conducted from September 2010 to October 2010 that elicited responses from truckers/carriers who haul California fresh produce.

There were two main goals of the trucker survey. One of the goals was to develop an understanding of the transportation issues that are having an effect on truckers who transport California produce within and outside of the state. The other goal was to take a snapshot of the characteristics of the trucking industry that ships California produce.

The trucking survey was developed utilizing a previous survey conducted by Hagen, Minami, Mason, and Dunston (1999) entitled *California's Produce Trucking Industry: Characteristics and Important Issues*. While many questions from this survey overlap the study by Hagen et al., this survey incorporated new questions that are related to the current economic and transportation environment. Representatives who transport California fresh produce were utilized in the design phase of the survey. These individuals provided feedback on important questions that should be asked, as well as, appropriate responses that participants would understand.

To obtain the sample, a branch of the American Truckers Association known as the Agricultural and Food Transporters Conference provided assistance. This group represents carriers/truckers on issues that affect the transportation of agricultural commodities. A letter was sent to a representative of this organization, which was forwarded to a set of truckers who ship California produce. In this letter, the truckers were asked to fill out an online survey regarding their thoughts about transporting California produce. A copy of the letter and survey are available from the authors upon request.

The survey of truckers and carriers had thirty-eight questions that can be broken up into eight major categories. These eight categories are:

- Fleet Demographics
- Transit Times
- Capital Issues
- Labor Issues
- Issues of Importance and Satisfaction
- Use of Lumpers
- Routes
- Factors that Affect Service Charges

The first category of questions elicited general demographic information about the respondent. This information was requested to develop a snapshot of the California produce trucking industry. Information was collected on fleet size, gross revenue from 2009, and percentage of produce that is shipped from California. This section also inquired about the firm's headquarters and how many employees they have employed inside and outside of California.

The next category of questions inquired about transit times. These questions can be broken up into three main types. The first type of questions asked about time spent loading and unloading produce. This part broke-up loading and unloading time into four areas--waiting time to load, loading time, waiting time to unload, and unloading time. The next type of question related to transit time inquired about the typical length of hauls for produce. These first two types of questions differentiated between full loads, mixed loads, and partial loads. The third type of questions inquired about whether produce takes more or less time to ship in comparison to other products the company handles.

The third category of questions investigated capital issues that these truckers are facing. In regards to capital, one question asked about the average age of their trucks and the average age of their trailers. It should be noted that at the time of the survey the U.S. economy was recovering from the "Great Recession". This recession led to a large capital shortage due to a recent downturn in the economy. Hence, a few questions were asked to gauge how this shortage was affecting the truckers. One of the questions investigated whether the truckers had any difficulty obtaining capital for fleet maintenance or expansion. Another question asked whether lack of capital was a hindrance to their future plans regarding maintenance/expansion of their fleet.

While the third category focused on capital issues, the fourth category of questions emphasized labor issues. One set of questions asked about the average age of the drivers in the fleet and whether the average age has increased over the past five years. Three questions were asked to provide an understanding regarding driver turnover and its effect. One question looked at how long the typical driver is employed with the company. Another question inquired about whether the company has had difficulty in the last three years obtaining drivers. A third question asked whether a lack of drivers is hindering the maintenance/ expansion of the trucker's fleet.

The fifth category of questions inquired about what issues were important to the truckers and their level of satisfaction regarding particular issues. The questions related to satisfaction were a subset of the issues of importance. These issues can be broken-up into three sets. One set of issues revolved around the shipper. Another set focused on the receiver. A third set of issues focused on transportation issues and characteristics of the truckers produce load (e.g., risk, perishability, and value).

The next category of questions inquired about lumpers, who are professionals hired to assist with loading and unloading the trucks. The first question in this group asked whether the trucker utilized lumpers for unloading some of their produce loads. If the respondent answered yes to this question, he/she was asked a set of follow-up questions. The first follow-up question asked what percentage of loads do the drivers require lumpers. The second follow-up question queried whether lumpers increase or decrease unloading time. The third inquiry asked about the rates that lumpers charge.

The seventh category of questions inquired about the trucker's routes and shipments. One set of questions asked about the characteristics of the routes (e.g., single vs. multiple stops, predictable vs. varied). Another question in this category asked about the destinations of the shipments. These destinations were broken-up into major regions of the United States (e.g., Midwest, Northeast, etc.). Two questions in this group asked about congestion. One of the questions regarding congestion inquired about the percentage of shipments that were affected by congestion on major routes (e.g., Interstate 5, Interstate 80, etc.). Another question on congestion asked about the typical delay time due to when congestion is encountered on a particular route.

The eighth category of questions asked about how the truckers would change the prices of their services if there were a permanent change in the set of selected factors. These factors included regulatory issues, costs of shipping, costs of shipping by other competitors, driver availability, and road congestion. In a competitive setting, it is expected that a 10 percent permanent increase in cost of transportation would lead to a less than 10 percent increase in what the trucker would charge. This is because any single cost factor may make-up only a portion of the total costs.

The last three questions in the survey were open-ended questions. The first question asked about what strategies the truckers employ to minimize delay due to traffic congestion. The second question inquired about negative impacts that have been experienced by the truckers due to unexpected delays. The third question asked the truckers to identify the most important factors that will affect the produce trucking industry in the next five to ten years.

Service Provider Perspectives/Concerns

There were 94 trucker/carriers who responded to the request to take the survey. Of these 94 truckers who responded, it appears that eight clicked through the questions in the survey without providing any responses. Hence these eight have been dropped in the tabulation of results taking the final amount of respondents to 86.

The respondents in the survey represented trucking companies who have headquarters in 32 different states. Figure 3.1 provides the number of respondents in the survey based on where their headquarters are located. Thirteen percent of the respondents have headquarters in California. Texas and South Dakota have approximately 7 percent each of the headquarters. Five respondents are headquartered in Wisconsin, while Missouri and Nebraska have headquarters of four of the respondents each.

Figure 3.1. State Location of Respondent's Headquarters

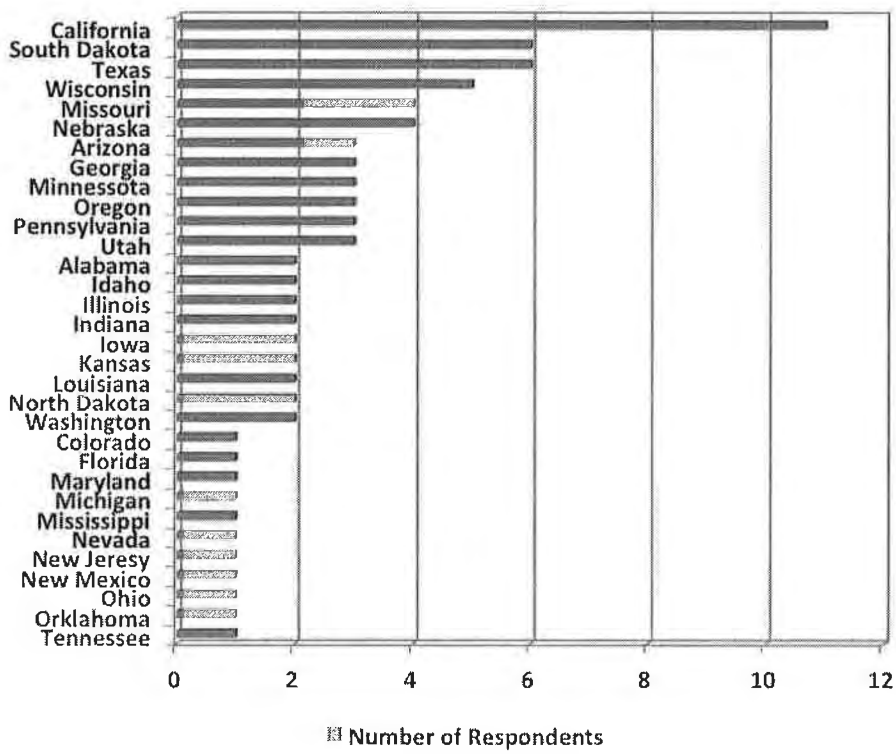


Table 3.1 provides the distribution of respondents across the number of drivers working for them outside and inside California. For those respondents who indicated that they had employees outside of California, 47.50 percent indicated that they employed between 1 to 5 drivers. Another 21.25 percent indicated that they employed between 6 and 25 truckers in their fleet. Only 2.5 percent of the respondents were representing companies that had over 1000 employees outside of California. For those companies that had truckers inside California, 61.54% had between 1 to 5 employees. There were no companies in the survey that had between 101 and 1,000 employees working in California. This information indicates that a vast majority of

respondents were from smaller trucking companies. Hence the general results of the survey are weighted towards small trucking firms.

Table 3.1. Distribution of the Number of Drivers Employed by Trucking Firms Who Responded to the Survey

Number of Drivers	Outside CA	Inside CA
1-5	47.50%	61.54%
6-25	21.25%	5.13%
26-50	10.00%	17.95%
51-100	6.25%	10.26%
101-500	7.50%	0.00%
501-1,000	5.00%	0.00%
Above 1,000	2.50%	5.13%

Figure 3.2 shows the distribution of respondents based on the number of trucks in their fleet, while Figure 3.3 provides the distribution of respondents by gross revenue in 2009. Forty-nine percent of the respondents have less than five trucks in their fleet, while two percent have more than 1000 trucks. A majority of the truckers, sixty percent, earned less than $1 million in revenue in 2009, while nearly nineteen percent earned over $10 million in revenue. Since nearly seventy percent of the truckers who responded to this survey have fleet sizes less than twenty-five trucks, as seen in the previous question the responses of this survey are primarily coming from small trucking firms. The truckers in the survey leased on average approximately fifteen percent of their fleet, with a vast majority of the truckers not leasing any part of their fleet. Approximately six percent of the respondents leased one hundred percent of their fleet.

Figure 3.2. Distribution of Respondents Based on the Number of Trucks in Their Fleet

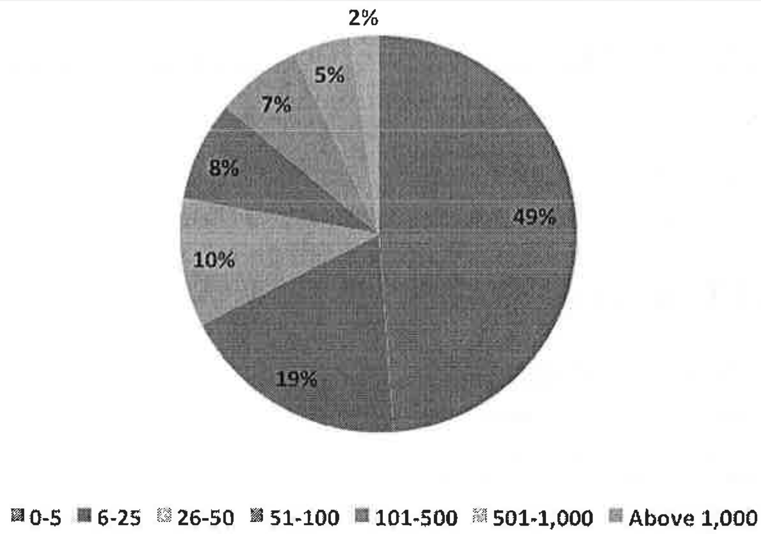
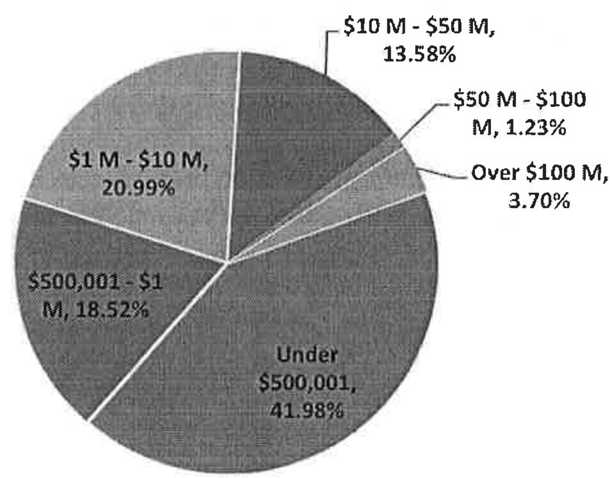


Figure 3.3. Distribution of Respondents by Gross Revenue in 2009



One of the questions on the survey asked the respondents to indicate what percentage of their loads are California produce. There were only two trucking companies in the survey that only shipped California produce. The average percentage of loads containing California produce is forty-two percent. Approximately thirty-seven percent of the respondents indicated that no more than twenty-five percent of their shipments are California produce. An equal percentage indicated that California produce made up between twenty-five and fifty percent of their total shipments. Nearly sixteen percent of the respondents indicated that over seventy-five percent of their total shipments are California produce.

One of the major factors affecting truckers is transit time. The transit time can be broken up into driving time and loading time. In the survey, a set of questions focused on the wait time for loading, load time, wait time for unloading, and time to unload California produce. This was done for full loads, mixed loads, and partial loads. In Table 3.2, it can be seen that the average wait time reported by the truckers in the survey was 6.85 hours for a full load, 9.30 hours for a mixed load, and 5.64 hours for a partial load.

The wait time for loading takes up the highest percentage of total loading and unloading time for all load types. Mixed loads appear to have on average the longest wait times and load times in comparison of the other types of loads. The average wait times and load times for a full load of fresh produce sum to 16.22 hours. Truckers spend approximately forty-percent of the loading and unloading time waiting to load the product. Eighty-nine percent of the truckers indicated that produce takes more time to load than other products that these individuals haul given the same in transit mileage.

To obtain a different perspective, the median hours were also calculated for loading and unloading times. In Table 3.2, it appears that the average data is skewed from the median data on the high side. This would imply that there are a few large responses in the data that are pulling the average above the median. Looking at the data closely shows that this is not a single data point pulling the average up. Over thirteen percent of the respondents reported a waiting time of at least 12 hours. By focusing on the median hours, a typical loading and unloading time for a full load of produce is 9 hours. Forty-four percent of this time is taken up by a truck driver waiting to load. Whether you are examining the average or median wait time before loading, both make up the highest percentage of the loading and unloading time for all types of loads.

Table 3.2. Loading and Unloading Time by Type of Load

Load Type	Segment Of Transit	Average Hours	Percentage of Total Time	Median Hours	Percentage of Total Time
Full Load	Wait Time Before Loading	6.85	42.23%	4.00	44.44%
	Load Time	3.46	21.33%	2.00	22.22%
	Wait Time for Unloading	3.03	18.68%	1.00	11.11%
	Time to Unload	2.88	17.76%	2.00	22.22%
	Total	16.22	100.00%	9.00	100.00%
Mixed Load	Wait Time Before Loading	9.30	40.61%	6.00	44.44%
	Load Time	7.15	31.22%	4.50	33.33%
	Wait Time for Unloading	3.29	14.37%	1.00	7.41%
	Time to Unload	3.16	13.80%	2.00	14.81%
	Total	22.9	100.00%	13.50	100.00%
Partial Load	Wait Time Before Loading	5.64	37.93%	3.00	37.50%
	Load Time	4.45	29.93%	2.00	25.00%
	Wait Time for Unloading	2.64	17.75%	1.00	12.50%
	Time to Unload	2.14	14.39%	2.00	25.00%
	Total	14.87	100.00%	8.00	100.00%

Another question in the survey related to transit was the length of the haul for California fresh produce. The truckers reported that the average length of a full load in miles was 1,961. Partial loads on average have the shortest haul of 1,686 miles. The truckers estimated that a mixed load on average traveled 1,872 miles. This distance would put the average load being delivered somewhere to the Midwest. Table 3.3 shows how the transit miles are distributed for full loads, mixed loads, and partial loads. Eight percent of the respondents indicated that their average transit distance was 500 miles or less for a full load. Another eight percent indicated that they travel greater than 500 miles but less than 1,000 miles for a full load. The highest percentage of respondents, thirty-two percent, travelled between 2,000 and 2,500 miles for a full load shipment of California produce. This travel distance had the highest percentage for all three load types: full, mixed, and partial.

Table 3.3. Distribution of Average Haul Length by Load Type

	Percentage of Respondents		
Average Length of Hauls (Miles)	**Full Load**	**Mixed Load**	**Partial Load**
0 to 500	8.00%	11.11%	17.14%
501 to 1,000	8.00%	8.89%	11.43%
1,001 to 1,500	12.00%	13.33%	11.43%
1,501 to 2,000	20.00%	13.33%	14.29%
2,001 to 2,500	32.00%	33.33%	31.43%
2,501 to 3,000	16.00%	17.78%	14.29%
Above 3,000	4.00%	2.22%	0.00%

The trucking firms in the survey indicated that the average age of their trucks in their fleet is 4.86 years, while the average age of their trailers is 5.59 years. Approximately fifty-five percent of the respondents indicated that they experienced difficulty obtaining capital in the last three years for expanding/maintaining their fleet. Typically, the smaller trucking firms indicated difficulty obtaining capital, while the larger firms responded that they did not have difficulty obtaining capital. Of the group that indicated difficulty obtaining capital, nearly eighty-four percent had less than twenty-five trucks in their fleet. There were no trucking companies with a fleet size over 500 reporting that they had trouble obtaining capital. Of the group of truckers who indicated that they had difficulty accessing capital, ninety-six percent believe that this difficulty has hindered their ability to maintain/expand their fleet.

The trucking industry is heavily reliant on qualified individuals to drive trucks as an occupation. The trucking companies in the survey indicated that the average age of their driver is 44.65 years old. For 59% of the companies in the survey, this average age has increased over the last five years. A typical driver will work for a trucking company for an average of 8.43 years. Forty-three percent of the trucking firms reported having difficulty finding drivers for expanding/maintaining their fleet. Of this group reporting difficulty, almost 96% believe that this difficulty finding drivers has hindered the maintenance/expansion of their fleet.

A select list of issues of importance was developed for the survey. This list can be found in Table 3.4 along with a distribution of responses that range from "Not Important" to "Very Important". The most important issue for the truckers in the survey was waiting time for loading their trailers. Over 92% of the respondents indicated this as a very important issue. Couple this result with the wait times for loading found in Table 3.2, and produce shippers should examine carefully the issue of waiting time for loading. The second highest important issue for truckers is the attitude of the shippers. This issue was closely followed by attitude of dock personnel and perishability of load. The top three issues for truckers are all related to issues with shippers. The issues of relative least importance were roadside regulations and attitude of other drivers.

Table 3.4. Truckers' Issues of Importance*

Issue of Importance	Mean Response	Not Important		Somewhat Important		Very Important
Wait time for loading	4.91	0.00%	0.00%	1.85%	5.56%	92.59%
Attitude of shippers	4.59	1.85%	0.00%	7.41%	18.52%	72.22%
Attitude of dock personnel	4.56	3.70%	0.00%	7.41%	14.81%	74.07%
Perishability of load	4.56	3.70%	0.00%	7.41%	14.81%	74.07%
Ability to load/unload easily	4.48	1.85%	0.00%	14.81%	14.81%	68.52%
Parking	4.48	0.00%	1.85%	16.67%	12.96%	68.52%
Attitude of receiver	4.41	1.85%	3.70%	9.26%	22.22%	62.96%
Wait time for unloading	4.38	3.77%	1.89%	15.09%	11.32%	67.92%
Availability of backload with current trailer	4.36	1.89%	5.66%	11.32%	16.98%	64.15%
Risk of shipment	4.31	1.85%	1.85%	20.37%	14.81%	61.11%
Value of load	4.25	5.66%	1.89%	13.21%	20.75%	58.49%
Attitude of other employees	4.17	1.85%	3.70%	20.37%	24.07%	50.00%
Attitude of dispatcher (carrier)	4.11	5.56%	3.70%	20.37%	14.81%	55.56%
Clear loading/unloading area	4.06	3.70%	3.70%	22.22%	24.07%	46.30%
Roadside regulation monitoring	3.94	7.55%	5.66%	20.75%	16.98%	49.06%
Attitude of other drivers	3.65	9.26%	9.26%	24.07%	22.22%	35.19%

*Not Important was assigned a 1, Somewhat Important was assigned a 3, and Very Important was assigned a 5 when calculating the mean response.

While the previous table presented results regarding the importance of particular issues to truckers, Table 3.5 provides information regarding truckers' satisfaction with certain issues from the previous table. The issue that truckers find the worst performance with is waiting time for loading. Given the wait times found in Table 3.2, it is no wonder that drivers are indicating a poor performance in this area. Over fifty-seven percent of the respondents recorded a poor performance for this issue. Availability of restrooms ranked second in poor performance with over fifty-three percent of respondents signifying a very poor performance record. It appears that the truckers in the survey believe that receivers of California produce are performing better than the shippers. The best performer in terms of mean response was other drivers.

Table 3.5. Truckers' Satisfaction of a Select Set of Issues*

Issue	Mean Response	Very Poor Performance		Moderate Performance		Excellent Performance
Wait time for loading	1.67	57.41%	20.37%	20.37%	1.85%	0.00%
Availability of restroom	1.94	53.70%	9.26%	29.63%	3.70%	3.70%
Attitude of shippers and their employees	1.94	42.59%	29.63%	18.52%	9.26%	0.00%
Parking	2.02	37.74%	32.08%	20.75%	9.43%	0.00%
Wait time for unloading	2.22	37.04%	18.52%	33.33%	7.41%	3.70%
Attitude of receivers and their employees	2.35	33.33%	22.22%	25.93%	12.96%	5.56%
Ability to load/unload easily	2.37	20.37%	31.48%	38.89%	9.26%	0.00%
Clear loading/unloading area	2.44	27.78%	14.81%	44.44%	11.11%	1.85%
Attitude of other drivers	2.69	12.96%	20.37%	53.70%	11.11%	1.85%

*Very Poor Performance was assigned a 1, Moderate Performance was assigned a 3, and Excellent Performance was assigned a 5 when calculating the mean response.

A set of questions was asked regarding truckers use of lumpers. Approximately 83% of the truckers have used lumpers to unload their trucks. Sixty-nine percent of respondents believed that lumpers decreased the unloading time. Over 97% of the truckers who used lumpers indicated that they were charged by the load rather than per hour where the average cost per load was $160. For the trucker that paid the lumper by the hour, he was charged an hourly rate of $45.

Trucking routes are important to the efficiency of truckers delivering their loads. Sixty-eight percent of the respondents indicated that their shipment of produce require only a single stop, while the remaining thirty-two percent are delivered to multiple places. Twenty percent of these truckers have predictable routes, while fifty-four percent have common routes that are not necessarily set. The remaining truckers have routes that vary widely. Table 3.6 provides the distribution of delivery regions for California produce. The highest percentage of loads, just over thirty-three percent, are going to the Midwest region of the country. The Southwest, Northeast, and South/Southeast each get approximately one out of six loads of produce from California based on the truckers in this survey. Around seven percent of the produce loads are staying within the state.

Table 3.6 Distribution of Delivery Regions for California Fresh Produce

Produce Destination By Region	Percentage of Loads
Instate destinations	6.76%
Pacific Northwest (Example: Seattle, Portland)	9.07%
Southwest (Example: Dallas, Houston)	14.29%
Midwest (Example: Chicago, Detroit)	33.98%
Northeast (Example: Baltimore, New York)	16.10%
South and Southeast (Example: Atlanta, Miami)	17.34%
Mountain (Example: Denver, Salt Lake City)	2.46%

One of the biggest issues that can affect a trucker's productivity is traffic congestion. A question on the survey asked the trucker to identify what percentages of their shipments are due to traffic congestion on California's major transportation routes. Another question inquired about what the typical delay was on each route due to congestion. Table 3.7 provides the results of these two questions. Interstate 5 had the highest average percentage of congestion at thirty-five percent. This congestion on average caused a typical delay of 3.21 hours. The route that had the second highest percentage of congestion was Interstate 80. The truckers in the survey found this route congested nearly thirty-two percent of the time. These truckers experience an average delay of 4.36 hours when they run into congestion on this route. This delay was ranked the second longest of the routes studied. The route that had the longest delay time at 4.63 hours was Interstate 15. This route had the fourth highest percentage of time being congested.

Table 3.7 Congestion and Typical Delay Times on Major California Routes

Major Routes	Percentage of Time Congested	Typical Delay in Hours Due to Congestion
I-5	35.03%	3.21
I-80	31.62%	4.36
I-10	27.78%	2.21
I-15	27.32%	4.63
I-40	26.06%	2.17
Port of LA/Long Beach	18.70%	1.82
Port of Oakland	16.14%	1.71
Other	14.05%	1.26
I-8	6.96%	0.76

There are many factors that affect the prices of the service truckers provide. Table 3.8 identifies a subset of factors that affect transportation costs. In the survey each factor was presented as a permanent rather than a transient change. For each factor presented, the survey inquired what percentage change in charges of service would occur if there was a permanent change in the factor. The two factors that garnered the highest percentage increase were regulatory based. The truckers in the survey indicated that if the new California regulations are permanent, then they expect to increase what they charge for shipment by at least twenty-eight percent. The 2010 Carrier Safety Administration legislation would potentially cause a nineteen percent increase in price of services charged.

The next two highest impacting factors are a ten percent permanent increase in fuel prices and a ten percent increase in road congestion. The truckers indicated that if there were a permanent ten percent increase in fuel prices, they would increase the price of services charged by approximately seventeen percent. This is an interesting finding because it may indicate that the truckers have some market power and/or the truckers did not understand the question completely. Since fuel costs make up less than 100% of the total costs to the transport goods, it is expected that a ten percent increase in fuel price should cause the price of service to increase by ten percent multiplied by the percentage of fuel costs in terms of total shipping costs assuming no market power. If you assume that fuel made up 100% of transportation cost, any increase over 10% would indicate that there was market power.

Table 3.8 Expected Change in Transit Prices Due to a Permanent Change in Selected Factors

Factor Affecting Transportation Costs	Percentage Change in Charges for Services
The New California Air Resources Board Regulations	28.92%
The Carrier Safety Administration 2010 Legislation	19.14%
10% Increase in Fuel Price	17.46%
10% Increase in Road Congestion	14.61%
10% Increase in Truck Maintenance Costs	12.44%
10% Increase in Trailer Maintenance Costs	12.38%
10% Decrease in Driver Availability	11.77%
10% Increase in Taxes	11.76%
10% Increase in Produce Shipping Insurance Costs	11.06%
10% Increase in Roadside Equipment Inspections	10.81%
10% Decrease in Rail Transportation Prices	10.14%
10% Decrease in Intermodal Transportation Prices	9.96%
10% Decrease in Airline Transportation Prices	9.22%

There were several open-ended questions that were asked on the survey. The first question inquired about the strategies truckers use to handle road congestion. A large majority of the responses indicated that they would schedule pick-ups and deliveries either at night or on off-peak congestion hours. Other strategies suggested by the truckers dealt with using technology to reroute the trucks away from congested roads. Two survey respondents indicated that they would avoid doing California hauls. Two other respondents indicated that they would manipulate their logbooks to get around regulatory constraints on the number of hours that could be driven.

An interesting result that comes out of this survey is that you have many truckers who are attempting to avoid congestion and there are long wait times for loading. These two findings beg two interesting questions. First, is the wait time so long because truckers who are trying to avoid congestion are scheduling when shippers are not prepared to ship? Or since everyone is attempting to avoid congestion, shippers are inundated with trucks that they cannot handle because they do not have the infrastructure to handle the amount of truckers who want to load at night?

Another open-ended question asked about the negative consequences for unexpected delays in shipments. While there were a few truckers who indicated there were no negative consequences, there was a large group that indicated that they loss backloads or other shipping opportunities from delays. Many pointed out that time was money for them. A few of the truckers indicated that they were fined for some of their late loads.

The final open-ended question asked the truckers to identify the most important factors that truckers will face in the next five to ten years. A preponderance of the respondents indicated the major factor in the future would be regulations. Many of the truckers specifically highlighted the CARB regulations. Another factor that garners support from several truckers was fuel prices. A few of the truckers were concerned about waiting times at the shippers and different costs to doing business. Another couple was concerned about availability of drivers and equipment.

Description/Summary of Shipper Survey

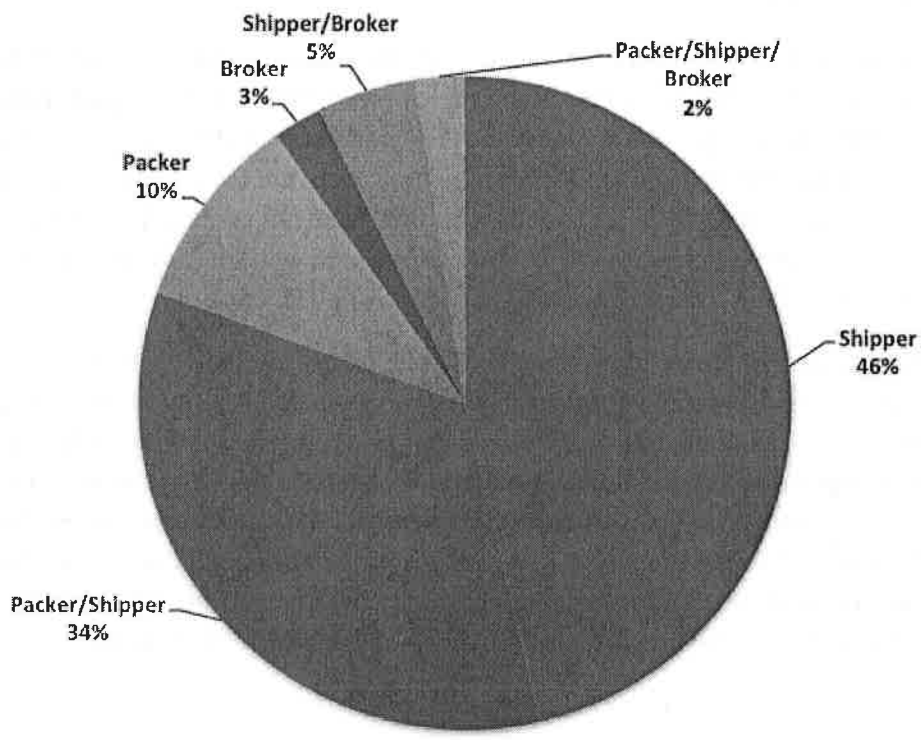
In July of 2010 an online survey was distributed to firms involved in the shipping of fresh fruit and vegetables. These firms were solicited from the members of Western Growers Association. Respondents were asked to answer thirty-four questions regarding the state of the transportation industry today with two primary goals in mind. The foremost goal was to garner a better understanding of the demographic information regarding the state and makeup of the shipping industry in California. The second goal of the survey was to try and identify potential problem areas that exist from the shipper perspective that may be inhibiting the competitiveness of California fresh fruit and vegetables.

The set of questions that were asked in the survey could be allocated to one of three major categories. The first set of questions queried about general demographic information regarding the shippers and their shipments. The second set of questions examined issues with truck availability and reliability. The third set of questions examined the shippers' perspectives and concerns of shipping produce in state and out of state. The specific questions as well as the letter sent to the participants in our study can be obtained through the authors upon request.

Respondent Demographics

In all, forty-two individuals responded to the shipper survey, with one of those individuals not completing any questions. This implies that the results of this survey are based on forty-one respondents. Approximately thirty-three percent consider themselves seasonal shippers, while the rest are year-round shippers. Figure 3.4 provides a breakdown of the respondents by type. Of the forty-one individuals who responded to the survey, nineteen individuals indicated that they were shippers. Fourteen of the respondents specified that they were both packers and shippers, while four revealed that they were only packers. There was one broker and two shipper brokers who also participated in the survey. One of the respondents did all three, i.e., pack, shipping, and brokering.

Figure 3.4. Distribution of Respondent by Firm Types



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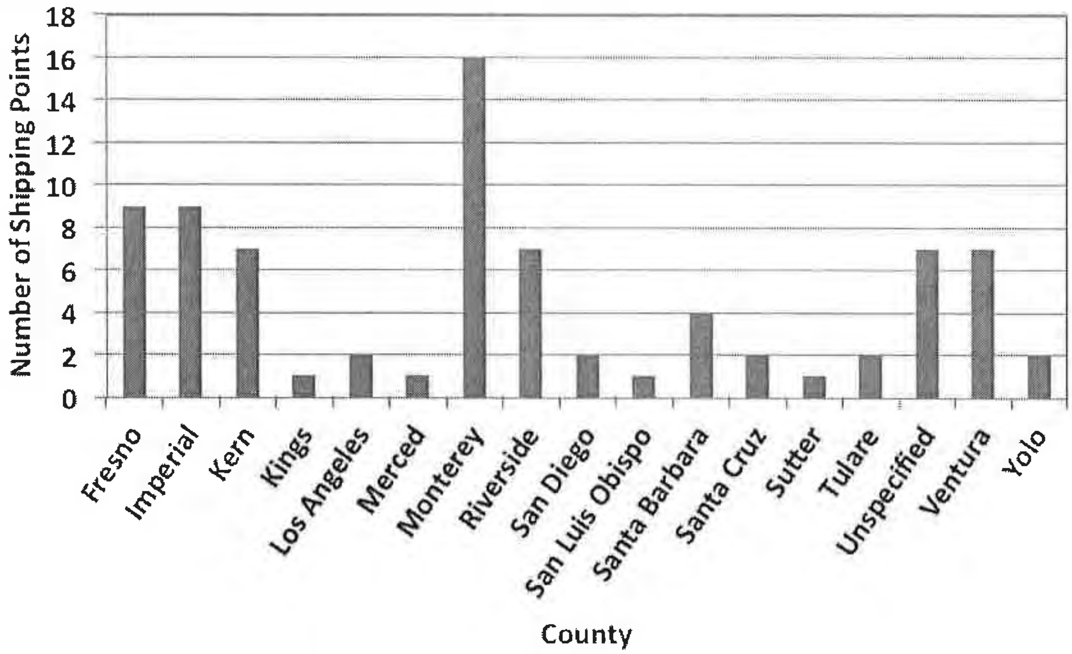
In a calendar year, the participants in the survey ship approximately 290,098 truckloads of fruits and vegetables in the continental U.S. The average number of truckloads for this group was 7,438. The largest shipper estimated that his company shipped 40,000 truckloads, while the smallest shipper did 100 truckloads. The median number of truckloads for the survey respondents was 3,000. The upper third of the largest producers shipped approximately eighty-two percent of the truckloads, while the lower third shipped less than three percent. The top three shippers in the survey in terms of truckloads identified themselves as only being shippers, rather than also doing brokering and packing.

Most participants in the study, ninety-two percent, ship produce to Canada and Mexico. In a calendar year, this group sent an estimated 56,830 truckloads to Canada and Mexico. This amount represents approximately sixteen percent of all truckloads that were shipped inside the continental U.S., and to Mexico and Canada. The largest shipper sent 8,580 truckloads of produce, while the smallest positive shipper only sent one truckload. The upper third of the shippers who sent produce to Canada and Mexico shipped 51,080 truckloads, which represents almost ninety percent of the total shipments to Mexico and Canada. In contrast, the lower third of this group accounted for only one percent of the Mexican/Canadian shipments. For those who shipped to Mexico and/or Canada, the average truckload for a respondent in the survey was 1,578 in a calendar year.

The participants in the survey were asked to provide the county and the state where there shipping points were. The respondents in the survey represent a broad group of counties and states where there shipping points are located. This group indicated that they had shipping points in thirteen different states outside of California. These states are located across the United States and represent all regions of the U.S. Even though they were not asked, a few of the participants indicated that they have shipping points in other parts of the world including Asia, Australia, Canada, Mexico, and the United Kingdom.

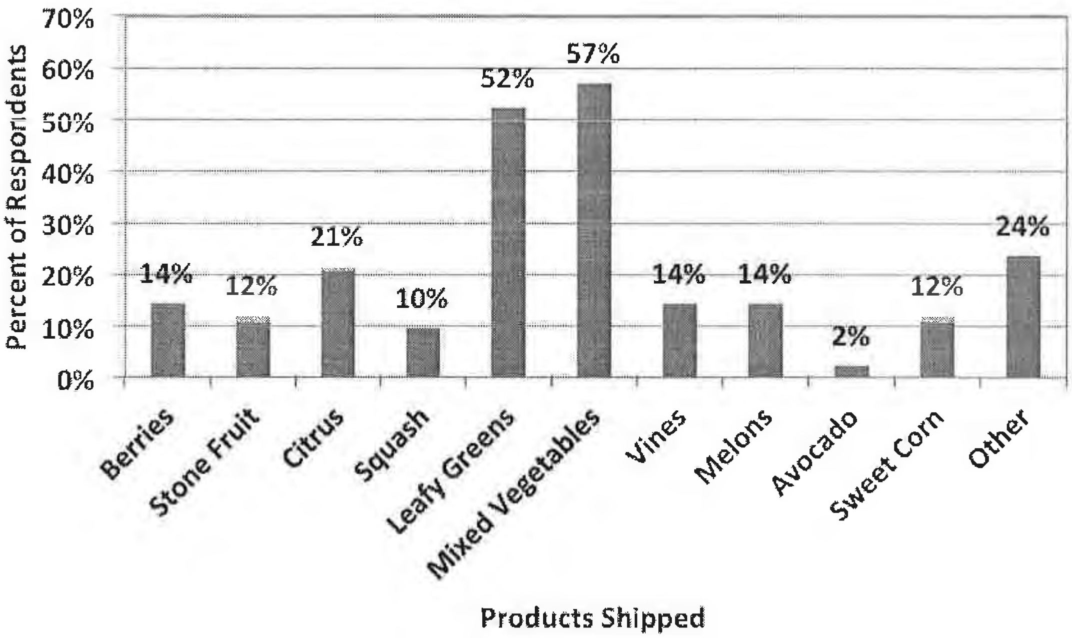
Figure 3.5 provides the number of respondents that indicated that they had a shipping point in a particular county of California. Participants in the survey had the ability to write-in up to five different counties. Examining this figure shows that sixteen out of the fifty-eight counties in California are represented in the survey. Monterey County had the largest number of shipping points represented with a total of sixteen. This is nearly double Fresno and Imperial counties, which had the second largest amount of shipping points represented in California. This result suggests one of two things. Either the survey had some bias in the respondents or there are many more shipping points in Monterey County than in Fresno and Imperial counties.

Figure 3.5. Primary Shipping Location for Respondent



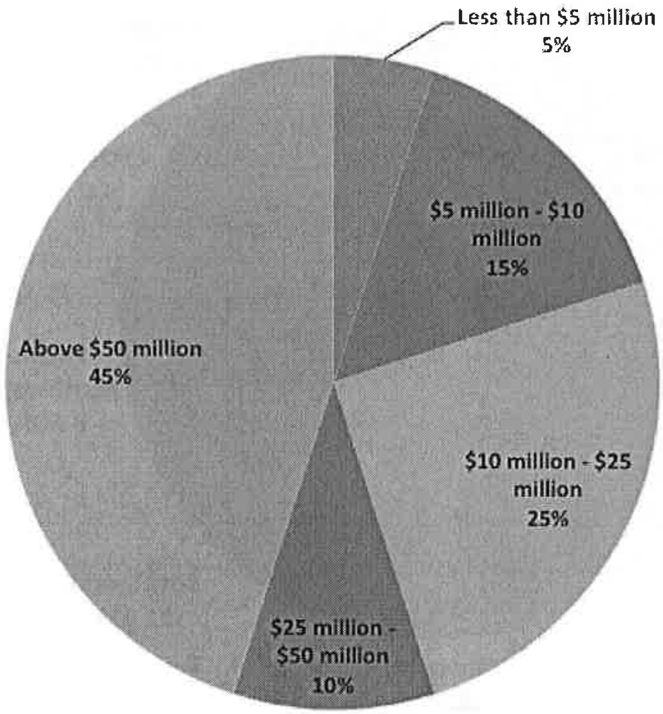
California produces well over three hundred different crops. In order to make the survey easier for the respondents, eleven category types were chosen based on the unique needs of transporting each of the type of crops. The respondents from the survey ship a variety of fruits and vegetables. Figure 3.6 provides a look at the percentage of respondents in the survey shipping particular types of products. While the survey has representation of all the types of product categories, the majority of respondents are shipping either leafy greens or mixed vegetables. This result coincides with the previous result in the survey where Monterey County had the highest number of shipping points. Over two-thirds of the respondents indicated that they shipped in more than one of the categories examined in the survey. Twenty-nine percent of the respondents shipped in only one of the categories. Another thirty-seven percent indicated that they shipped two category areas, while nearly twenty percent shipped three categories of products. There were very few firms that shipped more than three categories of fresh fruit and vegetables.

Figure 3.6. Type of Products Shipped by Respondents



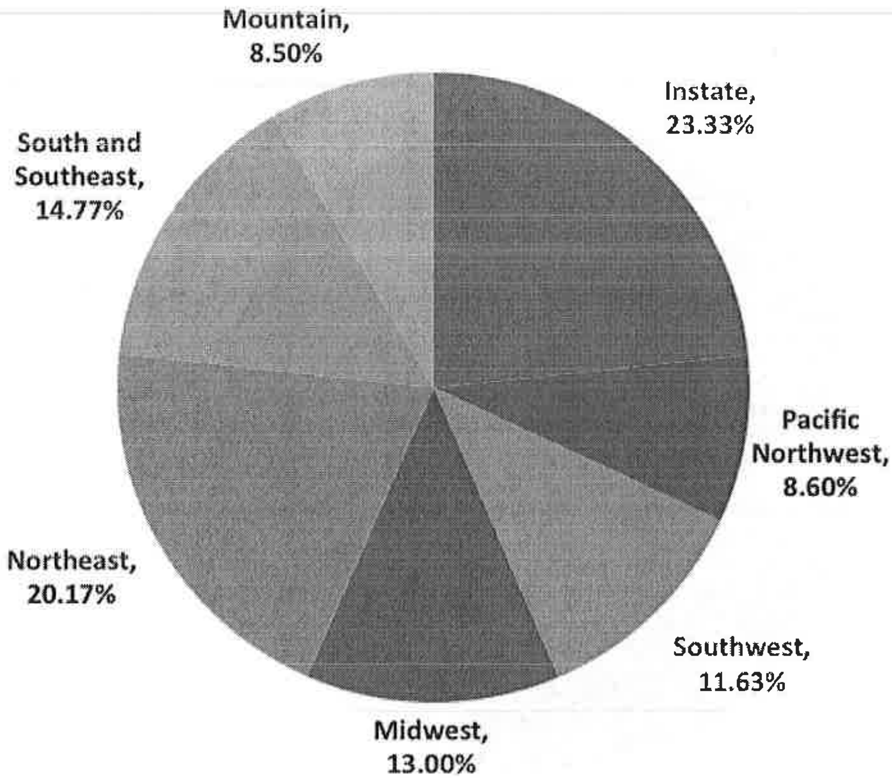
There were five categories that the respondents could use to indicate how much yearly gross revenue their firms received in 2009. Figure 3.7 provides the distribution of respondents based on gross revenue. Forty-five percent of the respondents in the survey reported that they make over fifty million in gross revenue. The next largest group was the shippers that made between ten and twenty-five million dollars in gross revenue, which represents twenty-five percent of the respondents. There were very few respondents in the survey, five percent, who make less than five million dollars in gross revenue.

Figure 3.7. Distribution of Respondent's Gross Revenue



Except for one respondent in the survey, each individual indicated that they shipped to multiple locations across the continental U.S. Figure 3.8 shows the percentage of shipments that the respondents ship to different regions across the country, with nearly one-quarter of shipments staying within the state. Approximately twenty percent of the shipments went to the Northeast. The Pacific Northwest and the Mountain states received the lowest percentage of shipments coming from California. Based on the population base of each, this is to be expected. When shipping produce across the country, shippers reported that they use temperature-recording devices on approximately seventy-seven percent of their shipments.

Figure 3.8. Percentage of Shipments Shipped to Different Regions in the U.S.



There are two primary ways that shippers quote prices to sellers, which represent the location where the seller takes control of the product. A shipping point price implies that the seller assumes the transportation costs, whereas a destination price has the seller paying the transportation costs. Respondents to the survey indicated that approximately eighty-eight percent of their current domestic sales are quoted at shipping point prices. The range in responses was a low of zero to a high of one hundred percent. When shippers look down the road five years, the percentage of prices quoted at shipping point reduces by five percent to eighty-two percent. Hence, in the next five years, the respondents to the survey expect that they will be more responsible for handling the trucking needs of the buyer.

Truck Availability and Reliability

Truck availability is an important issue for shippers of perishable fresh produce. Respondents to the survey indicated that on average, they experience difficulty getting trucks in a timely manner for ten percent of their in-state shipments. Over forty-five percent of the respondents indicated that they have experienced no difficulties in obtaining trucks, while nine percent of the respondents indicated that they experience difficulty in getting trucks in a timely manner for over half their shipments. For out of state destinations, the percentage of shipments that shippers are having difficulty finding a truck in a timely manner increases to fifteen percent. Twenty percent of the shippers from the survey indicated no difficulties getting trucks in a timely manner, while eleven percent had difficulty getting trucks in a timely manner with fifty percent or higher of their shipments. When the trucks arrive, fewer than five percent of them have issues with either the container/trailer or the refrigeration unit that delays loading.

Another important issue for shippers is that their shipments arrive to the buyer on time. Shippers in this study reported that on average just over six percent of their shipments arrive late to the destination. Over thirteen percent of the respondents indicated no late arrivals of shipments to their destinations. One individual who reported the worst late arrival percentage indicated that one-fourth of his shipments arrive late to their destination. Forty-five percent of the respondents reported that they have lost sales due to trucks arriving late to their destination points in the last year.

Shipper Perspectives/Concerns

The second objective of surveying California shipping firms was to develop an understanding of potential concerns that may be affecting the competitiveness of California agriculture. One of the questions in the survey asked shippers to rate various different domestic services offered by their carriers. These services were related to availability, dependability, timeliness of delivery, overall quality of service, proper refrigeration in transit, minimizing in transit damage, and attitude of the driver. Respondents were given the opportunity to rate these services as "Very Poor", "Average", or "Very Good". Respondents were also given the opportunity to respond between the "Very Poor" and "Average" ratings and the "Average" and "Very Good" ratings.

Table 3.9 provides the distribution of responses for each service rated. For each of the services, at least ninety-two percent of the respondent indicated that the service was average. Very rarely did the respondent indicate that the services were "Very Poor" or "Very Good". When asked to rate the carrier's ability to handle claims for delays, damage goods, etc., none of the respondents indicated the carrier's ability as "Excellent". Most of the respondents to this question, approximately forty-one percent, indicated that the carriers' ability in this area was "Fair", while almost thirty-percent indicated "Poor". Except for proper refrigeration, all other services had at least fifty-four percent indicating that the various services were considered average. The next highest response rate for each of the services was between the "Average Rating" and the "Very Good" rating. Very few shippers indicated that the service was either "Very Poor" or "Very Good".

Table 3.9. Domestic Carrier Services Ratings

	Rating				
Services	**Very Poor**		**Average**		**Very Good**
Availability of Service	0.00%	8.11%	64.86%	24.32%	2.70%
Dependability of Service	0.00%	2.70%	70.27%	24.32%	2.70%
Timeliness of Delivery	0.00%	2.70%	54.05%	40.54%	2.70%
Quality of Service--Overall	0.00%	8.11%	59.46%	29.73%	2.70%
Proper Refrigeration	0.00%	10.81%	40.54%	45.95%	2.70%
Minimizing In-Transit Damage	2.70%	8.11%	56.76%	29.73%	0.00%
Driver Attitude	2.70%	10.81%	62.16%	21.62%	2.70%

When the shippers were asked to rate the carriers' ability to handle claims associated with delays, damage goods, etc., over forty-percent indicated that the carriers did a "Fair" job. Nearly nineteen percent indicated that the carrier's ability to handle claims was "Good". Approximately thirty percent of the respondents indicated that the carriers are doing a poor job of handling claims, while none indicated that an excellent job was being done. Another eleven percent had no opinion on the question.

Shippers in the survey were asked to rank the top three most common problems encountered with carrier services. Table 3.10 provides the results of this ranking. Of the forty-one shippers in the survey, approximately fifty-six percent chose the availability of service as ranking in their top three most common problems. Of the group who selected availability of service as a top three ranked problem, nearly fifty-seven percent indicated that it was the number one problem. Timeliness of service garnered the next highest response rate at seventeen respondents, which equates to over forty-one percent of the total respondents to the survey. The third highest response rate was dependability of service at sixteen respondents. While proper refrigeration in transit had thirteen respondents ranking it in their top three, it had the second highest amount of individuals ranking it as their first choice for common problems. The respondents were given the opportunity to write problems under another category. The only problem that was written in for this response was cleanliness of the trucks.

Table 3.10. Ranking of the Top Three Most Common Problems Encountered with Carrier Services

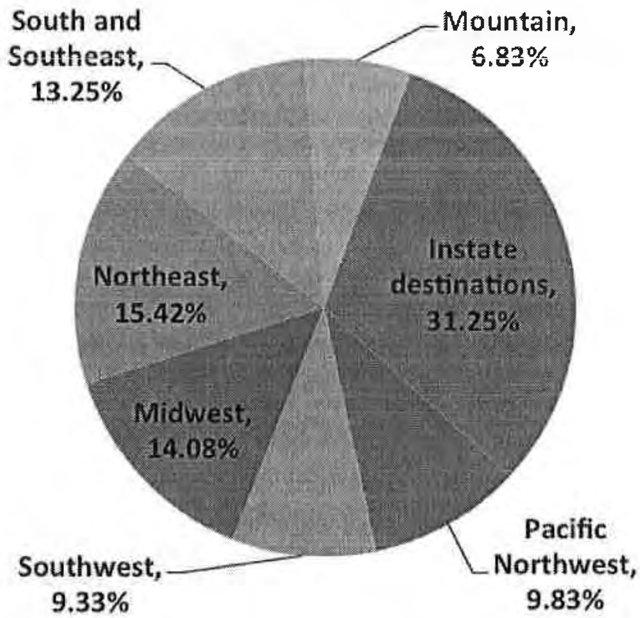
	Number of Respondents			
Issue	**First**	**Second**	**Third**	**Total**
Availability of Service	13	5	5	23
Dependability of Service	5	7	4	16
Timeliness of Service	4	7	6	17
Quality of Service - Overall	3	5	7	15
Proper Refrigeration in Transit	7	3	3	13
In-Transit Damage	2	7	5	14
Driver Attitude	3	3	3	9

Nearly seventy-six percent of the respondents who ranked the common problems in Table 3.10 indicated that the problems in this table were most common when shipping through a broker. Twelve percent of the respondents indicated that these problems are most common when shipping through a large trucking firm. Another nine percent identified independent carriers as the most common source of the problems indicated in the table. When asked about what type of shipments are these problems more common with, a third of the respondents indicated that partial loads were more common with service problems. An equal amount, nearly nineteen percent each, indicated that service problems were more common with full loads and multiple destination loads. The respondents indicated that on average twenty-two percent of their loads go to multiple destinations. Twenty-nine percent of the respondents chose mixed loads as having more problems with service. A vast majority of respondents, nearly, fifty-eight percent, indicated that the summer season was when the service problems are most prevalent. Twenty percent indicated that the winter season was the most prevalent season for service problems, while nearly nine percent indicated the spring season.

When shippers were asked about whether carrier services (e.g., dispatching, hauling, and unloading) were improving, remaining constant, or deteriorating, over twenty-nine percent indicated deteriorating services, while nearly nine percent responded that services have been improving in the past few years. Most of the respondents, nearly sixty-two percent, indicated that the service has been remaining constant over the past few years.

A set of questions inquired specifically about mixed commodity loads. Figure 3.9 provides a distribution of the destinations for the mixed commodity loads. The destination for the largest percentage of mix loads is in-state destinations at thirty-one percent. The respondents indicated that nearly sixty percent of their shipments are mixed commodity loads. Slightly over fifty-five percent indicated that the shippers had problems with mixed loads where commodities were not compatible. Seventy-five percent of respondents identified problems with temperature maintenance with mixed commodity loads.

Figure 3.9. Destination of Mixed Loads Sent by Shippers



The shippers were provided a list of concerns and asked to rate their level of concern for shipping produce for the next five years as a "Serious Problem", "Problematic", or "Not Important". They were also provided the opportunity to rate each concern as being between "Serious Problem" and "Problematic" and between "Problematic" and "Not Important". Table 3.11 provides a distribution of their responses for each concern. The concern that garnered the highest percentage at over fifty-nine percent of respondents indicating a "Serious Problem" was the cost of trucking. CARB regulations, shortage of drivers, and availability of trucks were all concerns that had more than forty percent of the respondents indicating a "Serious Problem". It appears that the shippers least concern was related to the limits on double-triple trailers for hauling commodities. Highway weight limits also seems to be an area that shippers are not overly concerned.

Table 3.11. Shipper Concerns for Shipping Produce over the Next Five to Ten Years

	Rating				
Issue of Concern	**Serious Problem**		**Problematic**		**Not Important**
CARB Regulation	45.95%	10.81%	24.32%	0.00%	2.70%
Shortage of Drivers	43.24%	24.32%	13.51%	8.11%	2.70%
Highway Weight Limits	5.41%	13.51%	29.73%	21.62%	13.51%
Limits on Double-Triple Trailers	2.70%	0.00%	16.22%	29.73%	35.14%
Hours of Service for Drivers	29.73%	13.51%	37.84%	5.41%	0.00%
Truck and Trailer Regulations	21.62%	24.32%	29.73%	10.81%	0.00%
Quality of Trucks, Containers, and Refrigeration Equipment	10.81%	35.14%	18.92%	21.62%	0.00%
Timely Arrivals at Destinations	13.51%	8.11%	35.14%	24.32%	2.70%
Timely Pick-Up at Shipping Points	13.51%	8.11%	27.03%	32.43%	2.70%
Cost of Trucking	59.46%	18.92%	8.11%	2.70%	0.00%
Availability of Trucks	40.54%	21.62%	21.62%	5.41%	0.00%

One of the last questions of the survey asked respondents an open-ended question regarding their opinion of the most pressing problems affecting produce trucking in the next five to ten years. There are four broad categories that a majority of the comments fell under. It appears from the general comment that the cost of trucking is what shippers believe is the most pressing problem in the next five to ten years. These general remarks also showed a great concern for the availability of drivers and the availability of trucks. A fourth broad category by this group expected in the next five to ten years is the regulatory environment in California regarding transportation. When asked what alternative shipping modes to trucking that the shippers might use, almost unanimously respondents are looking toward shipping via rail in the next five to ten years, with a few interested in intermodal transportation options. The perception of rail shipping still seems somewhat mixed and the knowledge of intermodal transportation options seems still in its infancy.

Summary of Key Findings from the Trucker and Shipper Surveys

The truckers in the survey indicated that they spent a large amount of time waiting to load produce at the shipper's facility. The issue of wait-time is highest on the list of issues truckers find are important and it is an issues that truckers believe the shippers have a high level of poor performance. They indicated that this wait time seems to be worse for produce than it is for other goods they haul.

Many truckers in the state face major time delays due to congestion of the roadways. Truckers who use Route I-5 and I-80 encounter congestion at least thirty-percent of the time on these routes. This congestion can lead to major delays in shipments, which can cause shipment to be late. The typical delay that occurs on these routes when congestion is encountered is over three hours. In order to deal with congestion issues, a large majority of truckers indicated that they schedule pick-ups and deliveries either at night or on off-peak congestion hours.

With truckers trying to avoid congestion, it appears that they could be creating a new problem for themselves. It seems that they are showing up to the shipping sites before the shippers are ready to load them. This may indicate that there needs to be better coordination between shippers and carriers so that carriers can avoid as much traffic congestion as possible, while minimizing the amount of wait time at the shipping points to load their products.

Access to capital during the time of the survey was challenging for smaller truckers in comparison to large trucking firms. The smaller trucking firms indicated difficulty obtaining capital, while the larger firms responded that they were not having difficulty obtaining capital. This lack of access to funds has hindered some small trucking firms from maintaining and expanding their fleet.

Both the truckers and the shippers are concerned about the regulatory environment in California. If the regulatory environment continues on its current course, shippers should expect that the price of shipping is going to increase over the next five to ten years. This is problematic for shippers because they are already concerned about the current cost of shipping their produce.

Other major concerns that shippers have are a shortage of drivers that are willing to ship their produce and the availability of service. Over forty-three percent of the shippers participating in the survey indicated driver shortages as a serious problem. Availability of service received the highest response rate for being the most common problem encounter by shippers regarding carrier services.

IV. Characteristics of Transportation Usage: Air and Rail

Rail

As indicated in the data reported earlier, rail movements of California fruit and vegetables are limited. Readily accessible public information on rail shipments is not available. In study team meetings with rail service provider proprietary data on shipment volumes by commodity was not forthcoming. Accordingly it is difficult to expand on the current understanding of trends in rail freight movement of California specialty crops. It is clear from the data that shippers utilize higher priced truck movement for goods with the implication that alternative lower priced rail transport has negative attributes that are not offset by potential marginal savings. However, if future truck shortages and increasing rates become more of a problem, shippers and receivers may be more willing to explore rail transport opportunities.

One effort underway to establish rail transport alternatives that attract shipments of California fruits and vegetables is the emergence of dedicated unit train movements. Railex LLC, Schenectady, N.Y. began service in Central California at its Delano terminal in 2008. To capture some of the transport market produce shipments, Railex provides trains with guaranteed cross-country service in 5 days to the firm's Rotterdam, N.Y. terminal, comparable with over the road truck transit times. The company contracts for train service through CSX Transportation and Union Pacific Railroad. Trains depart the facility twice a week on Wednesday and Friday afternoon, 55 refrigerated car units. In addition the firm provides support services such as cold storage and less-than-carload freight consolidation. Product departing from the Central Valley can make the cross-country journey by rail, be off loaded into cold storage and distributed by truck to area final markets at buyer's demand. The Delano facility offers an alternative to truck shipments but will likely need a successful and extended history to maintain and grow its customer base.

For the foreseeable future it appears rail will remain a small, but important option for some movements, particularly for commodities that are less perishable or have unique attributes that fit well with refrigerated railcar configurations. Railex currently is moving products such as table grapes, stone fruit, citrus and some vegetables such as celery, carrots and broccoli. In addition the service has expanded to include other agriculturally related products such as beer, wine, cheese, dried fruit and candy.

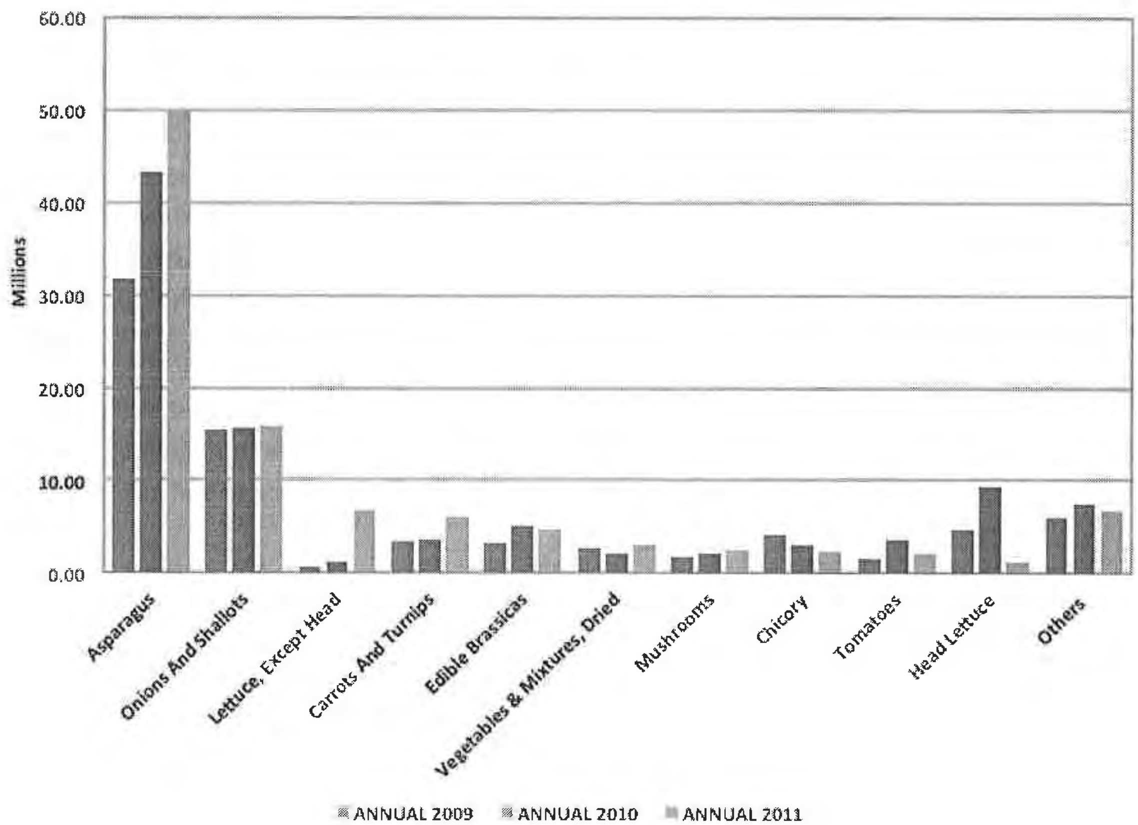
Air

Transport of specialty crops by air is limited in general to higher valued, perishable products for which freshness is an attribute customers are willing to pay a premium for. Nationwide, the average value of air shipments of edible vegetables and certain roots and tubers (HS Classification 07 commodities) is reported to have exceeded $118 million over the past three years.[12] Of that total, 77 percent is transported through California's main air terminals, where 65

[12] Source: http://www.wisertrade.org, data from U.S. Census Bureau, Foreign Trade Division. For a discussion of Wiser Trade data please see: O'Connell, Jock, Bert Mason and John Hagen. "The Role of Air Cargo in California's

percent moves through Los Angeles International Airport and 12 percent through San Francisco International Airport. A similar pattern is found for air shipments of edible fruits and nuts, citrus fruit or melon peel (HS Classification 08 commodities) with an average air shipment value of over $378 million during the past three years. In this case 76 percent of all movements by air are through California main air terminals. Shipments through Los Angeles International Airport and San Francisco International Airport were about equal averaging 38 percent from each location over the period 2009 to 2011.

Figure 4.1. HS:07 Edible Vegetables & Certain Tubers Total Value of Air Shipments Trough CA Ports



The commodity mix of airfreight specialty crop shipments is concentrated among a few major crops in each HS classification along with lesser amounts of a wide variety of other fruits, vegetables and nuts. For edible vegetables and certain tubers, 65 percent of air shipments are

Agricultural Export Trade", CATI Pub. #050502, California State University, Fresno, Center for Agricultural Business, 2005, page 70.

accounted for by fresh or chilled asparagus and fresh or chilled onions and shallots with a combined value of over $47 million (Figure 4.1). For edible fruits and nuts; citrus fruit or melon peel, 82 percent of the air shipments are accounted for by fresh fruits comprised primarily of cherries, peaches and strawberries with a combined value of over $352 million (Figures 4.2). A more detailed examination illustrates the important contributions of a few specific fruits and berries (Figure 4.3).

Figure 4.2. HS:08 Edible Fruit & Nuts; Citrus Fruit Or Melon Peel Total Value of Air Shipments Through CA Ports

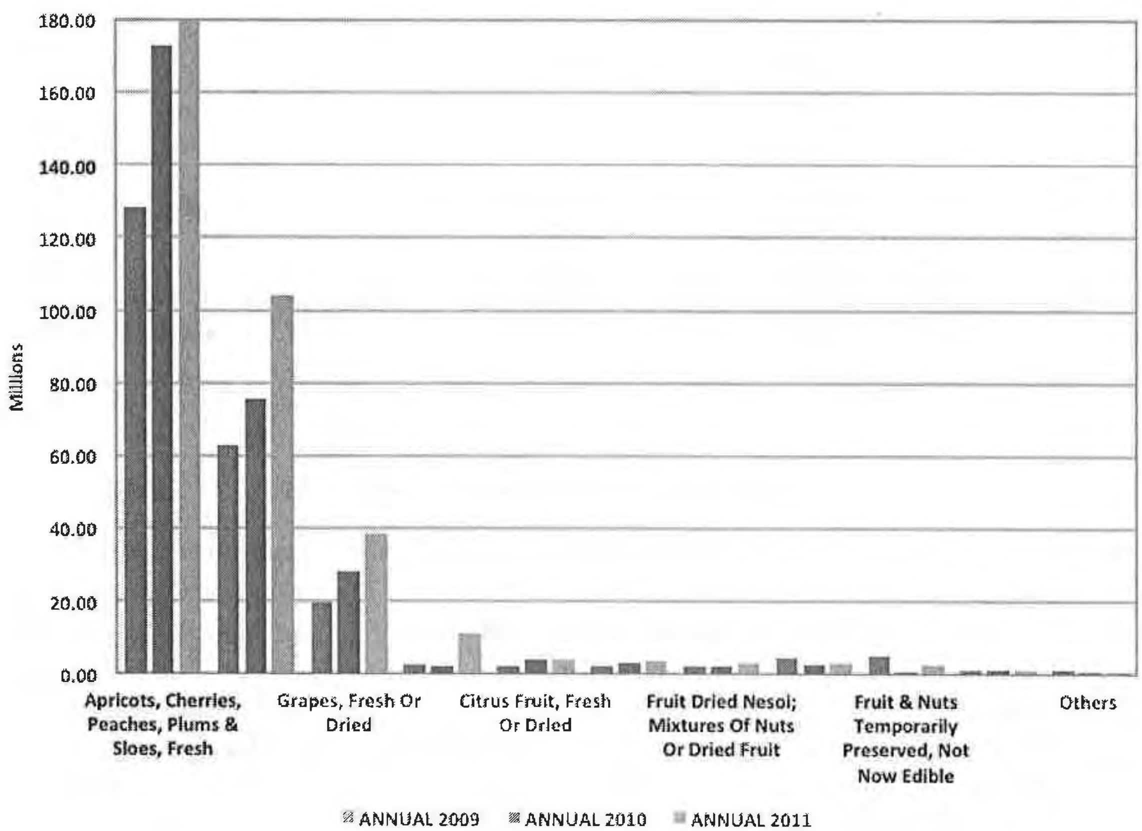
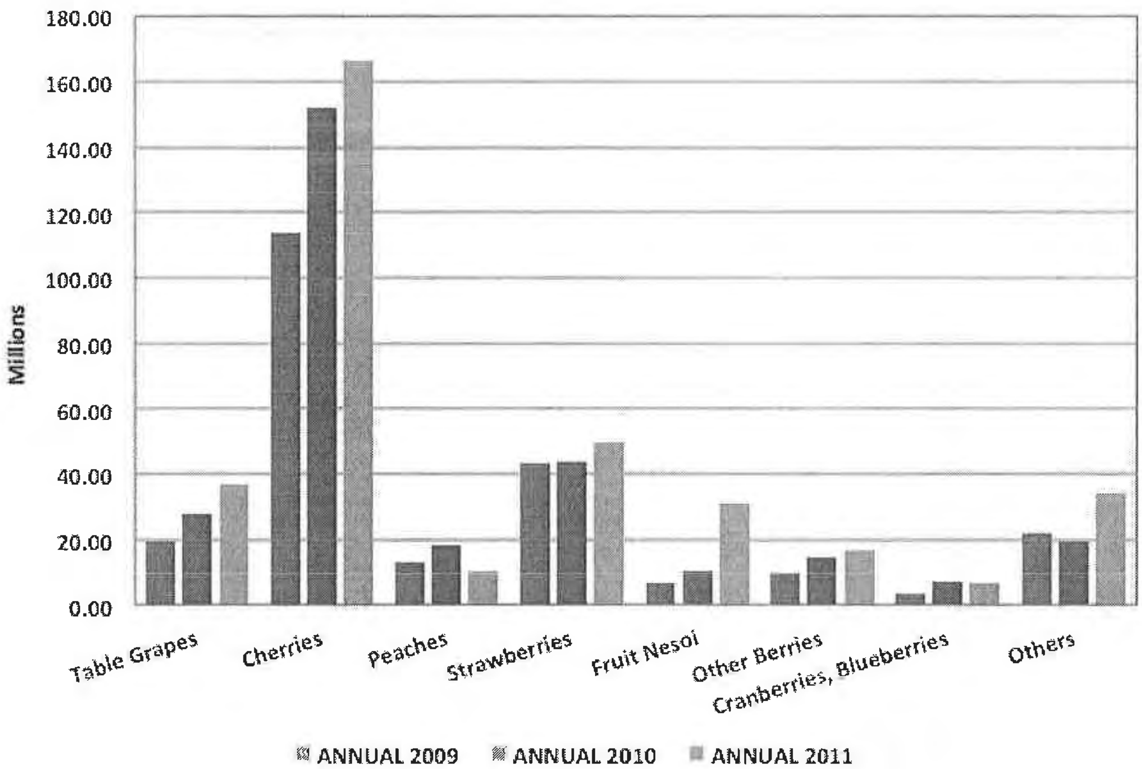


Figure 4.3. HS:08 Edible Fruits & Nuts; Citrus Fruit or Melon Peel Total Value of Air Shipments form CA Airports Selected Commodities



The customers for specialty crop air shipments like the commodities themselves are also concentrated among a number of specific countries. In the case of edible vegetables and certain roots and tubers, 95 countries are reported to have purchased HS 07 commodities delivered by air from the U.S. over the past three years. However, on average, 89 percent of the value of all shipments over the past 3 years has been destined for 10 countries, with the top two, Japan and the United Kingdom, accounting for over 53 percent of all air shipments during the same period. Partner countries for air shipments from California's major terminals for HS 07 commodities, as expected, are similar to the national figures.

In the case of edible vegetables and certain roots and tubers, 95 countries are reported to have purchased HS 07 commodities delivered by air from the U.S. over the past three years. However, on average, 89 percent of the value of all shipments over the past 3 years has been destined for 10 countries, with the top two, Japan and the United Kingdom, accounting for over 53 percent of all air shipments during the same period. Partner countries for air shipments from California airports of HS 07 commodities, as expected, are similar to the national figures.

In the case of edible fruits, nuts, citrus or melon peel, 88 countries are reported to have purchased HS 08 commodities delivered by air from the U.S. over the past three years. However, on average, 88 percent of the value of all shipments over the past 3 years has been destined for ten countries, with the top two, Japan and the Australia, accounting for over 45 percent of all air shipments during the same period (Figure 4.4). Partner countries for air shipments from California airports of HS 08 commodities, as expected, are similar to the national figures (Figure 4.5).

Figure 4.4. HS:08 Edible Fruits, Nuts, Citrus or Melon Peel Total Value of Air Shipments by Partner Country Average 2009 - 2011

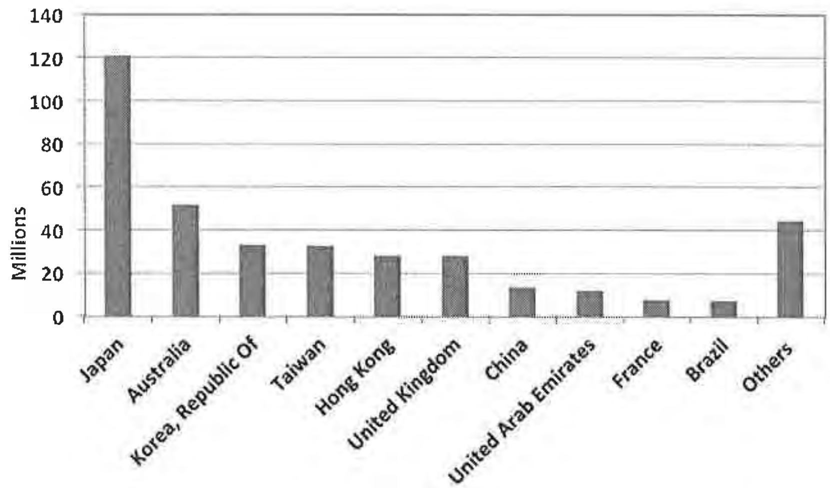
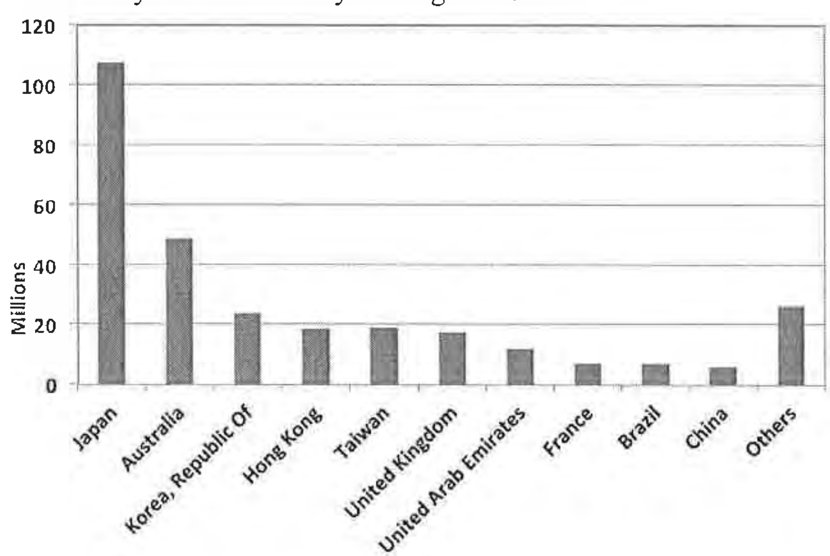


Figure 4.5. HS 08: Edible Fruits, Nuts, Citrus or Melon Peel Total Value of Air Shipments From California by Partner Country Average 2009 - 2011



Overall air transportation remains a limited, transportation mode for the movement of a small portion of California specialty crops into international markets. Trends suggest that while some large markets dominate airborne traffic at the present time, emerging markets continue to offer opportunities that will call for additional air carrier capacity and/or bidding up the rates on existing capacity to meet future demand.

V. Characteristics of Transportation Services: Ports

The movement of California fruits and vegetables by water is directed to export destinations. Transport to export destinations by ship takes place in dedicated ships and refrigerated containers. Publicly available shipment data by customs region was analyzed to determine the volumes moving by port of departure for the selected study commodities.

California Waterborne Exports

In 2009, California exported approximately $10.223 billion in principal commodities (California Agricultural Resource Directory 2010-2011). This accounts for one-third to one-fourth of all agricultural products produced in the state. In order for these products to be exported, they must leave one of the United States Custom Districts. California has three such districts–San Francisco, Los Angeles, and San Diego. Each district represents a location where agricultural products could leave California as exports. These exit points in California handle all four modal transportation--air, rail, truck, and sea vessel. Table 5.1 provides a listing of the locations that fall within each district.

Table 5.1. California Customs Districts

LOS ANGELES UNITED STATES CUSTOM DISTRICT			
Los Angeles	Port San Luis Harbor	Long Beach	Segundo
Ventura	Port Hueneme	Capitan	Morro Bay
Los Angeles Int. Airport	Ontario Int. Airport	Las Vegas, NV	DHL, Los Angeles
Gateway Freight Ser. Inc.	Aircargo Handling Service	Virgin Atlantic Cargo	TNT Express, LAX
IBC Pacific	Palm Springs User Fee, LAX	San Bernardino Int. Airport	Meadows Field Airport
Los Angeles	DHL-Hub Riverside	UPS-Ontario	
SAN FRANCISCO UNITED STATES CUSTOM DISTRICT			
San Francisco Int. Airport	Eureka	Fresno	Monterey
San Francisco	Stockton	Oakland	Richmond
Alameda	Crockett	Martinez	Redwood City
Selby	San Joaquin River	San Pablo Bay	Carquinez Strait
Reno, NV	San Jose Int. Airport	Sacramento Int. Airport	DHL Worldwide Express
Aircargo Handling Service	TNT Skypak	IBC Pacific	Federal Express, Oakland
SAN DIEGO UNITED STATES CUSTOM DISTRICT			
San Diego	Andrade	Calexico	San Ysidro
Tecate	Otay Mesa Station	Calexico-East	

All of the specialty crops in this study (celery, cherries, grapes, lettuce, oranges, peaches, strawberries, sweet corn, tomatoes, and watermelon) are exported through the three California custom districts. Table 5.2 provides a look at how much of each crop in terms of dollars is exiting the country through one of the three districts from 2006 to 2010. Appendix A provides a look at the top countries where these products are being shipped. At the Los Angeles custom district, grapes and oranges exceed the other crops in the study with grapes being the largest exported commodity in dollar terms. Except for 2008, cherries are the largest commodity leaving the San Francisco custom district. Oranges are typically the second largest commodity being exported through this district. In 2006 and 2010, grapes were the largest exported commodity out of the group being studied that leaves from the San Diego custom district. In 2007, lettuce was the largest of the studied commodities leaving the San Diego custom district, while strawberries were the highest export of 2008 and tomatoes was the highest in 2009.

Table 5.2. Total World Exports by Custom District of Select Group of Specialty Crops*

U.S. Custom Districts--Los Angeles

	World Total (Thousands of Dollars)				
Product (Fresh Market)	**2006**	**2007**	**2008**	**2009**	**2010**
Celery	5,659	4,655	5,157	5,010	4,459
Cherries	14,560	18,619	37,173	30,275	37,010
Grapes	248,121	271,088	328,292	308,825	314,415
Lettuce	7,186	8,196	5,784	5,242	6,642
Oranges	167,631	122,286	193,776	149,382	181,047
Peaches	19,529	22,301	32,488	26,381	31,117
Strawberries	7,036	6,305	10,480	17,699	14,316
Sweet Corn	454	408	6,226	1,508	2,110
Tomatoes	3,142	2,519	481	1,011	2,782
Watermelon	0	19	0	25	85

U.S. Custom Districts--San Francisco

	World Total (Thousands of Dollars)				
Product (Fresh Market)	**2006**	**2007**	**2008**	**2009**	**2010**
Celery	5,079	5,111	5,992	6,343	7,562
Cherries	56,628	61,817	63,753	75,679	102,140
Grapes	14,224	17,303	29,052	35,947	74,571
Lettuce	11,049	12,287	15,046	14,154	21,614
Oranges	43,626	33,617	69,299	64,075	45,329
Peaches	15,225	20,287	16,530	15,161	28,295
Strawberries	24,766	26,441	24,704	22,794	24,455
Sweet Corn	7,038	1,222	0	0	14
Tomatoes	918	468	109	12	83
Watermelon	62	49	53	101	446

U.S. Custom Districts--San Diego					
	World Total (Thousands of Dollars)				
Product (Fresh Market)	**2006**	**2007**	**2008**	**2009**	**2010**
Celery	1,424	1,192	1,709	953	1,380
Cherries	88	34	67	543	865
Grapes	18,902	14,558	23,462	9,201	19,183
Lettuce	16,107	19,527	20,884	7,205	6,546
Oranges	4,434	4,327	4,250	1,240	4,171
Strawberries	15,767	12,786	24,184	9,161	8,344
Sweet Corn	721	1,120	1,371	1,271	1,539
Tomatoes	7,478	12,276	6,132	12,122	5,002
Watermelon	257	222	313	144	107

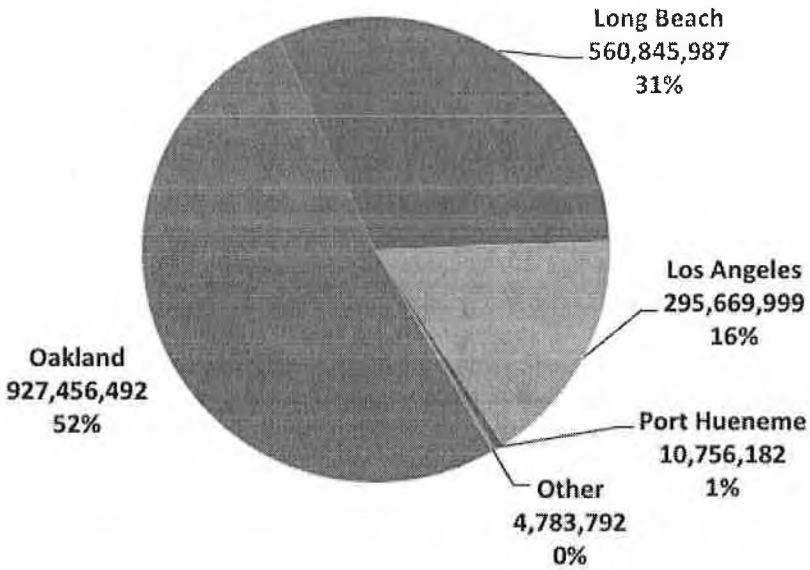
*Data Source: Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics, U.S. Customs District Data

Table 5.2 provides information regarding how much of each of the commodities being studied is leaving the state through the custom districts of California. In some sense, this table is masking where transportation issues are most important because it does not provide information based on the different modes. One of the modes embodied in the custom district data is product leaving ports.

Transportation of Specialty Crops through the California Port System

There are eleven major ports that serve California-- Port of Humboldt Bay, Port of West Sacramento, Port of Stockton, Port of Richmond, Port of San Francisco, Port of Redwood City, Port of Oakland, Port of Hueneme, Port of Los Angeles, Port of Long Beach, and Port of San Diego. The agricultural industry uses many of these ports to export their products. In 2010, nearly 1.8 billion kilograms of fruits and vegetables were shipped from these major ports. The four largest exporting ports during 2010 in terms of containerized vessel weight for shipping fruits and vegetables were Oakland, Long Beach, Los Angeles, and Port Hueneme (see Figure 5.1). The Port of Oakland is the largest exporter of fruits and vegetables by sea vessel out of the state of California. It shipped over 900 million kilograms of fruits and vegetables in 2010, which represents approximately fifty-two percent of all fruits and vegetables leaving California by sea. The next largest port for shipping fruits and vegetables is Long Beach. Around thirty-one percent of all fruits and vegetables leave from this port. Los Angeles is the third largest exporter of fruits and vegetables by containerized vessel weight.

Figure 5.1. 2010 CA Water Ports for Fruit and Vegetables Containerized Vessel Weight (Kilograms)



Out of the 1.8 billion kilograms of fruits and vegetables leaving California water ports, the largest share comes from fruit when measured in terms of weight. Over eighty-six percent of the containerized weight of fruits and vegetables can be attributed to fruits alone. The other fourteen percent is vegetable shipments. Figures 5.2 and 5.3 provide the weight in kilograms for 2010 that are being shipped out of the California ports for vegetables and fruits respectively. For both sets of commodities, the Port of Oakland has a fifty-one percent share of both products. The ranking for the second and third largest ports remain the same whether the category is vegetables or fruits, Long Beach is ranked second while Los Angeles is third. Long Beach and Los Angeles are closer in percentage terms for vegetables than for fruits. The conglomeration of other ports ranks fourth for vegetables, while the Port of Hueneme ranks fourth for fruits.

Figure 5.2. 2010 CA Water Ports for Vegetables Containerized Vessel Weight (Kilograms)

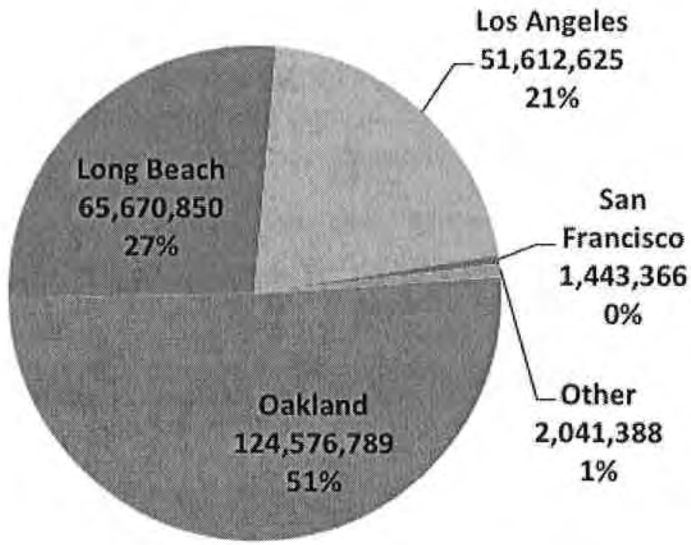


Figure 5.3. 2010 CA Water Ports for Fruits Containerized Vessel Weight (Kilograms)

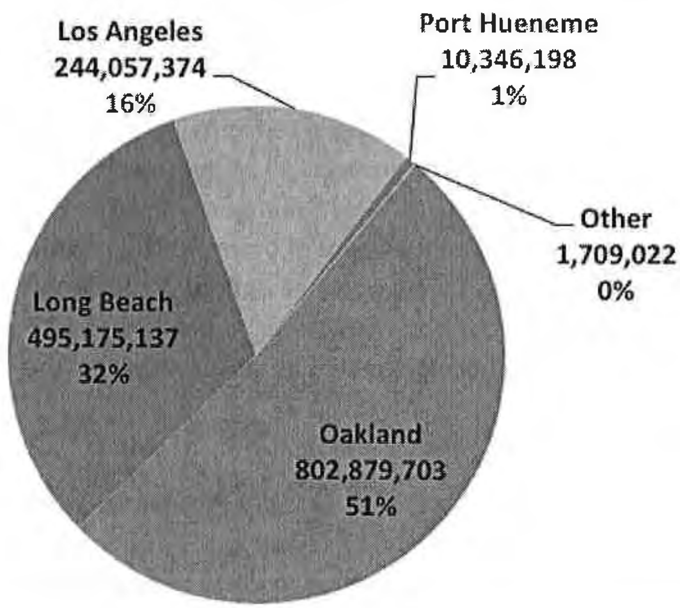


Table 5.3 provides information regarding how much of each of the commodities in this study are being shipped through the ports. It also provides the top three shipping ports for each of these commodities, as well as, the percentage of the total amount shipped for each of these ports. As

Table 5.3 shows, the Port of Oakland ranks first in the exporting of celery, cherries, lettuce, peaches, strawberries, and watermelons. For all of these crops, Oakland ships at least fifty percent of the total weight in kilograms. Long Beach is the top sea exporter of tomatoes, oranges, and grapes. The Port of Los Angeles is the largest exporter of sweet corn. The only other port that breaks into the top three for any of these commodities is Port Hueneme. It is the second largest exporter of cherries. In terms of weight, oranges and grapes are the largest of the commodity group in the study shipped by sea, while tomatoes are the lowest.

Table 5.3. The Top Three Ports by Containerized Vessel Weight (Kilograms) in 2010 for Shipping a Select Group of Specialty Crops

Commodity	Total Shipped from All Ports	Largest	% of Total	Second Largest	% of Total	Third Largest	% of Total
Celery	14,663,141	Oakland	63%	Long Beach	29%	Los Angeles	8%
Cherries	125,990	Oakland	88%	Port Hueneme	8%	Los Angeles	4%
Tomatoes	53,641	Long Beach	44%	Los Angeles	40%	Oakland	16%
Lettuce	27,677,230	Oakland	81%	Long Beach	11%	Los Angeles	8%
Sweet Corn	1,498,459	Los Angeles	88%	Oakland	8%	Long Beach	4%
Oranges	406,770,339	Long Beach	51%	Oakland	27%	Los Angeles	21%
Peaches	34,299,709	Oakland	50%	Long Beach	32%	Los Angeles	16%
Strawberries	2,073,652	Oakland	99%	Los Angeles	1%		
Grapes	163,721,785	Long Beach	54%	Los Angeles	28%	Oakland	16%
Watermelon	561,130	Oakland	79%	Long Beach	20%	Los Angeles	1%

While Table 5.3 provides the top three ports for shipping the commodities in this study, other ports in California ship some of the products. The port located at San Pablo Bay and the Port of San Diego ship celery. The Ports of West Sacramento and San Francisco have a small export share of lettuce. A relatively small amount of oranges also get shipped from Port Hueneme and the Port of San Diego. Peaches were exported out of Port Hueneme, the Port of San Diego, and Morro Bay. Port Hueneme, the Port of West Sacramento, and the Port of San Diego each had a small share of the grapes that were exported by sea vessel.

Transportation Issues Involving the Ports

For the crops that are a focus of this study, at least 98% of the exported crops are shipped from the ports of Oakland, Long Beach, and Los Angeles. To better understand the transportation issues that are affecting the ports, a visit was made to three different ports in the state to investigate what issues are affecting them the most when transporting specialty crops. The three ports that were selected were Oakland, Los Angeles, and Stockton. The ports of Oakland and Los Angeles were selected because they are ranked in the top three ports for the crops being studied. Since the port of Los Angeles and the port of Long Beach are right across from each other, they should face most if not all of the same transportation issues. Hence, only the port of Los Angeles was visited. The port of Stockton was selected because it represents an inland port that is in the heart of the Central Valley. Also, the port of Stockton is in the process of developing a marine highway that will transport goods from the Central Valley to the ports in the bay area, e.g., Oakland, San Francisco, etc.

On December 9, 2010 a visit was taken to meet with representatives at the Port of Los Angeles followed by a visitation with the Port of Oakland and Port of Stockton on August 22, 2011. A few notable points can be made after visiting the three California ports and discussing potential and current concerns with the various administrative representatives. On a general level, the various concerns that all the ports are faced with tend to be universal to all products exported from California. Congestion, stricter government regulation, and environmental concerns are all issues being dealt with. However, the consensus is that shippers and carriers understand that California has more stringent regulations and for the most part increased costs of these regulations has been shared by firms, state and federal agencies through grants, and the ports. Shipping firms are reducing costs through methods such as slow steaming, i.e., reducing travel speed to save on fuel costs, and dry-docking.

In addition, California producers do not face the same issues that exporting agriculture producers in the Midwest do. The abundance of import trade has created an excess supply of containers at California ports with some shipping companies actually returning empty containers to Asia. Furthermore, it seems that the demand for California agriculture in Asia has steadily been increasing. The major indicated hindrances to increased agricultural exports are the lack of foreign infrastructure and direct import relations. For example, Mainland China has seen a large increase in agricultural imports due to the increased middle class and current exchange rates. However, the lack of rail and road infrastructure has made it hard for demand to be met. As the factors that affect the cost of transporting California agriculture within the nation rise it appears that the agricultural industry may be pushed to increase Asian exports. While this may not pose a threat to producers it will directly affect consumers.

The different ports have been somewhat progressive in complying with new regulations and have capitalized on their comparative advantages. In addition, the standard shipping line creates a unique opportunity for the different ports. The major route from Asia has the liners stopping first at the Ports of Long Beach and Los Angeles, dropping most of their cargo then cruising up to the Port of Oakland where the remaining space is filled with exports back to Asia. Since the port of Oakland is the second port of call for many exporting ships, it makes sense why Oakland has over fifty percent of the share of fruits and vegetables being exported by sea vessel.

Port of Los Angeles

The Port of Los Angeles specializes in high volume imports of durable goods. Agriculture plays a small role in their export portfolio with specialty crops comprising an even smaller share of the port's total exports. Due to their size and proximity to the major metropolitan area of Los Angeles, the representatives of the Southern California port reported that they have enacted programs to help limit peak-hour congestion due to port business and have been proactive in complying with environmental regulations. The Pier Pass, which established off-peak operating, shifts for 6 p.m. to 3 a.m. and other such programs create incentives to deliver goods at non-peak hours. The port officials had no great concerns that may affect California specialty crops in general. One of the largest general concerns for the port that affects all of their business, including the transportation of specialty crops, is the constrained infrastructure.

Port of Oakland

Unlike the southern ports, the Port of Oakland is a net exporting port and their top exported commodities include agriculture. The Port of Oakland offers roughly two fewer days of travel time due to the standard shipping line as compared to other California ports shipping perishable goods. In order to comply with current environmental regulations, the port, as well as other ports in California, are currently installing infrastructure that allows vessels to plug into the port's electrical grid and turn off their engines historically needed to maintain refrigerated cargo. Port officials reported that current infrastructure is up-to-date and the port has the capacity to increase export volumes substantially.

Port of Stockton

The Port of Stockton is currently working on a barge system that will allow agricultural producers to fill both refrigerated and dry containers at their port and ship them downriver to the Port of Oakland where they will be transferred to container vessels for export. This federally funded program is meant to shift highway traffic to Oakland onto the major California waterways thereby reducing vehicle emissions and increasing the inner port profitability. In addition to this project, the port has recently acquired a substantial amount of former military property increasing their ability to expand operations. Their main commodity mix includes agricultural chemicals, some of which are processed in close proximity to the port. A representative highlighted two major issues with transporting crops in California that were related to the trucking industry. This representative mentioned that it is becoming more difficult for trucking companies to find qualified drivers due to stricter regulations that have been imposed recently. He also mentioned that the highway weight limits are causing some trucks that are moving to the ports to only be partially filled. He believed that both of these issues would make a marine highway invaluable to Central Valley agricultural producers.

VI. Analysis of California Regional Competitiveness

Section I of this report discussed the importance of transportation to the California specialty crop industry. The basic problem addressed was the impact that changes in agricultural transportation technology, infrastructure, and cost might have had on California's fresh fruit and vegetable regional competitiveness. Previous sections of this report have provided information on the demand for transportation services, and the characteristics of truck, rail, air, and port transportation services. Insights about the major transportation issues affecting California transportation competitiveness have been provided.

The objectives of this section of the report are to:

- Identify states that compete with California to supply domestic U.S markets with selected fresh fruit and vegetables during different quarters of the calendar year.
- To provide a spatial temporal analysis of the competitiveness of California to supply domestic markets based on transportation miles, transportation costs, and cost of delivered product.
- To empirically analyze California competitiveness for supplying selected fresh fruits and vegetables to domestic markets.
- To analyze the environmental concerns of greenhouse gas emissions from California truck shipments to domestic markets.

It is important to note at this point that competitiveness should not be confused with profitability. Competitiveness is defined here as a measure of the ability of one state's producers to supply their products to a given market of the U.S. relative to the ability of other producing states to supply those same markets.

Competitiveness can be thought of as the strategic advantage one state has over other states within the national fresh fruit and vegetable industry. Competitiveness in this analysis is measured by delivered cost of crop commodity and its availability. The assumption being that the state with the lowest delivered cost has a competitive advantage over other states producing and delivering the same crop commodity in the same time period.

Profitability is a measure of advantageous returns or results. It can generally be thought of as net revenue from business operations after subtracting business expenses from total sales revenues. Thus, it is possible that any given state's specialty crop industry can be competitive but not necessarily profitable in the short-run. This distinction is important because if transportation costs change over time due to any set of factors, a state's specialty crop industry can experience increasing or decreasing profitability while remaining competitive with other states' specialty crop producing industries.

Identification Analysis of Competitors for a Select Set of Specialty Crops

Given the nature of California agriculture, an in-depth examination of transportation's impact on every California produced commodity would be substantial. To make the analysis manageable, representative crops were chosen to model. Ten commodities were picked based upon their perishability, the competitive nature of the commodity, and the representativeness of the particular crops to all California produced commodities.

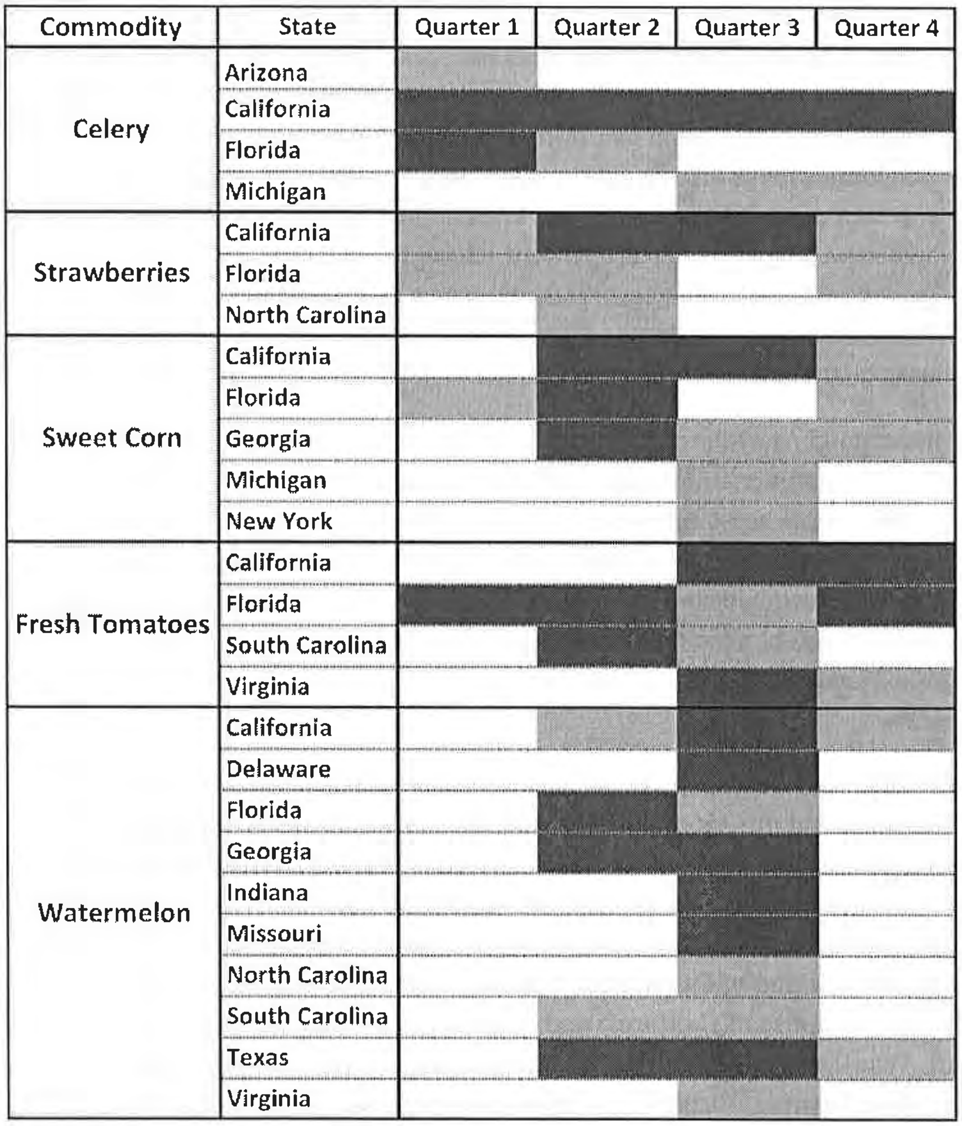
Those commodities that have little problems with perishability, such as those that do not require refrigerated transportation, were eliminated from the analysis due to the relativity small-perceived impact that transit time would have on their competitiveness. Commodities such as potatoes and onions can be shipped in unrefrigerated open containers by various modes. This allows producers to choose the most competitive shipping options marginalizing the transportation costs of those commodities.

Commodities that are solely produced in California or produced during a time of the year where no competition exists were also eliminated from the analysis. It stands to reason that during periods of uncompetitive production the relative effects on competition of transportation costs are reduced to zero. Again, while increased transportation crops will inevitably reduce profitability the focus of this study was to analyze the effects that transportation costs have on competitiveness. Given these restrictions the commodity list was narrowed to include the following categories of fresh fruits and vegetables: berries, stone fruit, citrus, gourds, leafy greens, mixed vegetables, vines, and melons.

From these groups, individual commodities were chosen based upon their data availability and the overlap in production seasons with other producing continental U.S. regions. The following commodities were chosen as ten representative commodities for the study: celery, cherries, corn, table grapes, lettuce, oranges, peaches, strawberries, fresh tomatoes, and watermelons. Original availability data was obtained from The Packer and AMS. Due to data limitations and inconsistencies between reporting agencies only five of the ten crops were modeled. The final five crop production times given by AMS are shown in Figure 6.1 by quarter, and all ten crop production times given by The Packer on a monthly basis are located in Appendix B.

The overlap of production seasons is an initial indicator as to the potential competitive nature that a particular commodity may have within the United States. Watermelons in June, for example, have seven states with high levels of production. The overlap in production capabilities indicates that for this commodity during the second quarter we can expect to see transportation costs having a large impact on the competitiveness of the commodity. Furthermore, the following quarter has twelve states producing watermelon at various levels and should exhibit an even greater transportation impact. Strawberries, on the other hand, have fewer regions competing with California but over more quarters. In addition to production regions being located at opposite ends of the continent, strawberries have a higher price/lbs than watermelon or celery, making for a good comparison of the effects that transportation costs can have on competitiveness.

Figure 6.1. Production Overlap for Selected Fresh Fruit and Vegetables by AMS reported movements, Dark Red: Heavy Production, Light Red: Light Production.



Competitive Spatial Analysis

There are many avenues that California fresh fruit and vegetable producers can compete upon including quality of the product, price, and availability. The identification analysis above focused on one aspect of availability, which pertains to when the product is available from a particular region. It demonstrated the quarters of the year that California competes with other regions across the country for the selected crops of this study (celery, cherries, grapes, lettuce, oranges, peaches, strawberry, sweet corn, fresh tomatoes, and watermelon). The prior analysis did not take into account the amount that was available in any given time for any particular region. This second aspect of availability will be treated later and will be demonstrated to be an important component to California's competitiveness in producing fresh fruits and vegetables.

This part of the analysis utilizes tools from ESRI's ArcGIS program to help visualize different competitive boundaries for a subset of the crops that are being analyzed in the report. Specifically, the Service Area tool in the ArcLogistics suite was used to draw boundaries of similar miles or similar costs. A competitive boundary in terms of this work can be defined as the farthest distance a producer in a region can ship to before another region has the shipping advantage. These boundaries focus on competition from the standpoint of production costs, transportation costs, and/or availability. Again, due to data limitations that will be discussed in the modeling section below, five of the ten crops were selected for this part of the analysis. These crops are celery, strawberry, sweet corn, fresh tomatoes, and watermelon. The data limitations also affected the analysis in terms of availability. Instead of examining crops on a month-by-month basis, quarters were chosen instead.

To obtain a better understanding of the competitive boundaries, three sets of maps were developed. The first set of maps examines the competitive boundaries based on mileage and availability. Availability in this sense means that any particular region can produce enough to meet the total demand. The underlying assumptions for this set of maps are that quality, transportation cost, and production costs are identical across the different production regions. Hence, the focus of these maps is which regions capture which markets based on a distance basis. This provides a foundation for understanding how transportation and production costs affect competitiveness.

The next set of maps present the competitive boundaries based on transportation costs. The underlying assumptions behind this set of maps are that quality and production costs are identical, *and each region has the ability to produce enough to meet all the demand within a boundary set.* These transportation costs were acquired from AMS at the USDA. There are four regions that had available transportation costs based on the data received from the USDA. These were the West, the Northwest, the Midwest, and the East. For the states examined in this study, the West was defined to comprise of California and Arizona. The Midwest encompasses Michigan, Missouri, Texas, and Indiana. The East encompasses Florida, Georgia, North Carolina, South Carolina, Georgia, Virginia, and Delaware. The Northwest is not defined in this study because none of the states in this region were used in the maps.

Table 6.1 presents the actual transportation costs for each of these regions by quarter for the 2010 calendar year. The table shows that in the first quarter, the average charge that a shipper would have to pay for shipping her fresh California produce would have been $1.79 per mile. This compares to $1.43 per mile that it would cost a Florida producer to ship his product in the first quarter. This implies that Florida producers have a $0.36 per mile advantage of shipping their produce across the country in comparison to California. The largest cost differential occurs in the fourth quarter where the producers in the West have a $0.68 per mile negative differential to those in the East. This transportation cost disadvantage is not an isolated situation. The transportation costs in the West are higher in each quarter than the other regions. This should cause the competitive boundaries in California to recede in comparison to the boundaries based on a per mileage basis. The question becomes by how much they recede. It should be noted that these trucking costs represent average trucking costs. Hence it is possible that a subset of producers in the West region have a smaller transportation cost than its competitors in other regions.

Table 6.1. 2010 Quarterly Regional Trucking Cost Per Mile for Refrigerated Transportation

2010 Regional Trucking Cost per Mile				
Quarter	East	Midwest	West	Northwest
1	$1.43	$1.66	$1.79	$1.60
2	$2.08	$1.88	$2.19	$1.67
3	$1.69	$1.95	$2.30	$1.82
4	$1.51	$1.82	$2.19	$1.88

Transportation costs on these maps were put into per box or per carton terms, i.e., the total transportation costs for a box of produce was distributed across the amount of boxes a truck could haul. In the case of celery, a typical truckload is 725 boxes. Since a cost of shipping celery is $1.79 per mile per truck, this would imply that for every mile that the truck must travel to transport a box of celery, it would add approximately $0.00247 per mile to the cost of the box assuming full recovery costs for transportation. For strawberry the amount of containers a truck can hold increases over five-fold to 3,750 cartons to the truckload. Watermelon had the least amount of boxes in a truckload at 435. A typical truck for transporting sweet corn is able to handle 1,035 boxes, while the typical truck for moving fresh tomatoes can handle 1,740 boxes.

The third set of maps examine how competitive boundaries change when factoring in production costs to the transportation costs. These maps, as with the prior sets of maps in this analysis, are based on the quality of the product being shipped is identical *and that each production region has the ability to produce all that is demanded.* The production costs that were used for this study are based on the shipping point prices that can be found in the Agricultural Marketing Service (AMS) Fruit and Vegetable Portal fruit and vegetable shipping point database. These data were used as a proxy for the actual production costs due to the limitation of the availability of actual production costs for each region. If the competitive boundary moves out based on this new information, this would imply that the region has a production cost advantage over the other regions.

A few points regarding this spatial analysis should be noted before examining the results. First, the production regions represented in the maps are the main production regions as shown in the movement data kept by the USDA AMS. While other producing regions may exist across the country, they tend not to be large enough to ship beyond their local region. Hence these regions have been left out of the pictures. A second point about the maps is that only one competitive region in the state is represented even though there may be multiple production regions within a particular state, e.g., celery in the fourth quarter is produced heavily in Salinas and Oxnard. This was done to assist in readability of the maps. From the standpoint of the competitive boundary, it does not drastically change the results of the boundary since these regions are typically within one-hundred to two-hundred miles of each other. The production area that was chosen in the state was either the highest production region in the state based on shipment levels or if the regions were very close to each other than a "midpoint" of the region was chosen. A third point to make is that refining the data to a quarterly view may imply competition when it does not directly exist. One production region may be heavily producing and shipping in one month of the quarter, while another production region may be producing heavily in another month of the quarter. Direct competition would exist only if one region's production capacity was extended to overlap with another production region. This emphasizes the importance of availability to the competitiveness of a region.

Results of the Competitive Spatial Analysis

For the sake of brevity, two commodities are examined in this section, celery and strawberries. These two crops provide the clearest set of maps to understand how transportation affects the competitiveness of California specialty crops. All other maps, which have been built for sweet corn, watermelon, and fresh tomatoes, have been placed in Appendix B.

The first set of maps, Figures 6.2 to 6.5, provide a look at the competitive boundaries for each celery producing region based on traveling miles for 2010. Hence, if everything were equal except for the mileage that the crop must travel to market, these maps represent where the competitive boundaries would lie. There are five rings for each production region. The first ring represents a 600-mile travel distance from the production region. The second region represents 900 miles from the production region. The final ring represents 1800 miles away from the production region. When two rings of the same mileage from differing production regions intersect, this point indicates a point on the competitive boundary between the two producing regions.

In the first quarter, the three main competitors of celery production are California, Arizona, and Florida. For California, the main production region is centered on Oxnard, while Arizona is centered around the Yuma area. Celery production in the first quarter for Florida has been placed in the Palm Beach area. In the second quarter, Arizona drops out of production leaving Florida and California. By the third quarter, Florida drops out of shipping celery for the national market and the Allegan area in Michigan begins to ship production. In this quarter the main production is occurring in the Salinas region. By the fourth quarter, production and shipping has picked-up in the Yuma production region and has moved from Salinas down to the Oxnard production region.

Under closer inspection of Figure 6.2, it is straightforward to see that California would capture the three major markets of Los Angeles, San Francisco, and Seattle competing on a per mile basis in the first quarter. Due to the competition with Arizona, on a pure mileage basis, California would only be able to sell to California, Oregon, and Washington. Arizona would have the competitive advantage for shipping to Dallas but it appears to be a small margin over Florida. Florida has the advantage of shipping to all the other major markets that are located on the Eastern seaboard and the upper eastern portions of the Midwest. When Arizona is no longer producing and the competition is between Florida and California, Figure 6.3, then each of the regions maintains the same major markets, as the first quarter and Dallas would source its celery from Florida. The competitive boundary in quarter two would approximately split Texas, Oklahoma, and Kansas in half leaving the western halves of each of the states to California and the eastern parts of the states to Florida.

In the third quarter as Florida drops out of production, Figure 6.4 shows that Michigan gains a large advantage of shipping celery to almost all the major markets. California is able to keep Los Angeles, San Francisco, and Seattle. California's competitive boundary in this quarter shifts westward in comparison to the second quarter. The new competitive boundary for these two regions is best seen by examining where the 1500-mile rings are intersecting with each other in Colorado and the upper northeast of New Mexico. In the fourth quarter with Arizona back in the competition and California production back in the Oxnard area, Figure 6.5, California still primarily would produce for the West coast. Dallas would go to the Michigan production region, while Arizona would be left with no major metropolitan regions.

Figure 6.2. Competitive Areas by Celery Producing Region on the Basis of Miles for 2010 Quarter 1

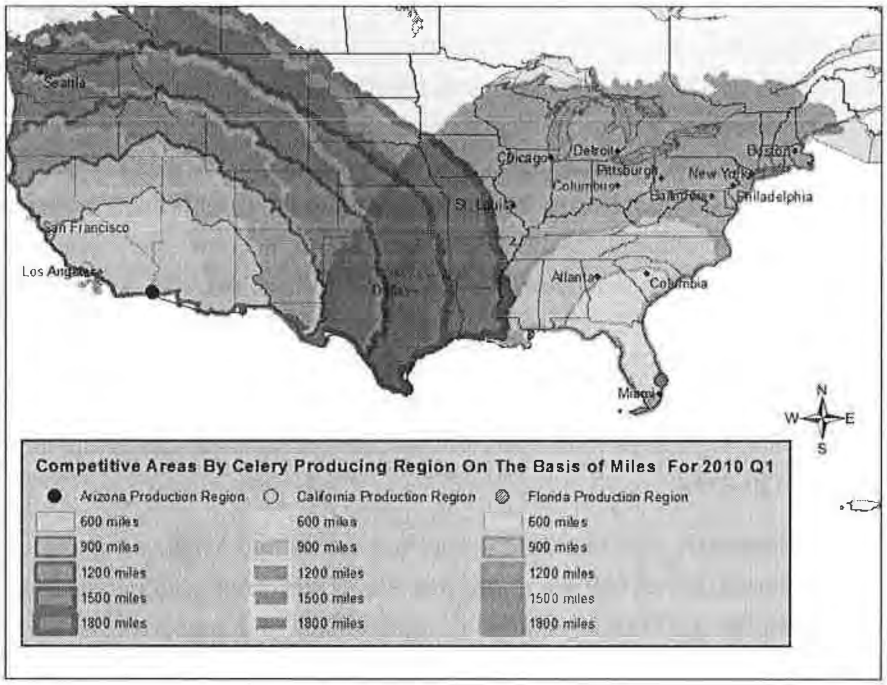


Figure 6.3. Competitive Areas by Celery Producing Region on the Basis of Miles for 2010 Quarter 2

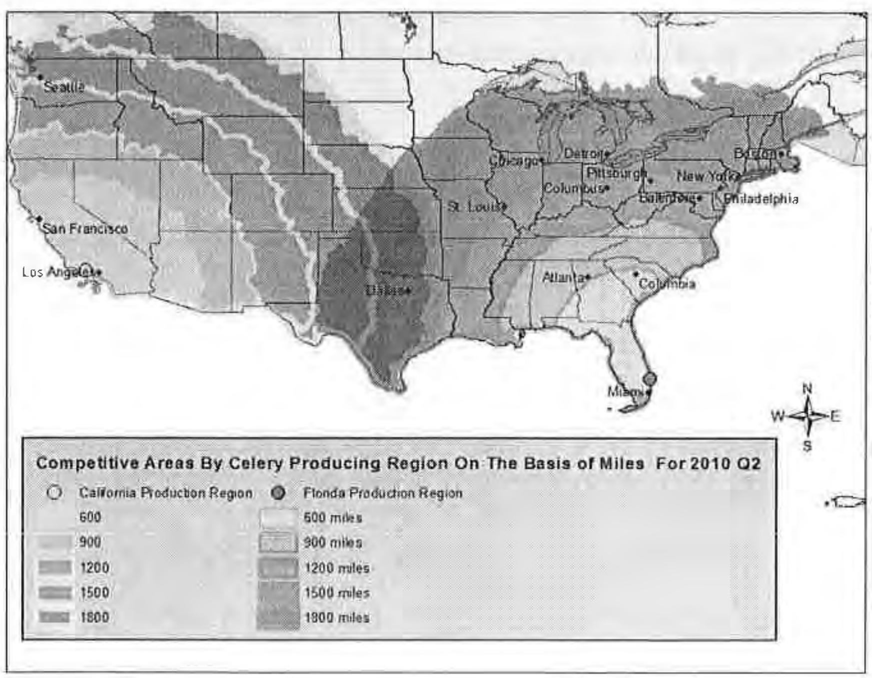


Figure 6.4. Competitive Areas by Celery Producing Region on the Basis of Miles for 2010 Quarter 3

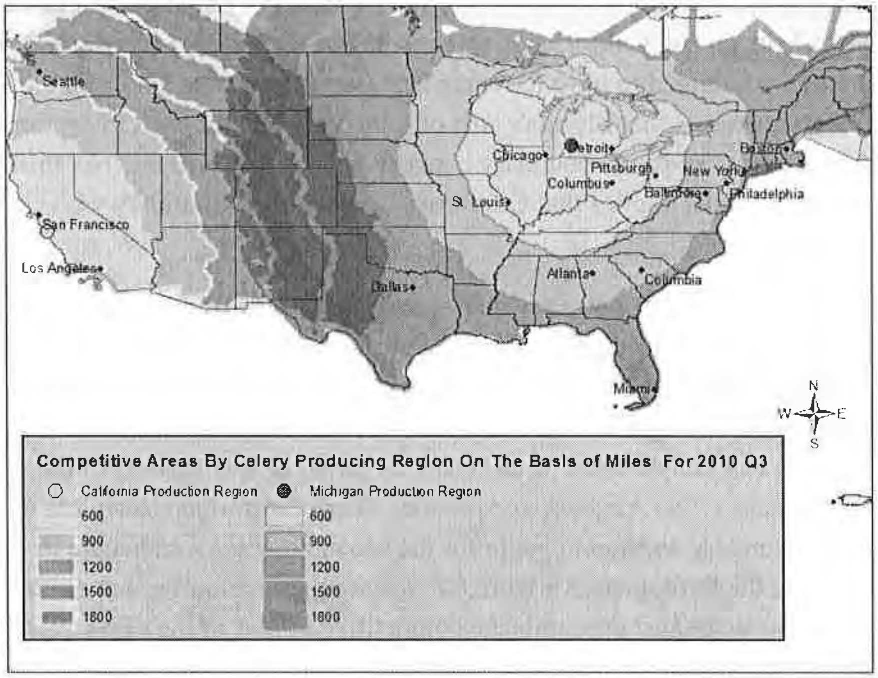
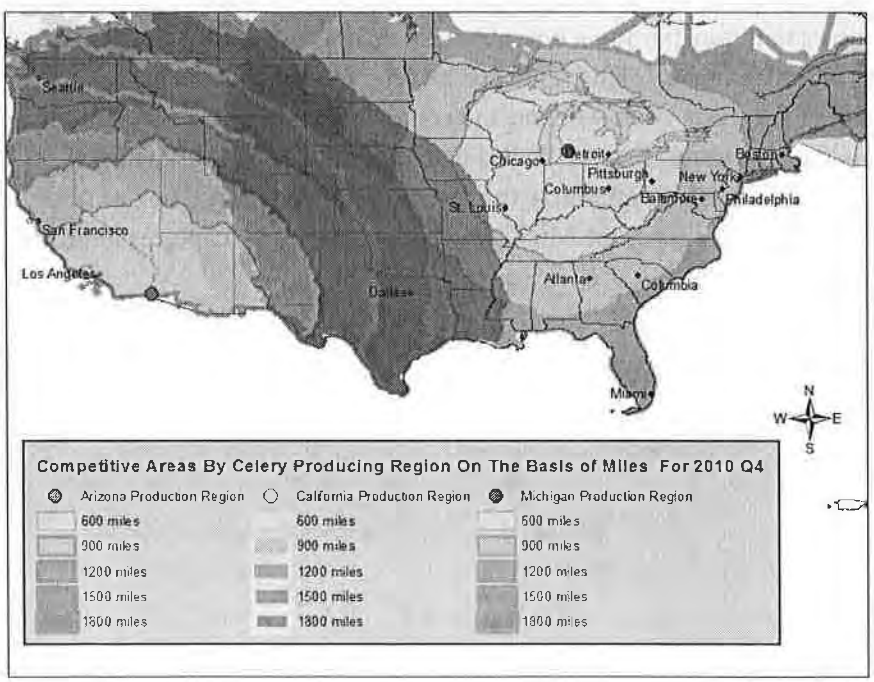


Figure 6.5. Competitive Areas by Celery Producing Region on the Basis of Miles for 2010 Quarter 4



While the previous four maps examined California's competitiveness for celery production on purely a travel distance basis, these next set of maps, Figures 6.6 through 6.9, factor in transportation costs that were shown in Table 6.1 from above as well as the number of boxes that can fit on the truck. In the first quarter, Figure 6.6, transportation costs has not affected the competitive border between Arizona and California in relationship to the mileage maps presented above because the two states are assumed to have the same transportation costs. The major change that occurs in the first quarter is that Florida's cost of transportation allows it to capture Dallas from Arizona. Hence, the competitive boundary between Florida and Arizona has shifted westward to Florida's advantage. This implies that California's competitive boundary with Florida would also shift westward.

Examining the maps in quarter two, Figure 6.7, show that when Arizona drops out of production and California is only competing with Florida, then the competitive boundary shifts the competitive boundary slightly to the west, although it is hardly noticeable. The map shows that Florida has a transportation cost of $4.00 per box of celery to Dallas while California is at $5.00 per box. It appears that Florida can deliver most of its celery for $4.00 or less to most of the major markets except San Francisco, Los Angeles, and Seattle, where California clearly has the advantage. The competitive boundary appears to begin for the second quarter somewhere in the range of $4.00 to $5.00 box. In the third quarter, Figure 6.8, the competitive border has shifted slightly westward in comparison to the just pure mileage competitive border in the same quarter. The change is hardly noticeable. Similar to quarter two, the competitive border between Michigan and California is in the $4.00 to $5.00 per box range.

Figure 6.9 represents celery transportation costs for the fourth quarter. This figure shows that Arizona has reentered the market for celery. California is able to capture each of the major West coast cities. The map shows that transporting a box of celery from California to Seattle accounts for approximately $4.00 of the box price. This same box of celery would have a transportation cost of between $4.00 and $5.00 a box from Arizona and somewhere around $7.00 a box from Michigan. The figure also demonstrates that the Dallas market would go to the Michigan production region if it were attempting to minimize the transportation cost for a box of celery. As the celery mileage maps showed above, the Michigan production region captures all the main East coast and Midwest major markets.

Figure 6.6. Celery Transportation Cost per Box by Production Region for 2010 Quarter 1

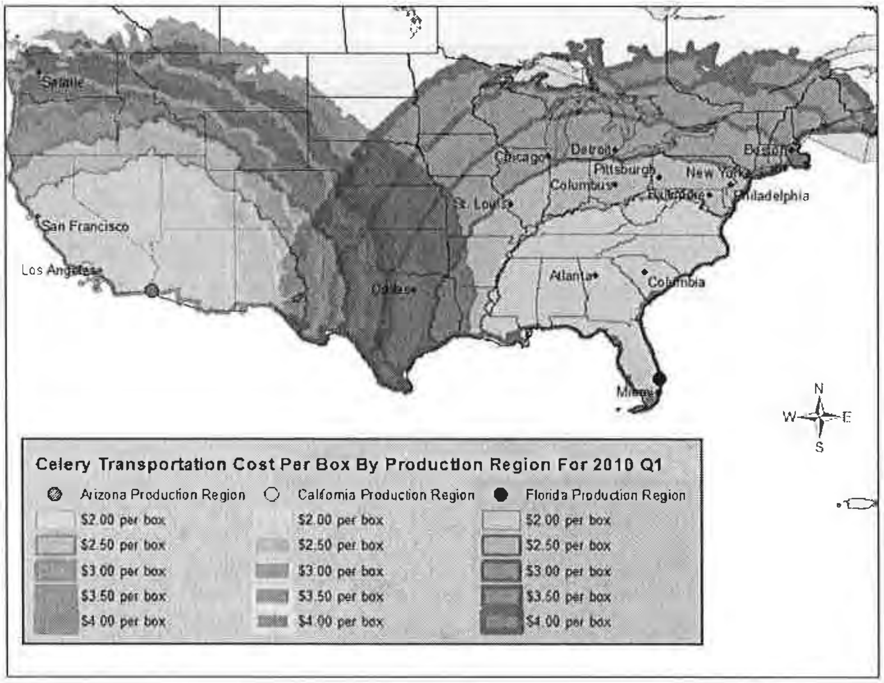


Figure 6.7. Celery Transportation Cost per Box by Production Region for 2010 Quarter 2

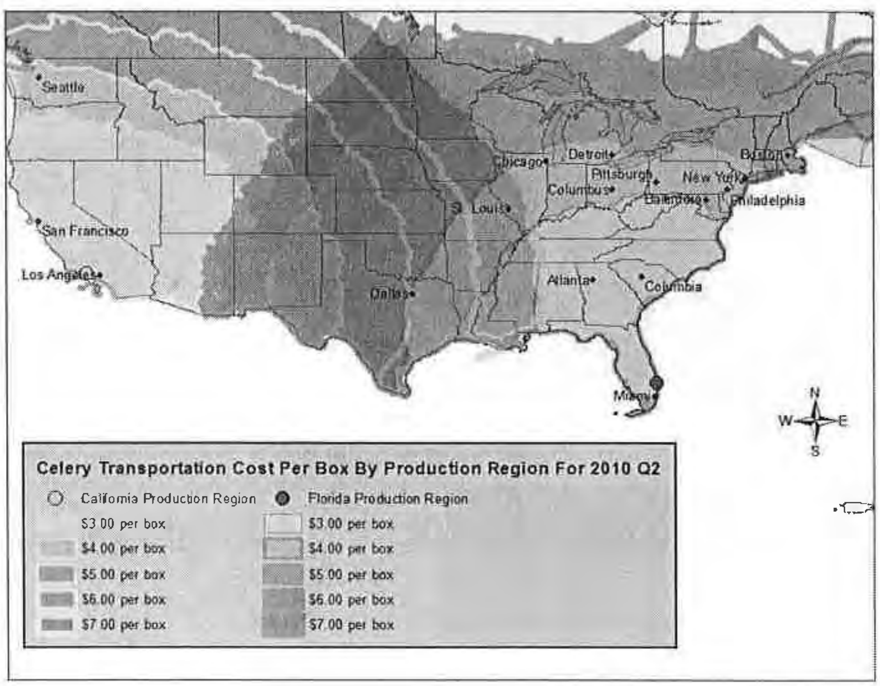


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Figure 6.8. Celery Transportation Cost per Box by Production Region for 2010 Quarter 3

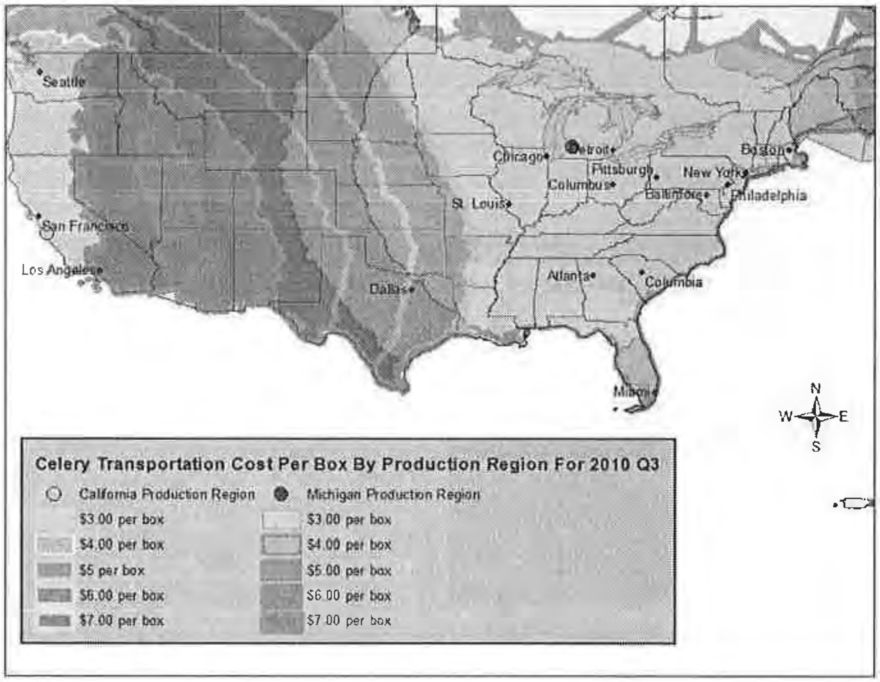
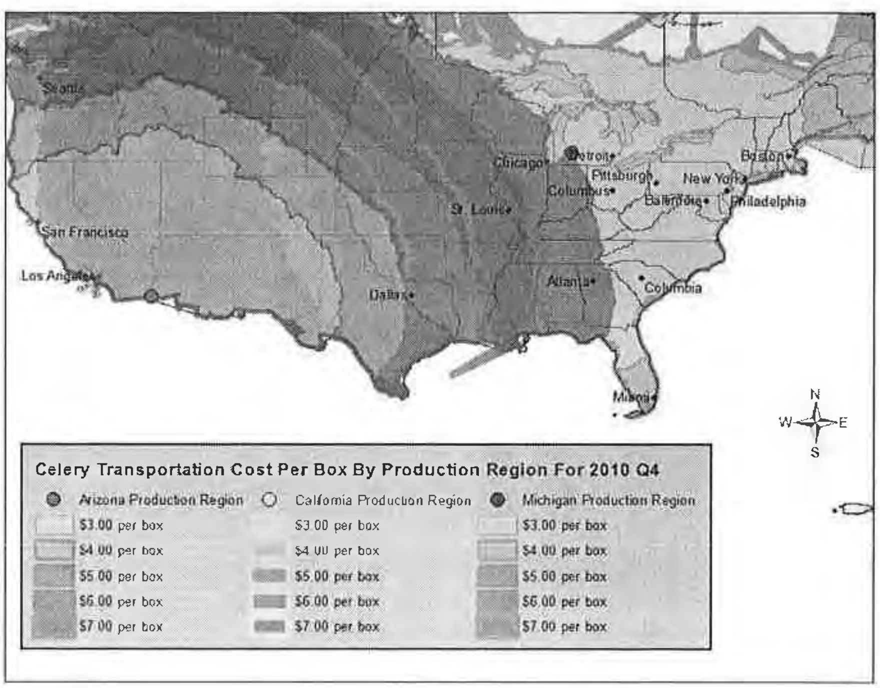


Figure 6.9. Celery Transportation Cost per Box by Production Region for 2010 Quarter 4



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The previous set of maps focused on visually examining how transportation costs affect the competitiveness of celery production for California producers in comparison to their other main national competitors. Figures 6.10 through 6.13 factor in the aspect of production cost with transportation costs. Specifically, these maps show what happens to the competitive boundaries when production costs are also taken into consideration.

The first transportation and production cost map, Figure 6.10, shows the importance of a region's production costs to its competitiveness. Since California and Arizona have very similar production costs in the first quarter, California still captures the major West coast cities of Los Angeles, San Francisco, and Seattle. Where the competitive situation really plays out is when examining Arizona and Florida. These two regions have a fairly sizable cost differential based on production even though Florida has a cost advantage when transporting. It should be noticed that Florida's first ring of comparable production and transportation costs does not appear until the $19.00 per box cost is achieved. If retailers were looking for a box price of $19.00 or less, retailers from half of the state could not get it from the main Florida production region. Based on this higher production cost, Arizona is able to capture both Dallas and St. Louis and is close to capturing Chicago. The competitive boundary between Arizona and Florida appears to begin in eastern Wisconsin, moving down diagonally east to west of Illinois, and following roughly the Mississippi river southwest.

In the second quarter, Figure 6.11, Florida and California are the main producers of celery. At $11.50 per box, California can cover a much larger area than the Florida production region showing California's large production cost advantage even with a transportation cost deficit. Given California's transportation and production cost it easily captures the Dallas market and nearly captures the St. Louis market. In the second quarter of 2010, California was able to produce and ship a box of celery to Dallas for just over $13.00 per box, whereas this same box of celery from Florida would cost $14.50 a box. Due to California's competitive production ability, the competitive boundary has shifted considerably eastward in comparison to where it laid based on mileage or transportation costs. While California's competitive boundary has been able to shift east due to its production cost advantage, Florida is still able to capture the East coast market and most of the larger Midwest markets.

As Florida drops out of production and Michigan starts producing in the third quarter, Figure 6.12, California's production abilities continue to show how transportation cost can be partially offset by producing more efficiently than its competitors. When transportation cost was the only consideration on which region captures a market, Dallas easily went to the Michigan production region. Due to California's productive ability, the competitive boundary shifts substantially eastward and California clearly captures Dallas. Michigan's production and transportation cost to Dallas is approximately $15.00, while California's cost is closer to $14.00 per box. When considering productive efficiency through production cost, the competitive boundary moves from approximately the eastward edge of the Rocky Mountains over to the eastward edge of North and South Dakota, Nebraska, and Kansas.

In the fourth quarter of production for celery, Figure 6.13, Arizona reemerges as a competitor to California. As expected, California still is able to capture the major West Coast markets. Arizona has the ability to capture the Dallas market. The competitive boundary between Arizona and Michigan has shifted eastward demonstrating Arizona's productivity of producing celery over Michigan. For California, the competitive boundary that it has with Michigan has not changed much from the third quarter.

Figure 6.10. Celery Delivered Cost per Box by Production Region for 2010 Quarter 1

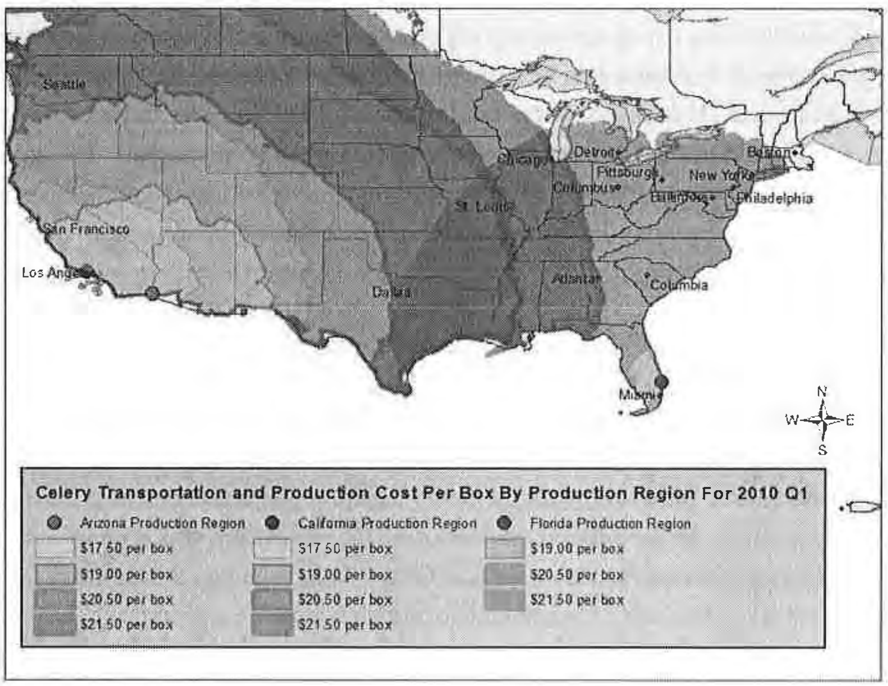


Figure 6.11. Celery Delivered Cost per Box by Production Region for 2010 Quarter 2

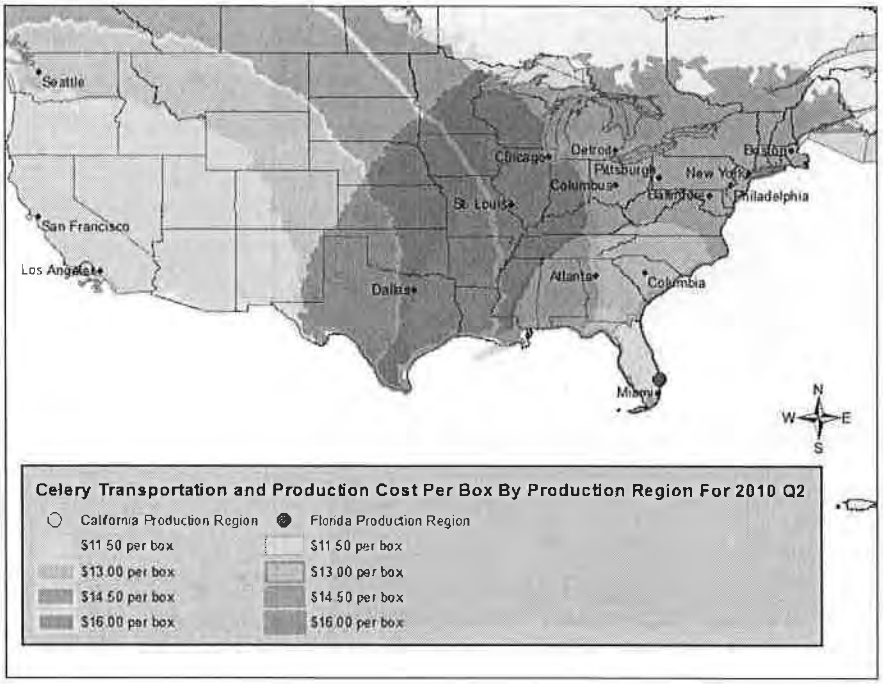


Figure 6.12. Celery Delivered Cost per Box by Production Region for 2010 Quarter 3

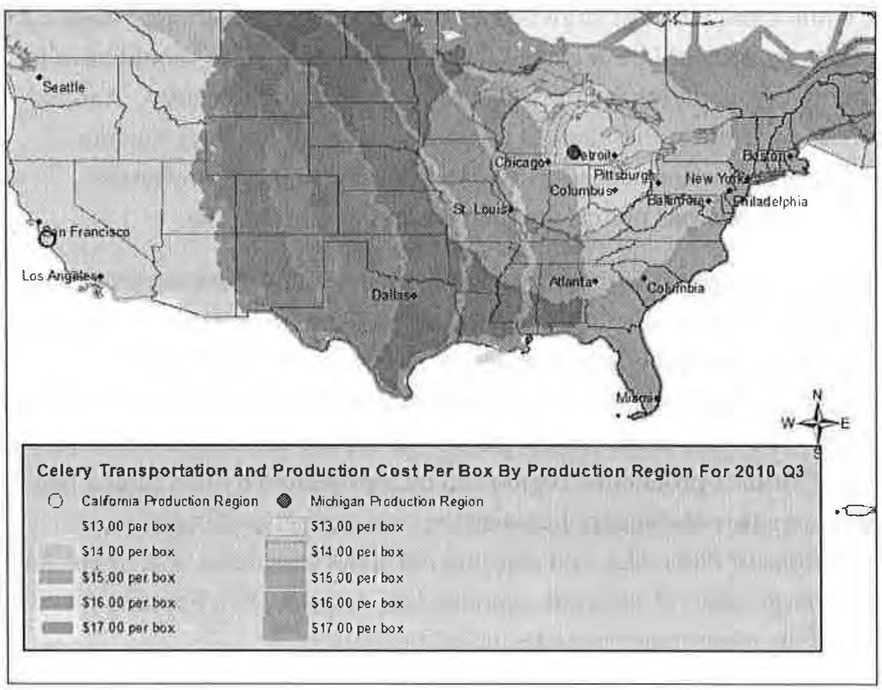
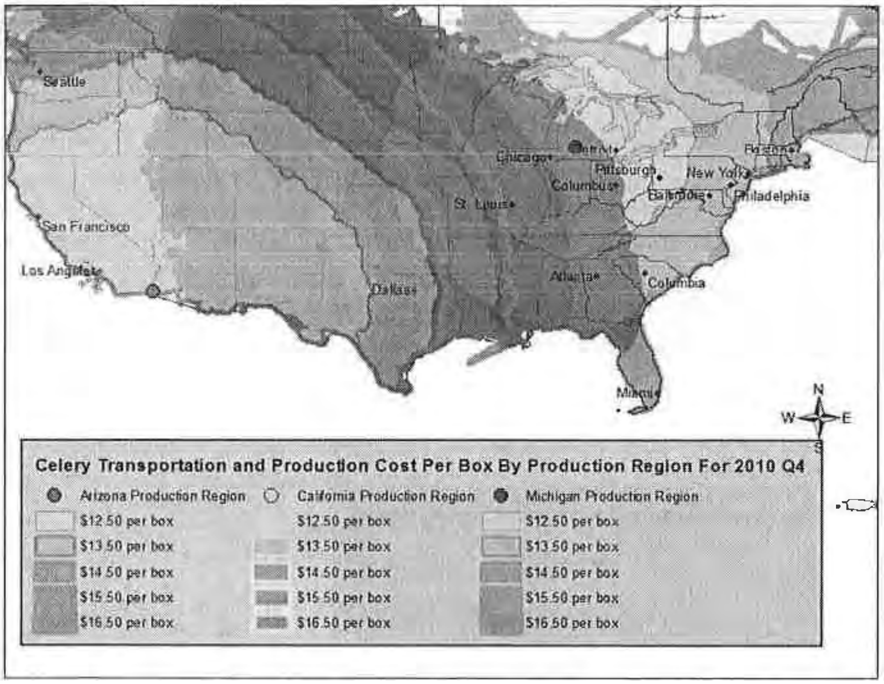


Figure 6.13. Celery Delivered Cost per Box by Production Region for 2010 Quarter 4



While celery can demonstrate how transportation affects competitiveness and production costs, a look at strawberries has another important aspect that needs examining. A truckload of celery encompasses 725 boxes, while a truckload of strawberries amounts to 3,750 cartons. With an increase in the number of boxes, it should be expected that transportation costs should have less of an impact on the competitive boundaries for strawberries in comparison to celery. Another issue that makes strawberries different is that there is no west coast rival for its production regions; its major competitor is on the East coast. A third aspect that makes strawberries different than celery is that California has no real competitors in the third quarter.

The first aspect to understand California's competitiveness in the realm of strawberries is who are its major competitors and how it would split the market up on a per miles basis. Figures 6.14 through 6.16 show how the market would be split between California and its competitors on a per mile basis for first, second, and fourth quarters. In the first quarter, California has one major competitor, which is Florida. The main production region in California can best be represented by Riverside County, while Florida's production region can be represented by the Tampa region. As Figure 6.14 shows, the competitive boundary between the two competitors based on miles goes through the eastern portions of Nebraska, and splitting the states of Kansas and Nebraska in half from east to west. Similar to celery, California captures Los Angeles, San Francisco, and Seattle, while Florida gets all the other major markets including Dallas.

In the second quarter of 2010, Figure 6.15, North Carolina enters into the competition for strawberries. While strawberry production is all over the state on smaller production fields, the eastern portion of the state was chosen as the basis for competition. California's production moves to the Oxnard region, while Florida is still producing in the Tampa region. Using mileage as a basis, the competitive picture between California and Florida does not fundamentally change. Where the real competition occurs, in terms of mileage, is between North Carolina and Florida. In this quarter, North Carolina has the ability to capture most of the major markets on the East coast. It must be stressed here that this is true only with the assumption that costs and productive capacity are identical which in reality is a very unrealistic assumption.

Figure 6.16 shows the picture for the fourth quarter. In this case, North Carolina is not in the market and Florida is still producing out of the Tampa region. California's production of strawberries has moved up to the Salinas region of the state. It should be noted here that based on production numbers, the Oxnard region ships slightly less than the Salinas region. In this quarter, the competitive boundary has moved slightly west in favor of Florida production in comparison to the first quarter. Now the competitive border goes through the center of Nebraska, the western portion of Kansas, and the panhandle of Texas. Florida captures all the major markets from Dallas east, while California captures the West coast market.

Figure 6.14. Competitive Areas by Strawberry Producing Region on the Basis of Miles for 2010 Quarter 1

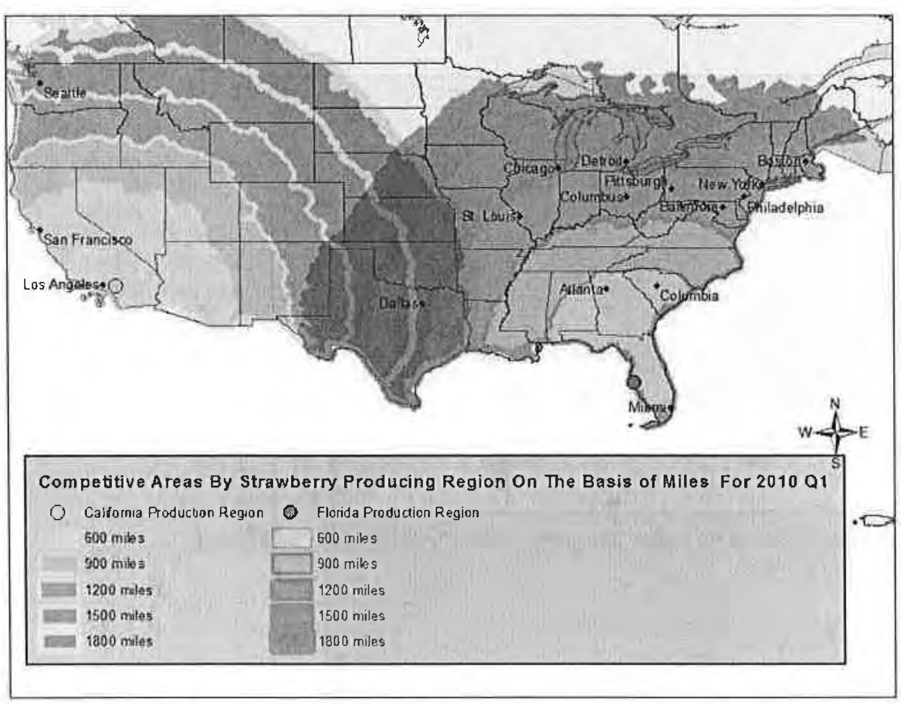


Figure 6.15. Competitive Areas by Strawberry Producing Region on the Basis of Miles for 2010 Quarter 2

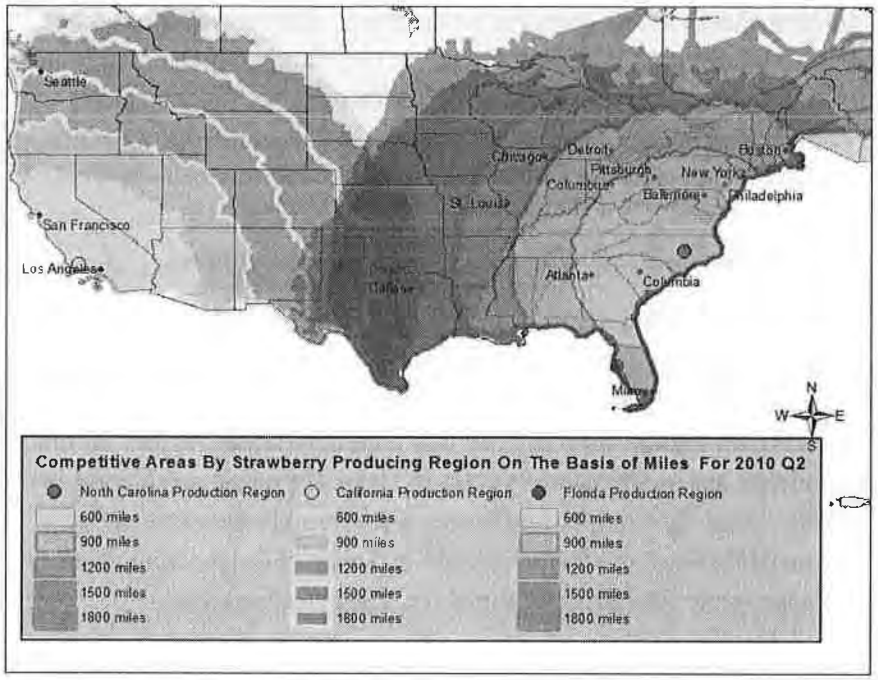
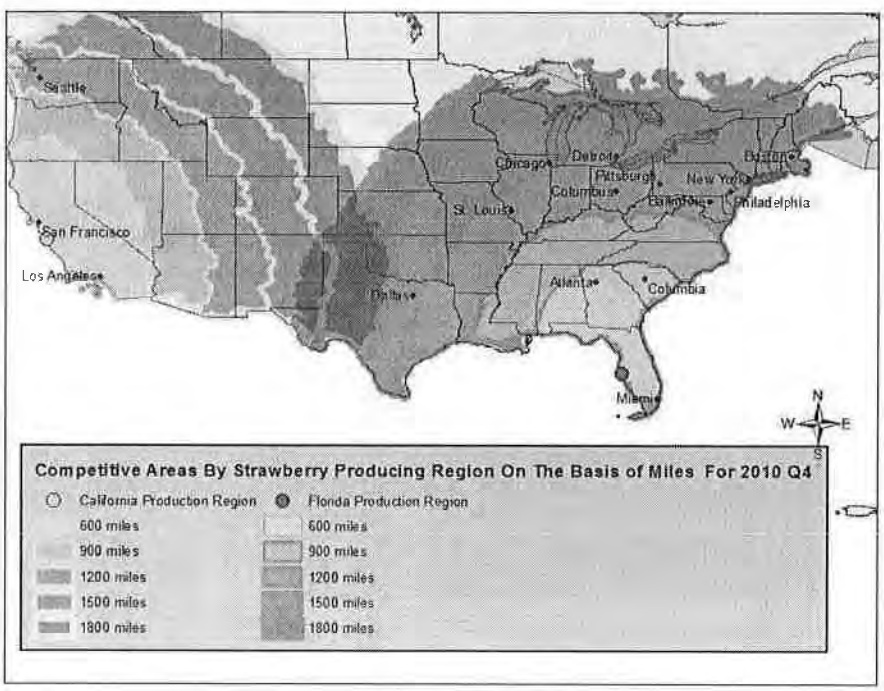


Figure 6.16. Competitive Areas by Strawberry Producing Region on the Basis of Miles for 2010 Quarter 4



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Figures 6.17 through 6.19 provide a look at how transportation costs affect the competitive boundary between California and its competitors. If one compares these transportation cost maps to the celery transportation cost maps, one should notice that the per unit transportation costs are much lower than per unit costs for celery. In this case, the competitive region can be represented by transportation costs are between \$0.20 and \$1.50. This compares to the celery transportation cost range that was between \$2.00 and \$7.00 per unit shipped. This highlights the important fact that the more units of production you can get on a truckload, the smaller the effect of transportation costs to the total value of the delivered carton/box of produce.

Examining Figure 6.17 shows that the competitive boundary between Florida and California has shifted westward in Florida's favor. The competitive boundary spans the eastern side of the Texas panhandle up through the western edge of Kansas, continuing through the middle of North and South Dakota. The two regions are still capturing the same markets as they were when mileage was the only consideration. California's transportation costs ranges from nearly \$0.00 for the Los Angeles market all the way up to approximately \$0.60 to deliver to the Seattle market. At a transportation cost of \$0.60, Florida is able to capture all the major Midwest and Eastern markets.

In the second quarter with North Carolina coming into production, the competitive boundary does not change much from the first quarter. Any change is not easily seen visually in Figure 6.18. While there are times that North Carolina would be considered California's major competitor, i.e., for regions higher north, Florida is its major competitor for the southern portion of the US. Since the transportation costs are assumed identical for Florida and North Carolina because they are in the same region, North Carolina still captures the same markets it did when only mileage was considered. The Florida production region captures Dallas.

Figure 6.19 demonstrates a dramatic change in the fourth quarter. The transportation cost differential between California and Florida is large enough to create a major shift of the competitive boundaries westward in comparison to the first quarter and the mileage map from the fourth quarter. The new competitive border now spans the middle of New Mexico and Colorado up through the eastern portions of Wyoming and Montana. Since the production region for California has moved to the Salinas Valley, it still has a per carton transportation cost of \$0.60. If the strawberries had to be sourced from Oxnard, the cost would exceed \$0.60. Florida still can reach the major Eastern and Midwestern cities with a transportation cost of less than \$0.60 per carton. For California to reach the Dallas market, it would cost in transportation over \$1.00 per carton.

Figure 6.17. Strawberry Transportation Cost per Box by Production Region for 2010 Quarter 1

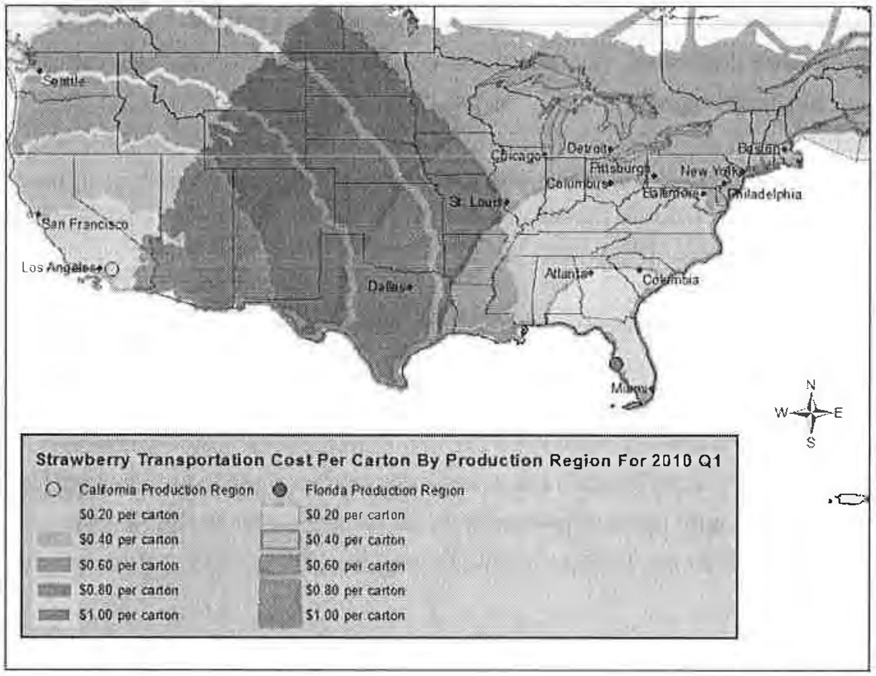


Figure 6.18. Strawberry Transportation Cost per Box by Production Region for 2010 Quarter 2

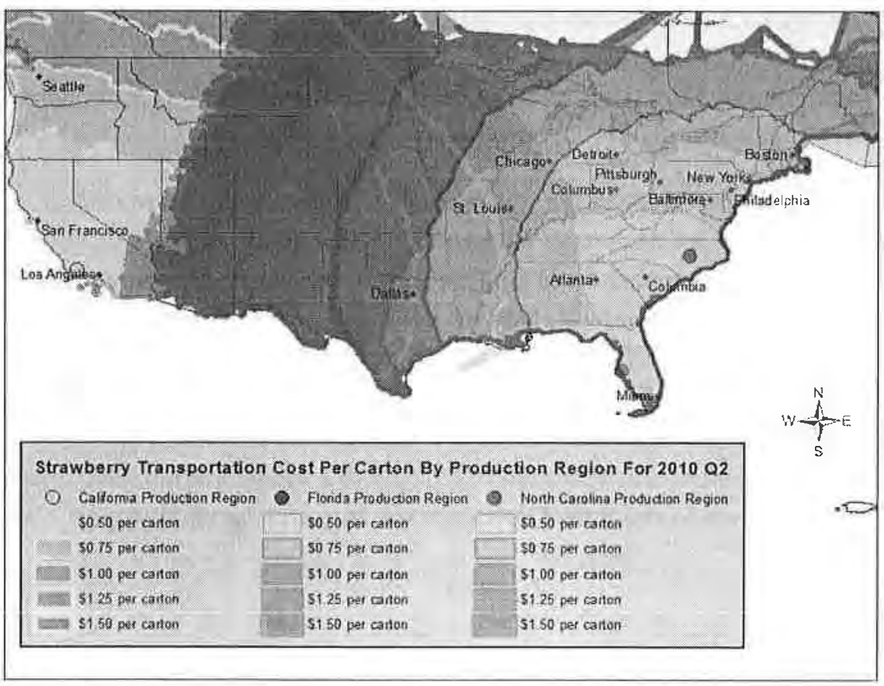
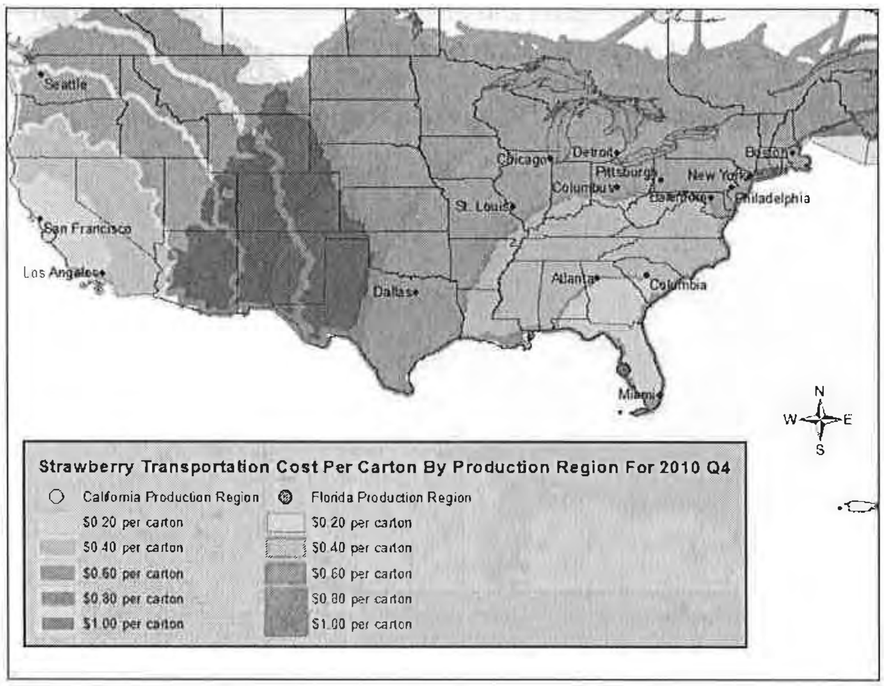


Figure 6.19. Strawberry Transportation Cost per Box by Production Region for 2010 Quarter 4



In comparison to celery, incorporating production cost for strawberries in the competitive analysis can have a profound effect on the competitive boundary between regions. Figures 6.20 through 6.22 indicate just how profound this effect can be. Examining the map, Figure 6.20, developed for the first quarter shows that Florida is able to capture all the major cities that are east of Dallas and including Dallas based on production and transportation costs. It would cost a California producer to deliver a carton of strawberries to Dallas approximately $16.60 per carton, while a Florida producer could get a carton of strawberries to Dallas for just over $16.40. The competitive boundary in the first quarter appears to split North and South Dakota down the middle from east to west, go through the heart of Nebraska, down through approximately the middle of Texas from east to west.

In the second quarter when North Carolina comes into production, Figure 6.21 shows that North Carolina is not even competitive with Florida and California. North Carolina's production costs are so high in comparison to each of these states that both Florida and California could deliver to North Carolina cheaper than the producers in the state can produce. Hence the map shows that the North Carolina strawberry industry is developed more for local markets rather than trying to compete at the U.S. level. The competitive boundary between California and Florida has moved west in comparison to the first quarter. This boundary is around the western borders of North and South Dakota, down through the eastern edges of Colorado and New Mexico. The transportation and production costs have dramatically decreased from the first quarter to the third quarter.

The fourth quarter shows the most dramatic effect to competition in the strawberry industry. Figure 6.22 shows that Florida is not competitive against California. While California can traverse nearly the whole nation with transportation and production cost of $16.50 per carton, Florida is not able to come into the market until a carton cost of $25.80 is reached.

Figure 6.20. Strawberry Delivered Cost per Box by Production Region for 2010 Quarter 1

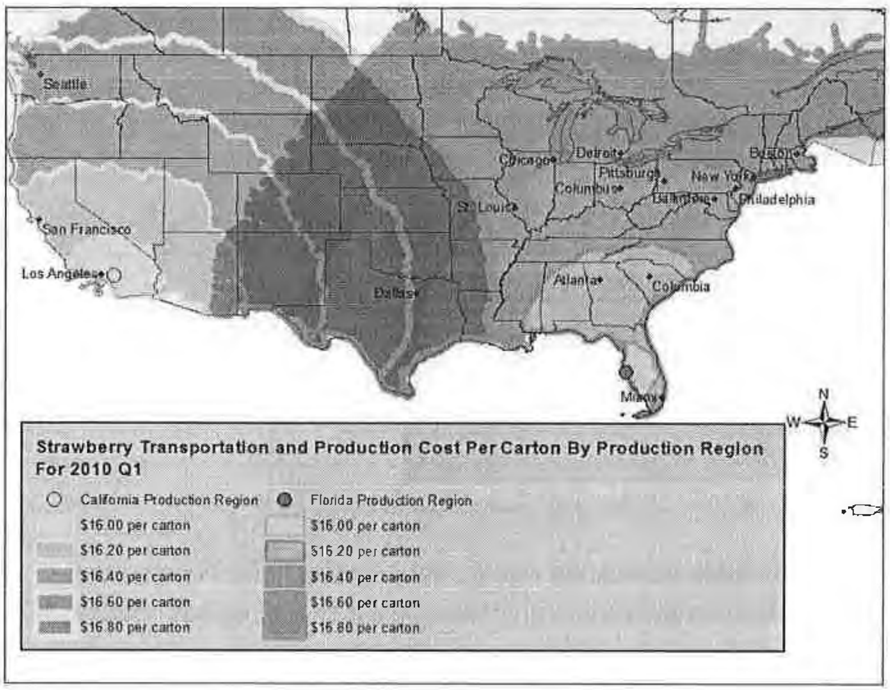


Figure 6.21. Strawberry Delivered Cost per Box by Production Region for 2010 Quarter 2

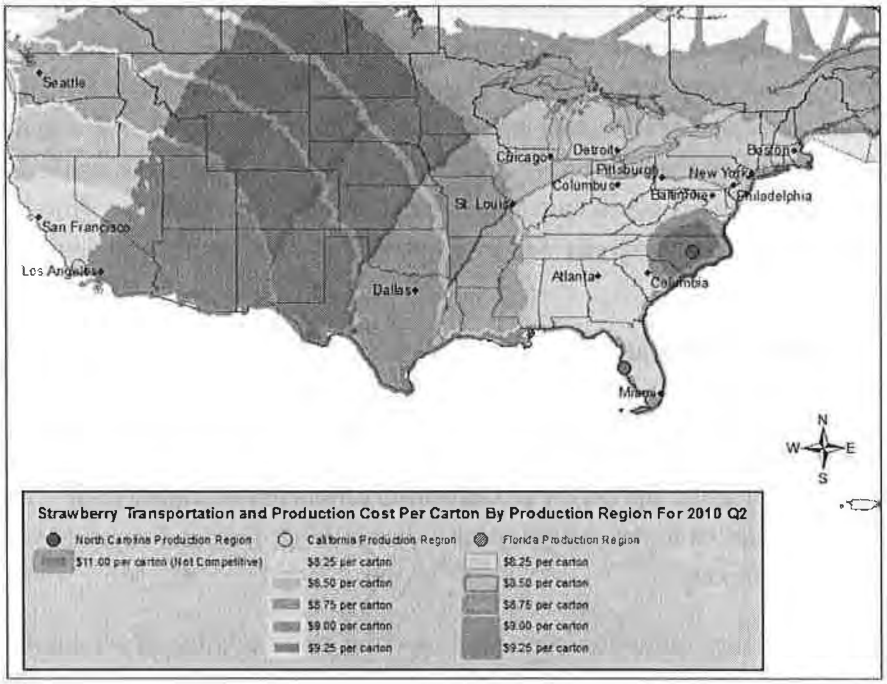
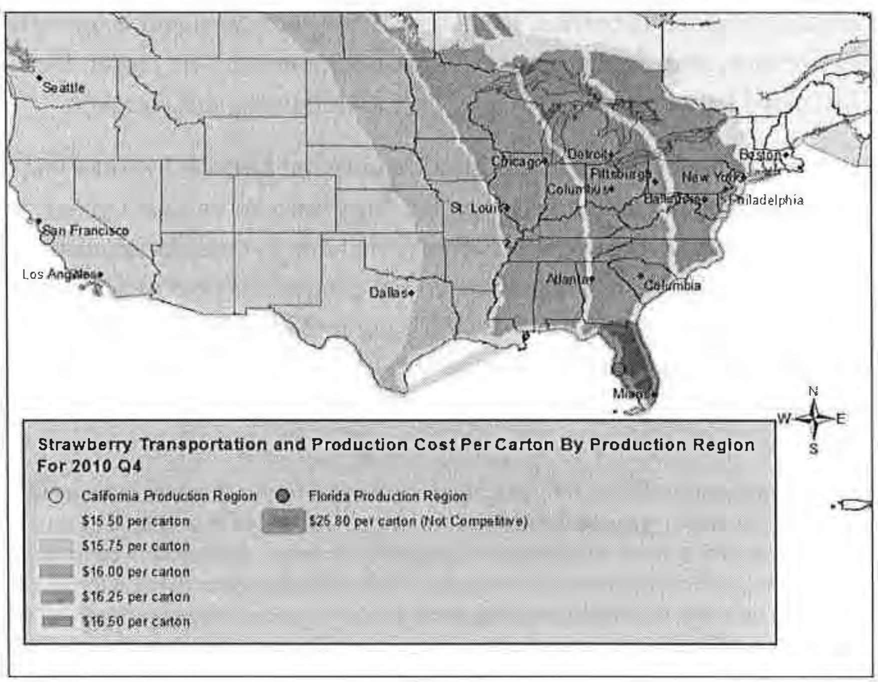


Figure 6.22. Strawberry Delivered Cost per Box by Production Region for 2010 Quarter 4



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The maps presented have allowed for visualizing the competitive boundaries between California and its competitors for strawberries and celery. These maps show that California has a much greater advantage producing strawberries in comparison to celery. While California in many cases has a production cost advantage over its competitors, it does not have a transportation cost advantage. Since most of the major markets are on the East coast, California can have a difficult time competing with its East coast and Midwestern counterparts. One major aspect that was not considered in this analysis was the amount of supply available from each region. This analysis had to assume that all producing regions could meet the demand of the major markets. This assumption is very unrealistic. The next analysis will take into account the supply and demand conditions of each of the crops.

State Specialty Crops Competitive Model

The state specialty crop competitive model (SPC) was developed to provide an analysis of the competitiveness of selected California fresh fruit and vegetable industries against that of competing states. The model focuses on the ability of California producers to supply their products to given U.S. markets relative to the ability of other states' fresh fruit and vegetable industries to supply those same markets[13].

The model is designed to analyze the competitiveness of competing states relative to availability of a select fresh fruit or vegetable to meet specific market demands. The shipment mode for the models is truck. It has been previously discussed that truck movement is the dominant transport mode for transportation of California and other states' specialty crops. Five of the selected specialty crops were modeled: celery, strawberries, sweet corn, fresh tomatoes, and watermelon. Cherries, table grapes, head lettuce, oranges, and peaches were not modeled. The reason for not modeling these crops is discussed below under Modeling, Data Limitations, and Issues.

There are competitive imports that move into the U.S. from Canada and Mexico by truck and imports from other supplying nations that are moved from the entry ports to various United States markets by truck. These movements have not been modeled due to considerations of seasonality, data limitations, and the desire to concentrate on the competitiveness of California in delivering to various U.S. markets with respect to its domestic competitors for those markets. Seasonality and data limitation issues are mostly related to Mexico truck shipments to U.S. markets. Mexico does ship fresh fruits and vegetables into U.S. markets during specific seasons

[13] Consideration was given to including an international transportation component to the competitiveness models. That consideration was dropped after the meetings with California Port officials. As noted in section 5 of this report those officials, in general, indicated that their major transportation concerns revolved around congestion, government regulations, environmental, and port infrastructure issues. Their consensus was that California has stringent regulations but for the most part the increased costs of regulations were shared between shippers, and state and federal agencies. Container supply does not seem to be an issue for California specialty crop exporters. The other issues that would create international transportation competitiveness issues include comparative advantages, trade agreements, and trade barriers. All of those issues are outside the scope of this study.

of the calendar year including two of the modeled crops, tomatoes and watermelons. However, the majority of those shipments occur when California producers are either not shipping those products or shipping minimal amounts. The data issue was with respect to obtaining accurate transportation cost information on Mexico shipments to the U.S.

The mathematical specification of the SPC model is as follows:

$$Min \sum_{r} \sum_{l} \sum_{q} Del\cos t_{rlq} * Shipments_{rlq}$$

$$S.T.$$

$$\sum_{r} Shipments_{rlq} \geq Demand_{lq}$$

$$\sum_{l} Shipments_{rlq} \leq Supply_{rq}$$

$$Shipments_{rlq} \geq 0$$

The objective function for the SPC model is to minimize the sum of the total delivered cost, or the price a buyer would pay, ($Delcost_{rlq}$ * $Shipments_{rlq}$) of supplying a specific specialty crop from state regions (r) to major market locations (l) by quarters (q) for a calendar year. The delivered cost ($Delcost_{rlq}$) is the sum of the per-unit (e.g. carton, box, cwt) shipping point price for a specific shipping point location in a given quarter plus the per-unit transportation cost to ship to a specific market in a given quarter of the calendar year. A weighted average shipping point price is used for states that have more than one region shipping a product in a given quarter. Table 6.2 shows the regional California production of the five crops modeled. Shipping point prices were used in order to ascertain the regional differences in product price competitiveness. They are the prices paid at the packinghouse door, which include both the producer and packer's gross margins.

The per-unit transportation cost to a given market in a given quarter is the truck cost per-mile for that shipping point times the distance in miles from that shipping point or a weighted distance if there are several regions in the a state shipping during that quarter of the year. The weighted distances were based on the percentage shipments from those state regions for any given quarter. The quarters of the year are January-March (quarter 1), April – June (quarter 2), July – September (quarter 3), and October – December (quarter 4). The choice of modeling with respect to quarters of the year rather than months was based on crop quarterly seasonality and the costs associated with increasing model complexity versus the value of monthly versus quarterly competitive analysis. It was determined that given data considerations and increased model complexity that monthly competitive comparisons would not provide significant additional information over quarterly comparisons.

Table 6.2. Regional California 10,000 lbs Supply for the Five Crops Modeled.

Commodity	California District - 10,000 lbs Supply	Q1	Q2	Q3	Q4
Celery	COACHELLA	1,267			632
	IMPERIAL VALLEY DISTRICT	1,488			
	OXNARD DISTRICT	22,809	25,220	209	14,641
	SALINAS-WATSONVILLE	24	1,787	17,890	17,143
	SANTA MARIA	1,051	3,318	6,108	6,329
Strawberries	ORANGE-SAN DIEGO-COACHELLA DISTRICT	1,846	1,140		8
	OXNARD DISTRICT	11,759	20,314		4,015
	SALINAS-WATSONVILLE	32	23,226	37,576	8,074
	SANTA MARIA	1,470	22,504	8,488	2,752
Sweet Corn	COACHELLA VALLEY		2,230		452
	IMPERIAL VALLEY DISTRICT		14,511	97	1,339
	SAN JOAQUIN VALLEY DISTRICT		1,214	16,747	2,672
Tomatoes	CENTRAL CALIFORNIA DISTRICT			27,356	12,719
Watermelons	CALIFORNIA-CENTRAL		1,384	26,536	1,747
	CALIFORNIA-IMPERIAL VALLEY		3,815	526	
	CALIFORNIA-SOUTH		1,951	429	

The shipping point locations are specific to each of the commodities that were modeled and based on Agricultural Marketing Service (AMS), USDA movement database[14]. The market demand locations are the metropolitan statistical areas (MSA) of Seattle, San Francisco, Los Angeles, Dallas, St Louis, Chicago, Detroit, Pittsburg, New York, Boston, Philadelphia, Baltimore, Atlanta, Miami, and Columbus[15]. As noted in section 2 of this report those market destinations were based on historical information that was last produced by AMS in their 1998 calendar year report on Fresh Fruit and Vegetable Arrival totals for 20 cities. The above fifteen named MSA's were selected based on population size and geographical locations. In addition, the total estimated demand for the MSA markets accounted for 30 – 35 percent of the domestic truck shipments data available from AMS for each modeled crop. Data from 2010 represented the most current available data at the time of analysis.

Delivered cost was selected as the competitive analysis variable because it contains the two values that can affect the competitiveness of California specialty crops against other producing regions. The delivered cost provides information on and allows for the differentiation of the possible offsetting impacts between state production abilities and differing transportation costs. The Shipments_{rlq} are the amounts of the selected specialty crop that would be shipped from each

[14] The AMS Fruit and Vegetable Marketing News portal http://marketnews.usda.gov/portal/fv

[15] The OMB defines a Metropolitan Statistical Area as one or more adjacent counties or county equivalents that have at least one urban core area of at least 50,000 in population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties.

state to each major market location in each quarter, given the objective of minimizing the sum of the total delivered cost.

It is important to note at this point that all the 2010 shipments from each of the shipping states were ultimately shipped to some market destination fulfilling the demand constraint of the model. The model determines the lowest delivered cost shipment from the set of possible competing state shipments to the fifteen MSA market destinations. There is no consideration given to contractual arrangements, perceived or actual quality differences, regional preferences, or monthly availability issues. The limitation here is that competition between states to many medium and smaller regional markets is not analyzed.

An example of the effectiveness of using the shipping point price and transportation cost to determine competitiveness is given by the following. Suppose for a given specialty crop in a given quarter that California has a shipping point price of $12.50/unit and transportation cost of $2.85/unit to Chicago, then the delivered cost to Chicago would be $15.35/unit. Let a competing production region have a shipping point price of $13.00/unit and transportation cost of $2.50/unit to Chicago, resulting in a delivered price of $15.50. California has a transportation cost that is $0.35 per-unit greater than the competing producing region however California's shipping point price is $0.50 per-unit lower than the competing production region. The lower shipping point price offsets California's transportation cost disadvantage, ceteris paribus. Thus, California's lower shipping point price allows it to maintain a competitive advantage in the given quarter even though California has a higher transportation cost. In this scenario, if both producing regions had the ability to produce enough product to fulfill domestic demand the region with the lowest delivered cost, California, will provide the entire domestic supply.

The objective function is constrained by the market demand for each major market and available shipments from each state for each quarter of the year ($\sum_r Shipments \geq Demand_{lq}$). The market demand constraint requires that the sum of all the state shipments for a specific crop to a specific market equal or exceed the market demand for that selected crop in a given quarter. Given the global cost minimizing objective function we can expect that the solution will equate Shipments with Demand.

There is limited data available on the MSA market demands for each of the modeled crops. The estimated demand for each of the fifteen markets was based on U.S. per-capita retail food availability data for 2009 (the latest per-capita consumption data).[16] The population of the individual MSA market was multiplied by the retail per-capita food availability for each modeled crop. This is a rough approximation of the true per-capita demand for each of the modeled commodities in each MSA market for the year. It is likely based on published information that the true per-capita demand in each MSA market will be slightly different than that estimated.

[16] Economic Research Service (ERS), USDA, The per-capita food availability database http://www.ers.usda.gov/data-products/food-availability-%28per-capita%29-data-system.aspx#26675

However, this bias, whether positive or negative, would have little effect on the end model results.

The competitive analysis is based solely on truck shipments of a specific unit for each of the modeled crops to satisfy the market demands. That demand could also be met by such factors as import shipments, deliveries by rail or piggyback shipments, or differentiated packaging/varieties (e.g. tomatoes could be shipped as mature greens, vine ripe, greenhouse, grape, etc.). Where possible and if they were considered significant (~5% or greater) adjustments to market demands were made to account for those factors. The adjustments were done so as to better reflect the market demand being met by domestic truck shipments of that crop.

The supply constraint requires that the sum of the shipments to the major market locations be less than or equal to the supply available from the states in a given quarter ($\sum_{r} Shipments_{rlq} \leq Supply_{lq}$). The supply constraint is based on the AMS domestic truck movement data for each of the shipping states that were relevant to the specific commodity being modeled.

Modeling, Data Limitations, and Issues

The introduction to this report notes that an important limitation to this study was availability of secondary data[17]. There is limited information available for domestic markets shipments and for shipping point prices. As noted earlier there has been an increase in the amount of fresh fruits and vegetables that are shipped through market contracts. Almost all the data used in the empirical analysis is from the Agricultural Marketing Service (AMS) Fruit and Vegetable Portal fruit and vegetable shipping point and movement databases.

Five of the ten selected fruit and vegetables were modeled. The reasons for not modeling all the selected crops differ. Sweet cherries are predominately produced in California and Washington. The AMS database on sweet cherry movement has data on California quarter 2 and 3 shipments and quarter 3 Washington movements. This would have allowed a competitive analysis between the two states in quarter 3. However, the shipping point database for sweet cherries contained only shipping point price data for California in quarter 2 and Washington in quarter 3. AMS shipping point price and movement data was only available for California.

The majority of iceberg lettuce is produced in California and during the winter in Arizona. Cook[18] notes

[17] Several attempts were made to obtain primary data from produce shippers and transportation firms. Although most agreed that the study was important, for confidentiality reason they felt they were limited in the types of amounts of proprietary data and information that they could share.

[18] Cook, Roberta. 2011. *Fundamental Forces Affecting the U.S. Fresh Berry and Lettuce/Leafy Green Subsector* CHOICES Magazine. 26(4) pp 3. http://www.choicesmagazine.org/magazine/pdf/cmsarticle_201.pdf

> The vast majority of iceberg, romaine and leaf lettuce is produced in California and during the winter in Arizona. The romaine and leaf lettuce shippers in California and Arizona are substantially the same as for iceberg lettuce, although market shares vary across shippers by lettuce type. The iceberg lettuce industry is one of the most concentrated in fresh produce with the top four and top eight California shippers controlling an estimated 60% and 80%, respectively, of the California and Arizona lettuce volume. In the iceberg lettuce industry, the land requirements for growing high quality product are quite specific, with the Blanco region of the Salinas Valley most coveted and tightly controlled by the same group of longstanding competitors.
>
> Accordingly, new entrants have not been a major threat, including in other regions of North America. In 2010, imports represented only 4% of U.S. iceberg lettuce utilization (USDA/ERS, 2011), despite some growth in summer/fall export production in eastern Canada. While the expanding "local" buying trend has brought new entrants from other states into the leafy green subsector as a whole, this has largely not been the case for iceberg lettuce. In addition to the technical production constraints for iceberg lettuce, declining consumer demand has likely dissuaded new entrants.

Based on this observation the transportation competitive issue does not apply and thus iceberg lettuce was not modeled.

The movement data for California oranges is limited to rail and piggyback. There is truck movement of California oranges but it appears that the industry is unwilling to provide that movement data to AMS.

An attempt was made to model peaches, however movement data was based on 25 pound boxes of peaches and shipping point price data was for 25 pound and 22 pound boxes. The 22 pound layer pricing information was for quarters 2 and 3 in California when much of the California peach movement occurs and quarter 3 in Washington when the majority of Washington peach movement occurs. Since the pricing structures were not compatible with the movement data, peaches were ultimately not modeled.

Table grapes were not modeled because AMS movement and shipping price data exists for only California.

Although the reduction of number of models from ten to five was a limiting factor to the competitive analysis, the conclusions that can be drawn from the five crops modeled appear to be accurate reflections of the competitive factors that are driving state competitiveness.

Two other data issues existed that lead to modeling decisions. The first is where small movements of a specific crop were reported for a state or region in a state and no shipping point price was available for those shipments. This issue existed for all the modeled crops. These shipments typically occurred at the end of production seasons for states or a region of the particular crop. In addition, shipments less than 1% of the total shipments of a state were not included in the competitiveness models.

AMS shipment data show movement based on a state, a region in a state, or a city. Examples include Michigan celery, central valley California sweet corn, or Santa Maria California strawberries. This necessitated determining a representative distance for each state's shipping point for each crop that was modeled. Two approaches were adopted. If a representative shipping point for a state's crop could be identified, that shipping point's mileage to each of the MSA markets was used in the model. For example, the majority of Virginia watermelon production is located in Hanover Courthouse County so that representative shipping point was chosen. On the other hand, if a state had multiple regions shipping during any given quarter then the individual shipping points were identified in AMS movement data and a weighted distance was calculated based on percentage movement. An example would be California strawberry production. Major producing regions include Oxnard, Santa Maria, and Salinas/Monterey, and Watsonville. The weighted distance would be calculated, based on the percentage movements from those areas in any given quarter. If the major producing regions were not identified in the AMS movement data then information about a specific state's crop was obtained from various Internet sources.[19] An example is Florida sweet corn. The AMS movement data for Florida sweet corn is identified as 'Florida' regions. Information on the percentage movement from the different Florida corn producing regions was gathered. Cities that had sweet corn production were identified and mileage from those cities to MSA markets was obtained from MapQuest and representative distance were calculated based on the percentage movements for the counties producing sweet corn.

It is a relatively strong assumption that the representative shipping points are an accurate reflection of actual movements of differing crops to different MSA markets. The actual accuracy of the representative shipping distance depends on whether the AMS movement data identified a specific point or whether the representative distant had to be calculated by identification of crop production locations and choosing representative cities within those identified location.

State Specialty Crops Competitive Model Results

The five crops modeled all show similar results with regards to the effects that transportation has on California specialty crop production. The focus of the discussion is on celery and strawberries in order to illustrate the different impacts possible, keeping in mind that the final

[19] The sources of the data varied depending on the crop. An example of a source that was used when obtaining information on crop production in different states was USDA Regional IPM Centers Information System http://www.ipmcenters.org/

allocation of commodities to MSA's is relative to actual production and the greater U.S. demand. Appendix C provides tables for each commodity specifying the difference between the shipping point price, transportation costs, and delivered costs.

The first observation of particular importance is the relative impact that an increase in any cost can have on the competitiveness of a commodity. Given the fixed size of truck transportation, 43,500 lbs capacity,[20] those commodities that are larger in size and/or have a smaller shipping point price per pound will feel the effects of an increased cost structure faster than others. For instance celery comes in a 60 pound carton, which amounts to 725 cartons per truck, that sell on average for $12.03/crtn or $0.20/lbs. Strawberries come in an 8 pound tray, with 3750 trays possible per truck, which sells on average for $13.26/tray or $1.66/lbs. The relative impact that transportation costs can have on a carton of celery is substantially larger than that for strawberries.

Celery supply and demand, Table 6.2, are categorized by large volumes of California production, nearly 20 million cartons/year, with the rest of the U.S. producing approximately 2.2 million cartons/year. Even if the rest of the U.S. had a competitive advantage on production and transportation they do not have enough supply to fulfill the 30-35% of demand that is met by truck shipments represented in the 15 MSA's here. Furthermore, the top demanding MSA's in quarter 2, New York and Los Angeles, require over 600,000 cartons of celery, far more than the other producing state Florida can supply. Even though the majority of major metropolitan areas are located on the eastern side of the U.S. the volume production advantage that California has over other states negates the potential effects of transportation costs. Michigan only competes in quarter's 3 and 4, Arizona in quarters 1 and 4, and Florida in quarters 1, 2, and 4 whereas California produces celery annually. We can expect that California will backfill celery supply for Eastern/Midwestern markets after the other producing states exhaust their own supply.

[20] The exception being strawberries which due to its lighter weights cubes out at 30,000 pounds per truckload.

Table 6.3. U.S. 60 lbs Carton Celery Supply and Demand

Supply	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
California	4,439,833	5,054,167	4,034,500	6,457,500	19,986,000
Florida	530,667	457,500		113,667	1,101,834
Michigan			381,833	87,833	469,666
Arizona	597,667			41,833	639,500
Supply	5,568,167	5,511,667	4,416,333	6,700,833	22,197,000

Demand	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Seattle	60,370	60,370	48,296	72,444	241,480
San Francisco	85,985	85,985	68,788	103,182	343,940
Los Angeles	254,439	254,439	203,551	305,326	1,017,755
Dallas	126,373	126,373	101,099	151,648	505,493
St. Louis	55,789	55,789	44,631	66,947	223,156
Chicago	187,645	187,645	150,116	225,174	750,580
Detroit	85,209	85,209	68,167	102,251	340,836
Pittsburgh	46,733	46,733	37,386	56,080	186,932
New York	374,793	374,793	299,834	449,751	1,499,171
Boston	90,289	90,289	72,231	108,347	361,156
Philadelphia	118,313	118,313	94,650	141,975	473,251
Baltimore	53,758	53,758	43,006	64,510	215,032
Atlanta	104,499	104,499	83,599	125,399	417,996
Miami	26,103	26,103	20,882	31,323	104,411
Columbus	36,425	36,425	29,140	43,710	145,700
Demand	1,706,723	1,706,723	1,365,376	2,048,067	6,826,889

Given the supply and demand amounts imputed along with shipping point prices the model allocated shipments of celery in the first quarter to the 15 MSA's by production region shown in Table 6.3. As specified, the model fulfilled demand in the different MSA's using the lowest delivered cost production region. For most markets this meant a sole supplier of celery.

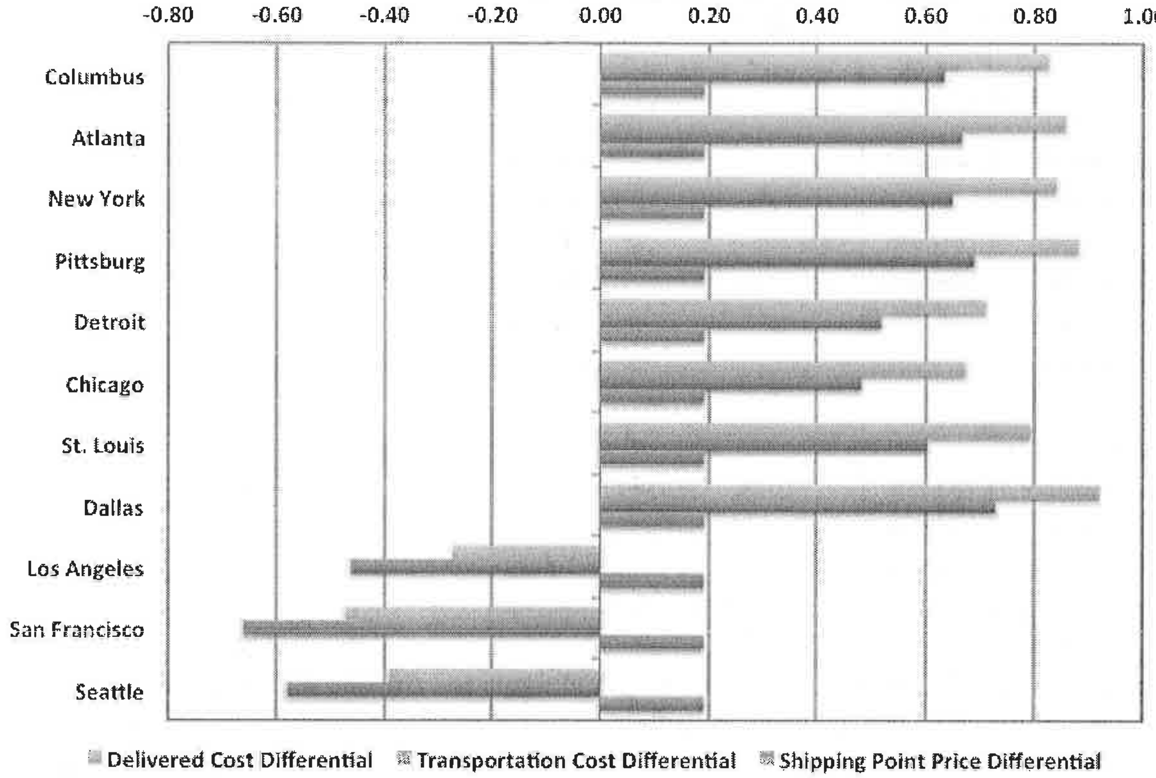
In the first quarter both Chicago and New York have two suppliers of celery, Table 6.3. The total demand for celery in Chicago was 187,645 cartons. California supplied 94.6% and Arizona 5.4% of Chicago's demand even with Arizona having a delivered cost advantage of $0.67/carton, Figure 6.2. This result emphasizes the importance of available supply to competition. In both the case of Chicago and New York, one supplier had the competitive advantage on the delivered cost but not the supply to fulfill the MSA's demand. In this case a residual supplier filled in the remainder of demand, California for Chicago and Arizona for New York.

Table 6.4. Quarter 1 Celery Demand and Delivered Quantities

Destination	Demand	California	Florida	Arizona
Seattle	60,370	60,370		
San Francisco	85,985	85,985		
Los Angeles	254,439	254,439		
Dallas	126,373			126,373
St. Louis	55,789			55,789
Chicago	187,645	177,595		10,050
Detroit	85,209			85,209
Pittsburg	46,733			46,733
New York	374,793		242,204	132,589
Boston	90,289		90,289	
Philadelphia	118,313		118,313	
Baltimore	53,758		53,758	
Atlanta	104,499			104,499
Miami	26,103		26,103	
Columbus	36,425			36,425

Figure 6.23 illustrates the difference between California and Arizona shipping point price, transportation costs, and delivered costs for quarter 1 celery shipments allocated by the model. California has a clear advantage in transportation costs over Arizona when shipping to Seattle ($0.58), San Francisco ($0.66), and Los Angeles ($0.46). This advantage overcomes the disadvantage in shipping point price ($0.20) and the model fulfills demand in those MSA's with California produced celery. Arizona has an advantage in the delivered cost, transportation cost, and shipping point price for the remaining MSA's and so the model allocates Arizona's supply to those markets with California backfilling Chicago demand where the difference between states' delivered cost is at it's lowest ($0.67).

Figure 6.23. Per Carton Delivered Cost, Transportation Cost, and Shipping Point Price Differentials for Celery Production between California and Florida in Quarter 1.



Strawberries, in comparison to celery, highlight the importance of shipping point price over transportation costs. Table 6.4 shows the total supply and demand for strawberries. In the first quarter there is a potential for transportation costs to have an impact on the allocation of shipments of strawberries. Both California and Florida have the potential to supply the 15 MSA's however the difference between shipping point prices, Table 6.5 is only $0.06. The allocation of strawberries throughout the MSA's is nearly solely based upon transportation costs in the first quarter.

The following three quarters tell a very different story. The second quarter has similar differences between California and Florida shipping point prices, however, Florida only has enough supply to service Baltimore and Miami completely. California is the residual supplier in Atlanta and supplies the remaining MSA's while the model does not allocate any of North Carolina's 275,000 trays. The third quarter has California as the sole supplier of strawberries. California has such an advantage in shipping point price in the fourth quarter, Table 6.5, that they again are the sole supplier to the 15 MSA's.

Table 6.5. U.S. 8 lbs Trays Strawberries Supply and Demand

Supply	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
California	18,883,750	83,980,000	57,580,000	18,551,250	178,995,000
Florida	13,493,750	2,582,500		1,120,000	17,196,250
North Carolina		275,000			275,000
Total	32,377,500	86,837,500	57,580,000	19,671,250	196,466,250

Demand	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Seattle	472,410	1,299,127	856,243	324,782	2,952,562
San Francisco	672,853	1,850,345	1,219,545	462,586	4,205,329
Los Angeles	1,991,036	5,475,348	3,608,752	1,368,837	12,443,973
Dallas	988,899	2,719,473	1,792,380	679,868	6,180,620
St. Louis	436,561	1,200,544	791,268	300,136	2,728,509
Chicago	1,468,363	4,038,000	2,661,409	1,009,500	9,177,272
Detroit	666,778	1,833,640	1,208,535	458,410	4,167,363
Pittsburgh	365,695	1,005,662	662,823	251,416	2,285,596
New York	2,932,831	8,065,286	5,315,757	2,016,322	18,330,196
Boston	706,533	1,942,965	1,280,591	485,741	4,415,830
Philadelphia	925,821	2,546,008	1,678,051	636,502	5,786,382
Baltimore	420,668	1,156,837	762,461	289,209	2,629,175
Atlanta	817,727	2,248,749	1,482,130	562,187	5,110,793
Miami	204,259	561,711	370,219	140,428	1,276,617
Columbus	285,030	783,834	516,618	195,958	1,781,440
Total	13,355,464	36,727,529	24,206,782	9,181,882	83,471,657

Table 6.6. Shipping Point Price, Average Transportation and Delivered Costs for Strawberries

Shipping Point Price				
Supply	Q1	Q2	Q3	Q4
California	15.88	7.92	7.76	14.37
Florida	15.94	7.65		25.70
North Carolina		10.88		

Average Transportation Costs				
Supply	Q1	Q2	Q3	Q4
California	0.98	1.20	1.26	1.20
Florida	0.52	0.75		0.54
North Carolina		0.60		

Average Delivered Costs				
Supply	Q1	Q2	Q3	Q4
California	16.86	9.12	9.02	15.57
Florida	16.46	8.40		26.24
North Carolina		11.48		

For the other three commodities: sweet corn, tomatoes, and watermelon, we find similar results. The allocation of supply to the modeled MSA's depends greatly on the container size of the commodity relative to its shipping point price. The differences between California and the other producing states' shipping point price, transportation costs, and delivered costs are located in Appendix C.

In the case of Watermelons the difference between shipping point prices are much smaller than the differences between transportation costs. In addition, California is the fourth largest supplier of watermelons. The competitive environment for watermelons on both the shipping point price and quantity supplied make it the most susceptible to changes in transportation costs.

California tends to be the sole supplier for the majority of the MSA's of fresh tomatoes in the third and fourth quarter and the sole supplier for the Western MSA's for sweet corn in quarters 2, 3, an 4. In every case the larger the container and smaller the relative shipping point price the greater the effect that transportation costs have. However, for the other producing states the ability to supply the 15 MSA's modeled is limited, resulting in transportation costs having a marginal effect on the competitiveness of California fresh fruit and vegetables.

Environmental Concerns Associated with California Specialty Crop truck Transport

Major buyers like Wal-Mart are in the process of encouraging suppliers to measure their carbon footprint and report to measuring bodies like the Carbon Disclosure Project. These buyers are being encouraged to identify how they can benefit from a transition to a low carbon economy.[21] To meet such buyer demands, more attention will need to be focused on the total cost associated with transportation of specialty crops from surplus production regions to deficit demand centers. To begin to understand how such changes may impact the environment requires some measure of the current situation with regard to environmental quality.

In the move toward accounting for and managing greenhouse gas emissions the first step is to measure them. A straightforward method to estimate is the greenhouse gas (GHGs) emissions associated with the current movement patterns of California specialty crops is to utilize a mass balance approach. For purposes of illustration in this report our focus is limited to carbon dioxide emissions associated with the movement from California to the terminal market areas defined earlier by the 15 city delivery points. Shipment distance was simple average of the distance from California production areas (Table 6.1). Based on information supplied by industry collaborators the GHGs estimates associated with outbound movement of the study commodities was calculated as:

$$GHGE = QF * CC * FC$$

Where GHGE is the measure of metric tons of CO_{2e}; QF the quantity of fuel used; CC the carbon emissions per unit of fuel use; and FC the percentage of carbon dioxide released during use.

[21] Wal-Mart Sustainability Supplier Assessment: *www.**walmart**stores.com/**Sustainability**/*

The estimates for emissions per truck are based on several key assumptions provided by industry sources. First, the expected average gas mileage used in the model estimate is 5.8 miles per gallon. The second key assumption is that the carbon coefficient is 10.04724. This coefficient is the estimated amount of carbon that is emitted per gallon of combusted. The third key assumption is that 99% of the fuel used is combusted. Given these key assumptions, the estimates of per truckload emissions for each destination based on the mass balance approach described above are presented in Table 6.2. The emissions per truck load for the cities covered in this study range from 0.31 metric tons of CO2 equivalent up to 5.22 metric tons.

Table 6.7. Average Transport Miles

	Ship From:						
Ship To:	Fresno CA	Salinas CA	Santa Maria CA	El Centro CA	Oxnard CA	Rancho Palos Verdes CA	Average
Atlanta GA	2,301	2,397	2,305	2,032	2,230	2,202	2,245
Baltimore MD	2,826	2,923	2,830	2,615	2,755	2,727	2,779
Boston MA	3,112	3,197	3,116	2,941	3,042	3,013	3,070
Chicago IL	2,144	2,229	2,148	2,045	2,074	2,045	2,114
Columbia SC	2,510	2,605	2,536	2,241	2,439	2,412	2,457
Dallas TX	1,557	1,654	1,561	1,250	1,486	1,459	1,495
Detroit MI	2,409	2,494	2,413	2,275	2,338	2,310	2,373
Los Angeles CA	219	303	170	212	61	31	166
Miami FL	2,870	2,966	2,906	2,548	2,797	2,757	2,807
Nashville TN	2,132	2,228	2,136	1,913	2,061	2,033	2,084
Philadepphia PA	2,845	2,972	2,849	2,634	2,774	2,746	2,803
Pittsburg PA	2,561	2,674	2,564	2,350	2,490	2,462	2,517
San Francisco CA	192	106	264	591	388	404	324
Seattle WA	928	895	1,053	1,347	1,144	1,160	1,088
St. Louis MO	1,956	2,052	1,959	1,744	1,884	1,856	1,909

Source: GoogleMaps.com

Table 6.8. Emissions Per Truck Load

	Average Mileage from Shipping Points	MPG	Quantity of Fuel (Total Gallons)	Carbon Coefficient	Fraction Combusted	Kg/Load	Emissions per Truck Load (MT CO2)
Atlanta GA	2206	5.8	380	10.04724	99%	3783	3.78
Baltimore MD	2747	5.8	474	10.04724	99%	4712	4.71
Boston MA	3043	5.8	525	10.04724	99%	5219	5.22
Chicago IL	2096	5.8	361	10.04724	99%	3594	3.59
Columbia SC	2457	5.8	424	10.04724	99%	4217	4.22
Dallas TX	1451	5.8	250	10.04724	99%	2489	2.49
Detroit MI	2351	5.8	405	10.04724	99%	4031	4.03
Los Angeles CA	181	5.8	31	10.04724	99%	310	0.31
Miami FL	2762	5.8	476	10.04724	99%	4736	4.74
New York NY	2833	5.8	488	10.04724	99%	4858	4.86
Philadelphia PA	2771	5.8	478	10.04724	99%	4752	4.75
Pittsburg PA	2485	5.8	428	10.04724	99%	4261	4.26
San Francisco CA	370	5.8	64	10.04724	99%	635	0.64
Seattle WA	1133	5.8	195	10.04724	99%	1943	1.94
St. Louis MO	1877	5.8	324	10.04724	99%	3218	3.22

Source: Industry Collaborators; Mass Balance of Emissions

Table 6.9. Emissions by Destination: Celery by Truck

CELERY-TRUCK	Number of Truck Arrivals	Emissions Per Truck Load (MT CO_2)	Total Yearly Emissions (MT CO_2)
Atlanta GA	1,305.94	3.78	4,939.99
Baltimore MD	2,223.63	4.71	10,477.10
Boston MA	1,350.06	5.22	7,046.12
Chicago IL	4,456.09	3.59	16,016.53
Columbia SC	97.06	4.22	409.36
Dallas TX	1,932.44	2.49	4,809.27
Detroit MI	2,814.84	4.03	11,347.74
Los Angeles CA	4,667.87	0.31	1,446.57
Miami FL	1,076.52	4.74	5,098.94
New York NY	3,211.92	4.86	15,602.52
Philadepphia PA	1,517.72	4.75	7,211.74
Pittsburg PA	1,411.83	4.26	6,015.67
San Francisco CA	1,226.53	0.64	779.21
Seattle WA	2,355.99	1.94	4,577.22
St. Louis MO	1,676.55	3.22	5,395.97
Total	31,325.00		101,173.96

Combining the estimates presented in Table 6.2 with the allocation of distribution by commodity provides a first approximation of the carbon footprint associated with the movement of any of the study commodities to any of the selected destinations. For example the results for the movement of celery by truck are presented in Table 6.3, where 100,000 lb. units are converted to 40,000 lb. truckloads as used in USDA/AMS daily movement reports.[22]

In a similar fashion the carbon footprint associated with the movement of the study commodities by rail may be approximated. In the case of rail transportation the emission factors used in the calculation include conversion factor of 3.67 (CCF) to convert the amount of carbon burnt in transit to equivalent amounts of CO2 (every 12 grams of carbon burnt releases 44 grams of CO2). Given the gallons per mile used (GPM) and the mass density (MD) of conventional diesel of equal to 3167 grams/gallon, with carbon content (CC) of 0.86, the amount of carbon burnt (CB) is equivalent to:

$$CB = GPM * MD * CC$$

Combining these values allows for the deamination of CO2 generated in grams per mile by:

$$CO2 = CCF * CB$$

[22] For example see: USDA, AMS, Fruit and Vegetable Programs, Market News Branch, Daily Shipment and Crossings Report for Selected Commodities: http://www.marketnews.usda.gov/portal/fv

Assuming a class 1 freight locomotive under normal conditions and train tonnage is in the range of 2.5 miles per gallon the equivalent CO2 per mile would be 24.98 kg per mile or about 22.2 lbs. of CO2 per gallon.[23] Because of the difference in cargo capacity truck freight emissions are calculated to be around 13,900 ton miles per ton of CO2 while rail freight emissions are reported to be around 37,200 ton miles per ton of CO2.[24]

The calculation of the carbon footprint associated with the movement of specialty crops becomes more meaningful when viewed in the context of what the value/cost of such a measure implies. For example if the customers value the attribute associated with a company accounting for GHG emissions and the willingness to offset them in some way, what might be the cost? One way to establish such a value is to apply the current price for carbon to the total emissions associated with the movement of an individual commodity. Once established that value may then be expressed on a per-carton or related sales quantity to establish the eco-system cost associated with the purchase of a given commodity for a given origin. In this way consumers could better determine the impact on a measurable environmental effect of the purchase of a product from a distant location compared to one produced “locally”. It is important to emphasize that such a measure is only a small part of the total system costs as truck transport from origin to destination represents only around 11 percent of the life-cycle GHG emissions associated with a given product transformation from farm to retail.[25]

The price of carbon varies depending on the market upon which it is based. Surveys of existing market prices in April 2012 suggest a range of prices per metric ton CO2 with a low of $2.75 to a high of $29.[26] Incorporating these cost with the emissions per truckload provides a simple estimate of the current value the market places on the negative externality in the form of CO2 emissions associated with a given product movement. For example a truckload of produce moving from California to Boston creates 5.22 metric tons of CO2 emissions. Choosing a cost at the higher end of the range $25.35 per metric ton reported for Sustainable Travel International, a firm that facilitates carbon footprint offsets for personnel and business travel, results in a per truckload cost (carbon offset value) of $132.33.

When expressed as a cost per unit the actual value the market places on the externality, and hence recovery cost to offset the negative externality link to produce transportation, is relatively small. The average refrigerated truck rate for produce movements from California to Boston is

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[23] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Fact #576: June 22,209 Carbon Dioxide from Gasoline and Diesel Fuel. U.S. Environmental Protection Agency, "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel," February 2009. http://www1.eere.energy.gov/vehiclesandfuels/facts/2009_fotw576.html

[24] Texas Transportation Institute. “A modal Comparison of Domestic Freight Transportation Effects on the General Public”, March, 2009.

[25] 2008. Weber, Christopher L. and H. Scott Matthews. “Food-Miles and Relative Climate Impacts of Food Choices in the United States”, Environmental Science Technology, Vol. 42, pp. 3508-3513, 2008.

[26] http://www.ecobusinesslinks.com/carbon_offset_wind_credits_carbon_reduction.htm

reported to be $2.37 per mile, or $7,212 per delivery.[27] In this example the addition of a carbon offset duty would amount to an additional 1.8% in the cost of the transit from origin to destination, based on 40,000 lbs. of cargo. This equates to $0.0033 per pound in additional costs to the product. For a commodity such as celery, with a Boston terminal market price of $19 per 55 lb. carton the individual unit price offset cost would be about $0.01 per pound.[28]

Clearly this is a starting point for understanding how transportation of produce impacts the environment. A product life cycle analysis would need to be done for each commodity to more accurately measure the environmental effects. Such an accounting would need to include, but not necessarily be limited to: the net balance between any sequestration value from plant growth, emissions from machinery used in production, emissions from backhaul movement and many other.

[27] http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5097094

[28] USDA, AMS, Fruit and Vegetable Market News, Terminal Market Report, Boston, May 23, 2012.

VII. Summary and Recommendations

The U.S transportation system moves agricultural commodities and products through a vast network of food system handlers, processors and distributors to domestic consumers and coastal ports for export to international markets. An agricultural transportation system that provides reliable, safe, and cost efficient services is critical to the current and future successful marketing of U.S. food products.

The USDA reports that the agricultural sector is the largest user of freight transportation services in this country.[29] By aggregating the movements of raw agricultural commodities with the movements of processed products and agricultural inputs, agriculture accounted for 31% of all ton-miles transported in the U.S. in 2007.

The focus of this study was to bring into perspective and provide information on agricultural transportation issues that can affect the competitiveness of California specialty crop producers as they compete for domestic and international markets. Competitiveness is defined here as a measure of the ability of one state's producers to supply their products to a given market of the U.S. relative to the ability of other producing states to supply those same markets. Competitiveness can be thought of as the strategic advantage one state has over other states within the national fresh fruit and vegetable industry.

Competitiveness and profitability need to be considered as separate measures of an industries well-being. Profitability is a measure of advantageous returns or results. It can generally be thought of as net revenue from business operations after subtracting business expenses from total sales revenues. It is possible that any given state's specialty crop industry can be competitive but not profitable in the short-run. However, competitiveness is a necessary condition for firm profitability in the long-run. This distinction is important because if transportation costs change over time due to any set of factors, a state's specialty crop industry can experience increasing or decreasing profitability while remaining competitive with other states' specialty crop producing industries.

The specific objectives of the study were to:

- Gather primary and secondary data on the various modes of transportation. This data would include product market and transportation market information by region and specialty crop sector.
- Identifying those transportation modes (truck, rail, air, ports) where the California specialty crop grower, shippers, and transportation industry firms are experiencing or may experience changes in their regional and international competitiveness due to logistical and cost issues associated with current and projected changes in

[29] U.S. Department of Agriculture, Transportation Services Division, Agricultural Marketing Service. *Study of Rural Transportation Issues.* April, 2010.

transportation technology, infrastructure, and agricultural transportation markets. The importance will be identified by specialty crop category and California region.

- Evaluate the impact that changes in agricultural transport technology, infrastructure, and agricultural transportation markets will have on the future competitiveness of California specialty crop producers in the regional and international marketplace.
- Provide policy makers and other stakeholders involved with agricultural transportation issues suggestions on maintaining or improving the regional and international competitiveness of California specialty crop industries through changes and improvements in existing transportation mode services.

The information and data gathering that lead the results and recommendations of this study are contained in section II through VI of this report. Section II looks at the demand for transportation services, Sections III, IV, and V discuss the characteristics of truck services through two surveys of truckers and shippers, rail and air services and port services. Section VI provides qualitative and quantitative analysis of California competiveness relative to other states producing similar specialty crops.

There are two key finding from this study. The first relates to the results of the empirical analysis of California regional competitiveness. The findings of the competitive spatial analysis and the state specialty crop competitive model analysis indicate that transportation costs, shipping point prices, and product availability all have an effect on California specialty crop competitiveness but the effects of each are not uniform. Product availability appears to be the leading factor in determining an individual state's specialty crop competitiveness.

The following are general observations of the relative importance of the three competitiveness factors. Where a California product has a competitive advantage in shipping point price, a relatively low transportation cost differential, has multi-seasonal product availability, and significant production capacity over other states, it will be the dominant supplier to most U.S. markets for most seasons of the year (e.g. strawberries). If a California product has comparable shipping point prices, and comparable unit transportation costs to U.S markets but has large production capacity relative to competing states then its market competitiveness is primarily in the western states and it will be the residual supplier for all but the most western markets (e.g. celery). If a California product has a comparatively higher shipping point price, higher per-unit transportation cost, and relative higher production capacity its competitive advantage shifts to the western states and it is a residual supplier to more eastern markets.

There are other combinations of these factors that could affect California specialty crop competitiveness in different ways:

- California has competitive advantage in western markets for most specialty crops, it will be a residual supplier for specialty crops to more eastern markets when its production capacity for that product is greater than other states producing similar products but it has higher shipping point prices and per-unit transportation costs to the eastern markets.

- If its product's shipping point prices are lower relative to the per-unit transportation cost and it has a dominant production capacity, then it will have the dominant competitive advantage to most U.S. markets and other states will be residual suppliers.

Thus, there are trade-offs between shipping point prices, per-unit transportation costs, and production capacity on their impact of California specialty crop competiveness. However, the most significant factor affecting California specialty crop competitiveness is its production capacity. The next most important factor is shipping point prices. The least important factor of the three is per-unit transportation costs. Higher per-unit transportation cost can shift the California competitiveness boundary slightly to the west but changes in shipping point prices and production capacity are the major drivers of California specialty crop competitiveness.

This does not mean that transportation costs are not a profitability issue. If prices are being quoted on a delivered basis by specialty crop shippers then the changes in transportation cost will directly affect firm level profits. The specialty crop shippers that responded to the survey from this study indicated that a relatively small percentage (12%) of sales was done on a delivered price basis but they expect that it will likely increase to 18% in the next five years.

The second set of study findings are based on the results of the California specialty crop shipper and trucker surveys. The competitive issues highlighted by those surveys are highway infrastructure with emphasis on congestion, logistical inefficiencies with regards to loading and unloading produce, and the California regulatory environment.

The ability of existing highway infrastructure to meet the current demand for transportation services associated with the distribution of California fresh fruit and vegetables, particularly movements by truck, will be a challenge in the future. Vehicular traffic volume increases will continue to compete for space along major arteries within the population growth centers and across transcontinental pathways.

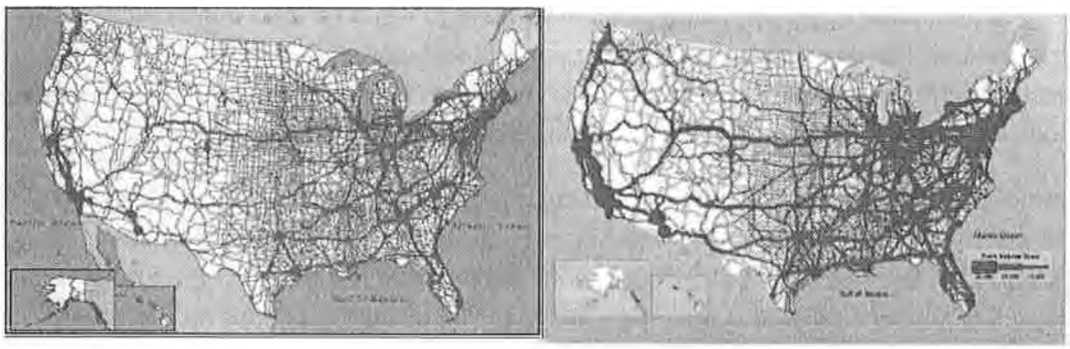
Estimates predict increased congestion that will likely add to the difficulty associated with the timely delivery of perishable commodities. The Federal Highway Administration estimates of increased daily truck traffic are illustrated in Figure 7.1.[30] Assuming no change in existing network capacity the number of highways with recurring congestion and larger truck volumes is expected to increase nearly four-fold by 2040.[31] The following information supports the concern

[30] Estimated Average Annual Truck Traffic, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework.
[31] U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Performance Monitoring System; and Office of Freight Management and Operations, Freight Analysis Framework, Version 3.1, 2010.

about congested highways. The major routes in California experience considerable congestion. According to the survey respondents I-5 is congested 35% of the time and delays due to congestion are an average of 3.2 hours while I-80 is congested 31.6% of the time and has congestion delay averages of 4.36 hours. The other major routes experience similar percentage congestion and delay times. For products located in the Central Coast of California, such as lettuce and strawberry, these congestion issues have deleterious effects on trucker's relative wages who move these products.

Figure 7.1. Estimated Average Daily Truck Traffic 1998, 2020.

1998 2020



Congestion costs are difficult to accurately measure. However, the impacts can be substantial relative to:

- increases in air pollution due to reduced speeds and idling engines;
- delays in arrival dates and times which create additional costs for the receiver;
- accident liabilities;
- disruptions of marketing efforts;
- increases in operating cost incurred by trucking firms; and
- decreases in driver supply.

The Rand Corporation's Supply Chain Policy Center has studied the impacts of highway congestion on U.S. transportation efficiencies[32]. They made a series of recommendations. Their recommendations include:

- Add physical highway capacity by adding traffic lanes or permitting larger trucks
- Build truck-only lanes.
- Spread transportation demand across time and space by using congestion periods for peak periods.

[32] Richard Hillestad, Ben D. Van Roos, and Keenan D. Yoho ***Key Issues in Modernizing the U.S. Freight-Transportation System for Future Economic Growth*** Rand Corporation 2009

- Shift trucking activity to off-peak traffic periods.
- Use information technology systems to identify real-time traffic breaks and routing for congestion avoidance.

Each of these recommendations is subject to political debate and cost consideration. However, virtually every transportation stakeholder agrees that if the congestion issue is not addressed it would significantly increase the cost of moving goods and services, and disrupt supply chains of national importance including the transport of agricultural commodities and products.

The logistical inefficiency issue raised by the trucker survey concerned truck's waiting time to load and unload product. The truckers in the survey indicated that they spent a large amount of time waiting to load produce at the shipper's facility. The issue of wait-time is highest on the list of issues truckers find are important and it is an issue that truckers believe the shippers have a high level of poor performance. They indicated that this wait time seems to be worse for produce than it is for other goods they haul. For a fully loaded truck the average wait to load time is 6.85 hours, average load time is 3.46 hours, average wait to unload time is 3.03 hours, and the average time to unload is 2.88 hours for a combined total of 16.22 hours or two 8 hour days.

The logistical inefficiency issue combined with the congestion issue lead to a major concern of both specialty crop shippers and truckers, which is a future shortage of truck drivers. Nearly eighty-one percent of specialty crop shippers indicated that shortage of drivers was a serious or problematic concern over the next five to ten years. Since truck drivers are paid for miles driven, the impact of the hours spent loading and unloading a truck combined with highway congestion issues reduces the effective wage a truck driver can earn. Those issues also lead to fatigue and time spent away from home.

The two issues of highway congestion and wait times also lead to a concern about future truck supply. Both congestion and wait time reduce the return on investment by trucking firms creating an environment of increased risk and uncertainty on the part of truck firms relative to their investments and to California specialty crop producers and shipper domestic market competitiveness.

Competitiveness was earlier defined as a measure of the ability of one state's producers to supply their products to a given market of the U.S. relative to the ability of other producing states to supply those same markets. A major competitive advantage California specialty crop producers have is their production capacity and productivity. That advantage requires that the current transportation system does not deteriorate further or a more efficient transportation system can be obtained. If specialty crop products cannot be delivered to domestic markets in a timely manner to meet marketing and market demand consideration then those markets will turn to alternative sources if there are available supplies or additional production is possible in other states.

The California specialty crop industry cannot directly affect the congestion issue except through lobbying efforts. However, there are logistical efficiency issues that should be addressed by the industry. Specialty crop shippers should consider working with trucking and logistic firms to form coordinated supply chain transport programs. These programs, through logistical planning and operations, and using information technology systems and databases to assist with the timing and movement of trucks through the highly congested areas of California, could reduce driver wait times. These programs will increase the effective wage of truck drivers and should improve the return on investment for trucking firms thus eliminating some of the uncertainty with regard to those issues over time.

The last competitiveness issue brought forward by the survey results was the California environmental issue. Ninety-seven percent of the specialty crop shippers that filled out the survey indicated that California Air Resource Board (CARB) regulation were a serious problem to shipping produce over the next five to ten years. Asked how changes in various factors could affect the charge for transportation service the shippers indicated that the new CARB air quality and fuel policies would increase charges for transportation services by approximately 30%.

There has been much heated debate about the impacts of the California regulatory environment on California agriculture and affiliated industries. The authors of this paper and others have participated in several studies looking at the impact of the California regulatory environment on California agriculture in general and for specific specialty crops.[33]

The California regulatory environment is seen by California agriculture and its affiliate industries as complex, duplicative, and unresponsive to industry concerns. The preferred approach of the regulatory policy making bodies is to set standards to achieve some specific and general environmental goal and normally have some time horizon for compliance. This contrasts with a market-based approach to addressing environmental concerns. There is considerable debate concerning which is the preferred approach.

An example of a market-based approach is the environmental analysis concerning greenhouse gas emissions. An analysis conducted in this study concluded that an estimated total of approximately 101,174 metric tons of CO2 equivalent greenhouse gas is emitted to ship celery from California to the major metropolitan areas that were a part of this study. Looking at the

[33] Examples of studies done include:
Sean Hurley ***A Synopsis of the Regulatory Environment Affecting California Specialty Crops*** January 2005 California Institute for the Study of Specialty Crops http://digitalcommons.calpoly.edu/agb_fac/58/
Sean Hurley, et al. ***Analysis of the Regulatory Effects on California Specialty Crops: An Examination of Various Issues Impacting Selected Forest Products, Tree Fruit, Nut, and Vegetable Crop Industries*** January 2006 California Institute for the Study of Specialty Crops http://digitalcommons.calpoly.edu/agb_fac/47/
Jay E. Noel, Mechel Paggi, and Fumiko Yamazaki ***The Impact of California Regulatory Compliance Costs on California Orange Producer Profitability*** 2008 Center for Agricultural Business, California State University Fresno http://cab.cati.csufresno.edu/

Boston market, one of the farthest domestic markets in the continental U.S. from California, and incorporating a market price for carbon, it was found that the per-pound cost for celery would increase by around $0.01 to account for a carbon tax offset.

It is not clear to the authors of this study what, if anything, can be done about California's regulatory environment. Many California agricultural industries have individually and combined to lobby and inform California lawmakers about the cost and uncertainties created by the regulatory environment. The best the authors can advise is to continue those efforts.

Appendix A

Table A.1. California Fresh Fruit Shipments by Month: 2010

Commodity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
TRUCK:													
Apples	20							190	323	268	80	54	935
Apricots					66	78	39	11	2				196
Avocados	52	93	229	429	736	692	905	774	631	563	251	36	5391
Cherries, Sweet					641	598							1239
Grapes	70				139	804	1294	2723	3271	2950	2743	1153	15147
Kiwifruit	15	4								12	24	23	78
Nectarines					114	618	806	722	566	119			2945
Peaches					143	766	1048	1004	676	311	1		3949
Pears							257	460	348	183	21		1269
Plums					26	354	715	751	590	269	19		2724
Raspberries	27	26	23	27	99	168	115	129	141	112	61	29	957
Strawberries	190	350	1268	1982	2380	2301	1803	1477	1267	773	367	147	14305
PIGGYBACK:													
Apples								4	5	8	11	1	29
Apricots					1								1
Grapefruit						9	6	6	8				29
Grapes							8	18	57	20	14	5	122
Kiwifruit													
Lemons	7	10	18	30	39	49	51	44	25	19	23	29	344
Nectarines					1	7	7	10	5				30
Oranges	148	166	224	174	115	86	65	57	51	41	83	91	1301
Peaches					3	10	17	17	11	3			61
Pears								1	4				5
Plums						4	6	5	4	2			21
RAIL													
Apples								18	41	12	3		74
Apricots						1							1
Avocados						2	10	4	4				20
Grapefruit					2	3	3	11	8				27
Grapes						16	10	43	164	122	54	25	434
Lemons		2	11	8	3	2	8	2		2	9	5	52
Oranges	303	347	419	366	286	259	101	63	69	70	105	247	2635
Peaches					1					3			4
Plums									1	4			5
Tangerines, Mandarins, Tangelos & Tangors	1												1

Source: Fresh Fruit and Vegetable Shipments by Commodities, States, and Months, Agricultural Marketing Service, Fruit and Vegetable Programs, USDA, FVAS-4 Calendar Year 2010, Issued February 2011.

Table A.2. California Fresh Fruit and Vegetable Shipments by Month: 2010

Commodity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
TRUCK:													
Artichokes	31	59	30	52	51	46	51	49	65	60	59	41	594
Asparagus		5	110	181	122	7							425
Beans				17	19					10	39		85
Broccoli	307	264	376	526	476	496	498	509	478	476	425	395	5226
Cabbage	115	98	104	91	99	105	114	135	115	95	103	94	1268
Carrots	482	470	564	537	516	613	741	788	747	796	709	690	7662
Cauliflower	167	134	249	277	284	293	269	295	288	297	206	188	2947
Celery	883	847	1039	987	1110	1130	831	882	880	1093	1711	1137	12530
Corn, Sweet				374	985	554	658	579	365	179	199	33	3926
Lettuce, Iceberg	495	442	713	1806	1939	2145	2162	2110	2122	2108	958	324	17324
Lettuce, Other	91	79	106	236	243	242	223	225	224	259	170	83	2181
Lettuce, Romaine	268	269	459	1017	1081	1090	1004	953	1057	1176	811	337	9522
Melons, Cantaloupe					514	922	1497	3021	2213	768			8935
Melons, Honeydew					28	173	558	996	825	126			2706
Melons, Watermelon					197	670	983	1123	555	111			3639
Onions	166	57	38	105	788	889	1224	1142	468	317	163	100	5457
Peppers, Bell	12	1		73	306	512	658	668	613	510	418	59	3830
Spinach	30	31	36	45	55	49	45	46	46	49	41	34	507
Tomatoes						74	994	1100	1340	1293	394	7	5202
PIGGYBACK													
Broccoli	8	9	27	46	42	42	38	32	30	29	24	5	332
Carrots	58	50	56	63	42	44	39	38	36	33	36	35	530
Cauliflower	2		2	14	12	18	16	14	15	10	9	2	114
Celery	89	76	93	119	109	99	77	70	70	62	90	95	1049
Lettuce, Iceberg	36	37	52	158	135	152	133	134	143	112	63	14	1169
Lettuce, Other				12	10	9	7	7	7	8	4		64
Lettuce, Romaine	18	15	34	95	84	88	76	70	82	67	45	13	687
Melons, Cantaloupe					7	17	39	129	90	35			317
Melons, Honeydew						7	13	42	42	8			112
Melons, Watermelon						8	26	21	21	3			79
Onions				1	78	114	157	95	45	6			496
Peppers, Bell				3	18	24	29	32	37	29	20	3	195
Tomatoes						4	31	31	33	42	17		158
RAIL													
Broccoli	17	40	34	92	48	35	18	6		16	10	3	319
Carrots	90	48	73	57	73	98	104	77	68	51	63	55	857
Cauliflower		4	20	8		3						1	36
Celery	27	38	29	32	66	63	43	24	21	30	91	76	540
Lettuce, Iceberg	7		4	3	3	21	28	3	4	4			77
Melons, Cantaloupe					6	119	94	201	122	62			604
Melons, Honeydew					2	29	17	38	44	9			139
Onions	2			5	34	68	101	49	12	2		2	275
Peppers, Bell				1	3	3	7		1				15
Tomatoes						4	15	12	13	17			61
AIR													
Asparagus				1									1

Source: Fresh Fruit and Vegetable Shipments by Commodities, States, and Months, Agricultural Marketing Service, Fruit and Vegetable Programs, USDA, FVAS-4 Calendar Year 2010,

Appendix B

Figure B.1. Production Overlap for Selected Fresh Fruit and Vegetables by The Packer reported production time, Dark Blue: Heavy Production, Light Blue: Light Production

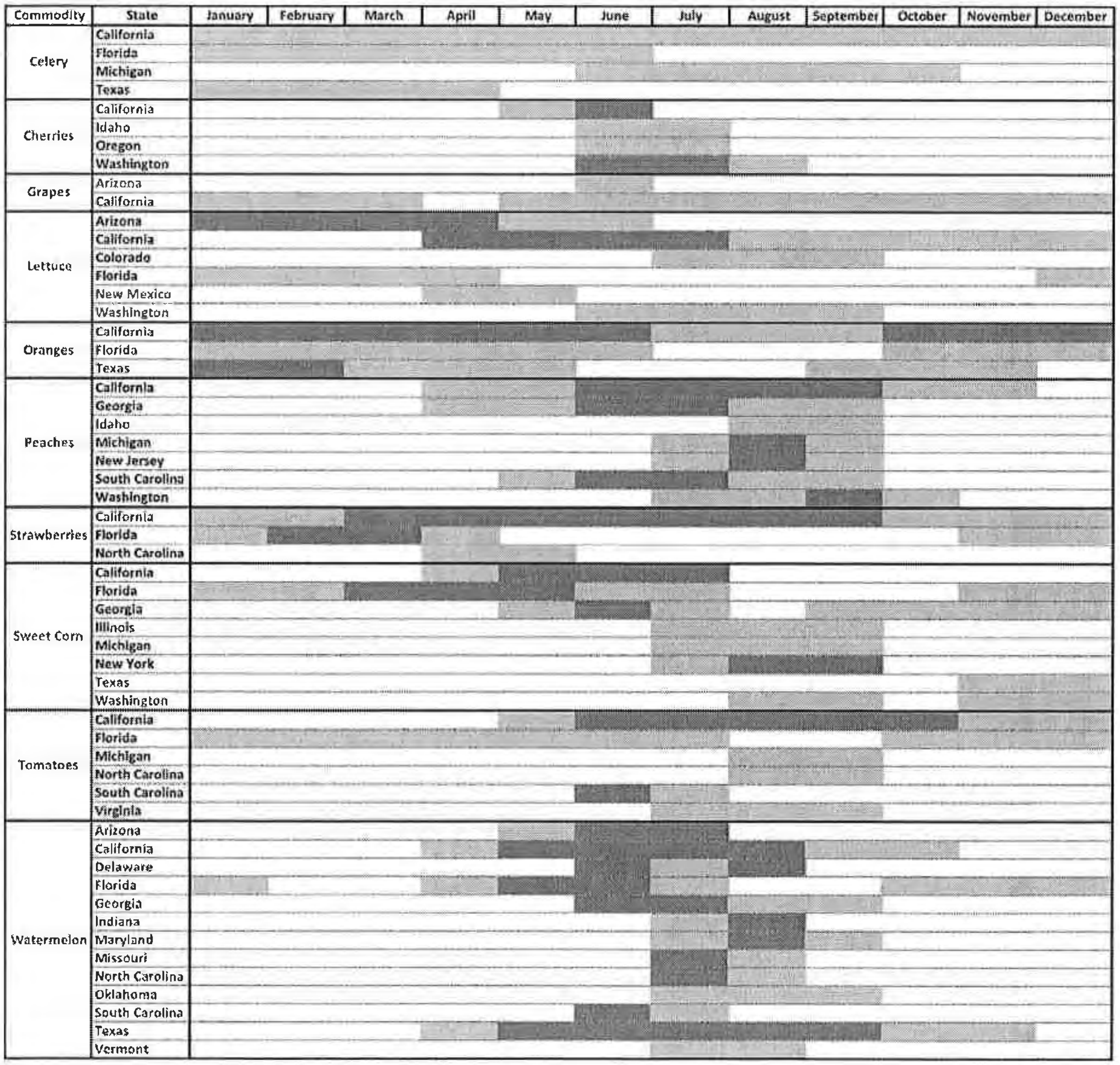


Figure B.2. Competitive Areas by Sweet Corn Producing Region on the Basis of Miles for 2010 Quarter 2

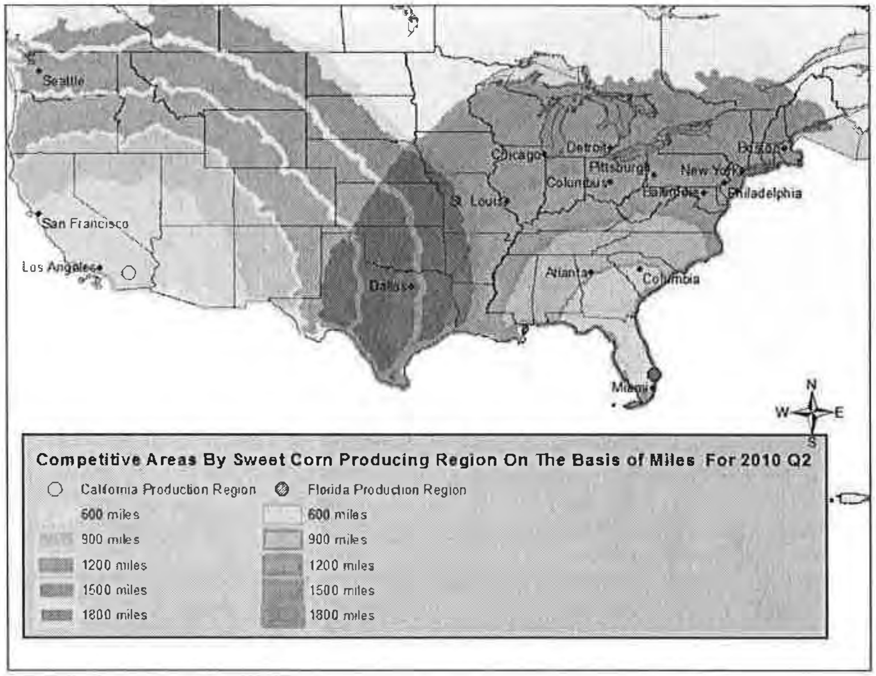


Figure B.3. Competitive Areas by Sweet Corn Producing Region on the Basis of Miles for 2010 Quarter 3

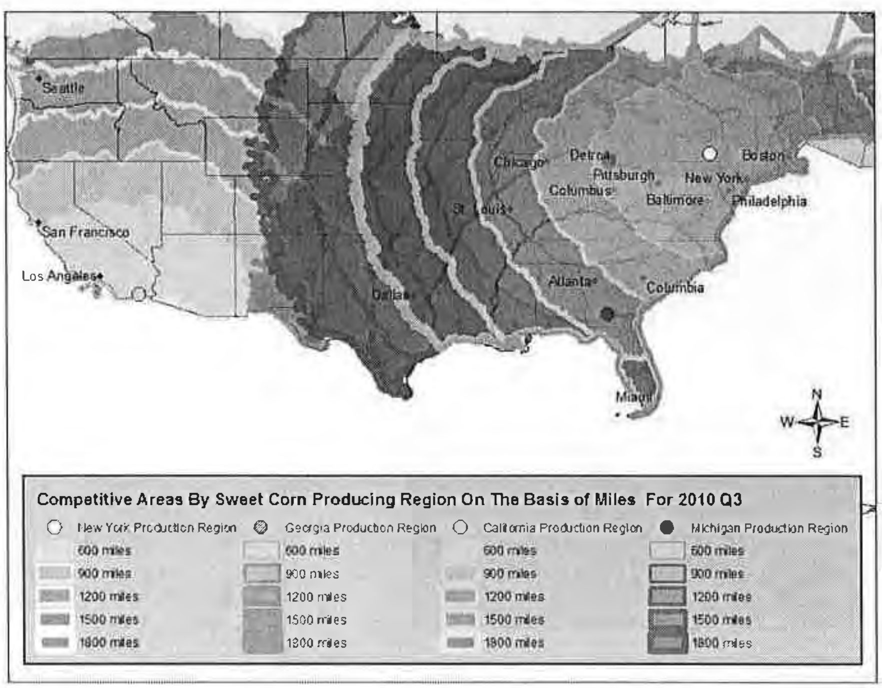


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Figure B.4. Competitive Areas by Sweet Corn Producing Region on the Basis of Miles for 2010 Quarter 4

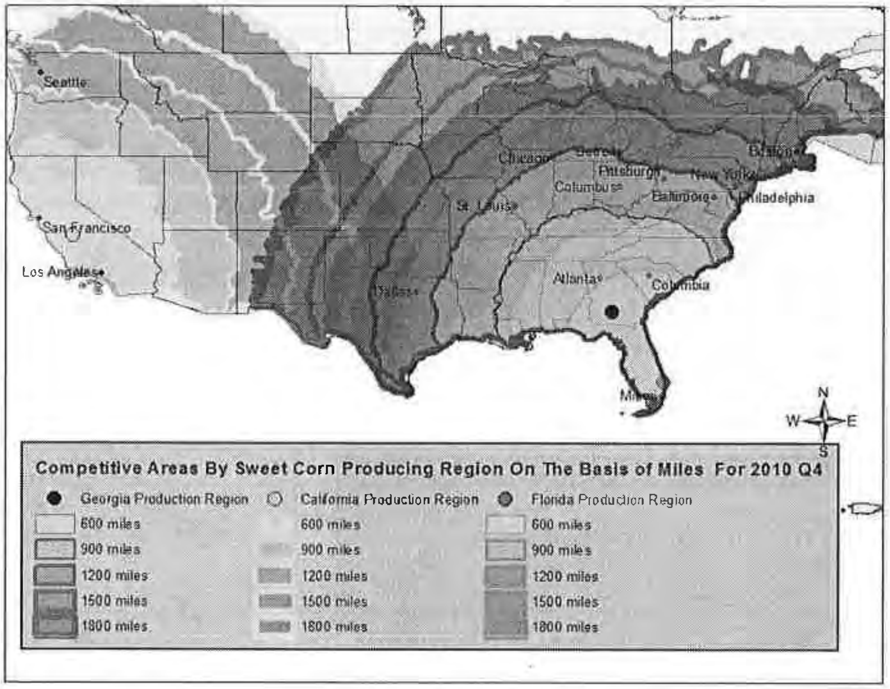

Figure B.5. Sweet Corn Transportation Cost per Box by Production Region for 2010 Quarter 2

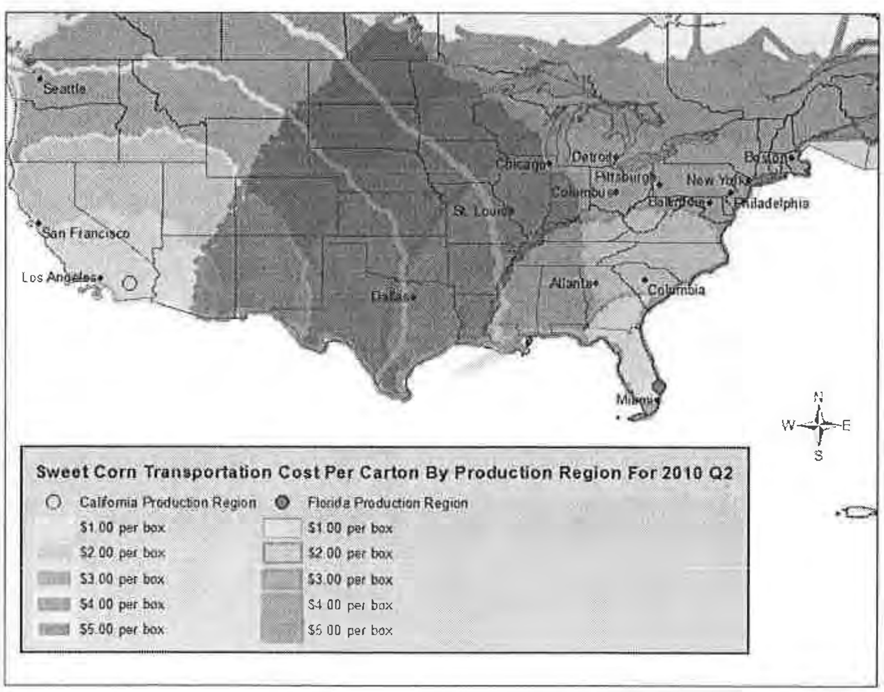

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Figure B.6. Sweet Corn Transportation Cost per Box by Production Region for 2010 Quarter 3

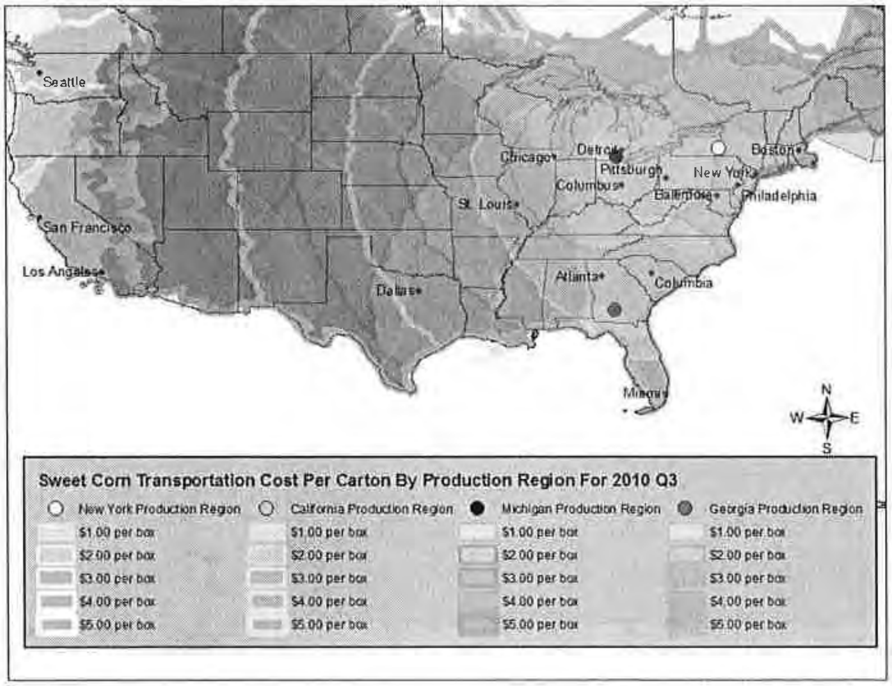

Figure B.7. Sweet Corn Transportation Cost per Box by Production Region for 2010 Quarter 4

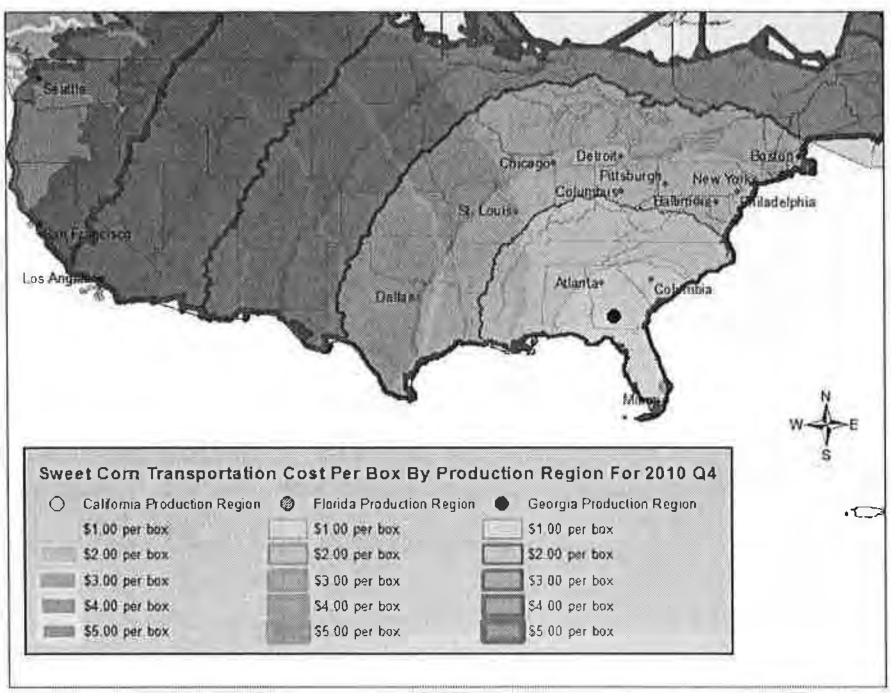

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Figure B.8. Sweet Corn Delivered Cost per Box by Production Region for 2010 Quarter 2

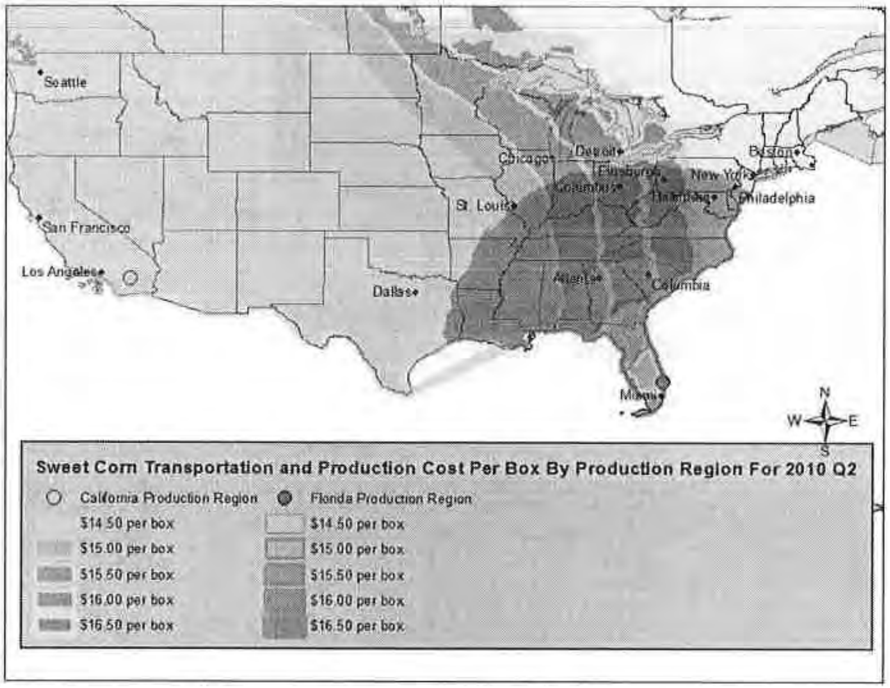

Figure B.9. Sweet Corn Delivered Cost per Box by Production Region for 2010 Quarter 3

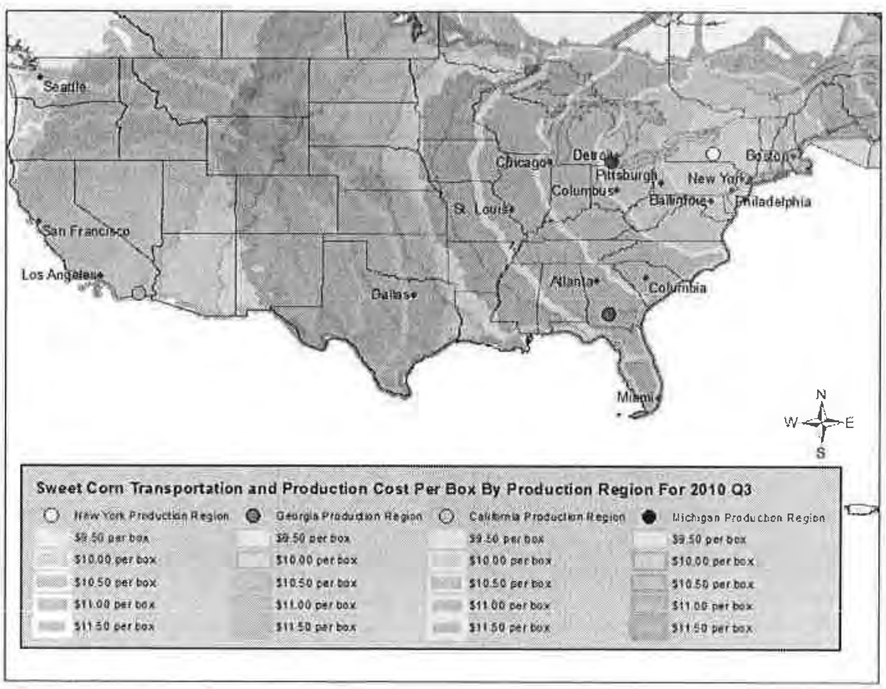

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Figure B.10. Sweet Corn Delivered Cost per Box by Production Region for 2010 Quarter 4

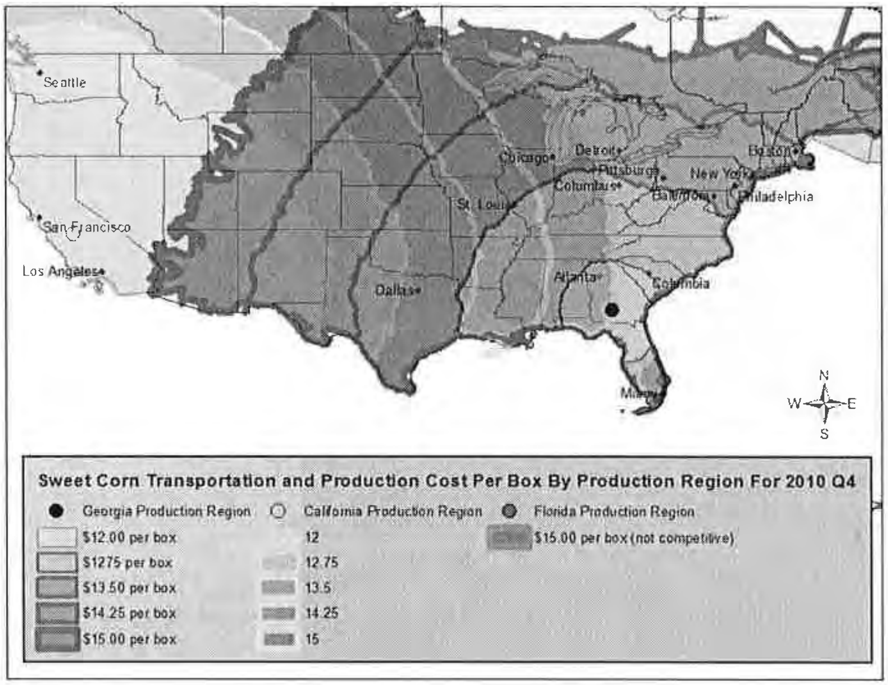

Figure B.11. Competitive Areas by Fresh Tomatoes Producing Region on the Basis of Miles for 2010 Quarter 3

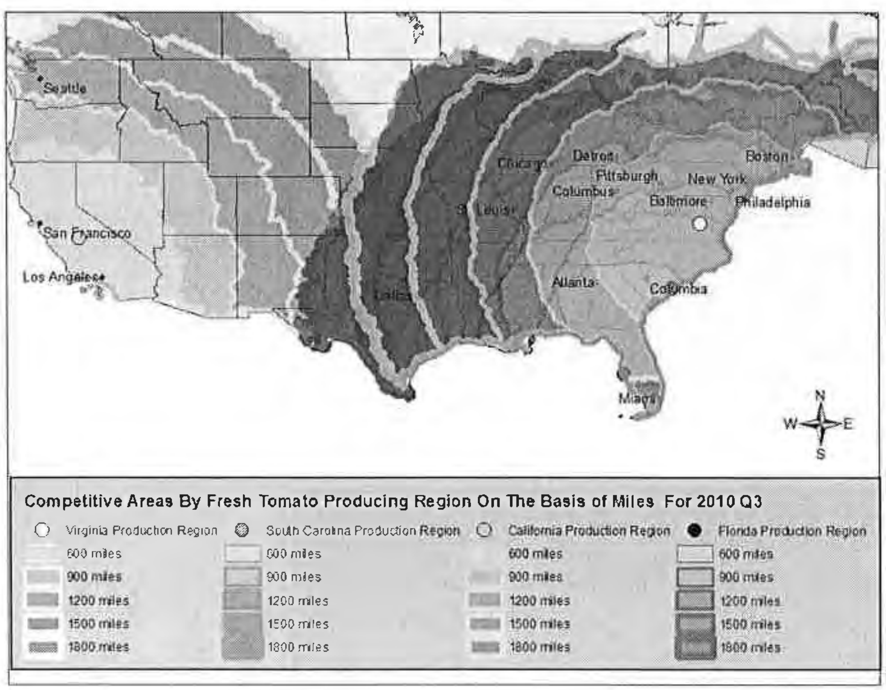

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Figure B.12. Competitive Areas by Fresh Tomatoes Producing Region on the Basis of Miles for 2010 Quarter 4

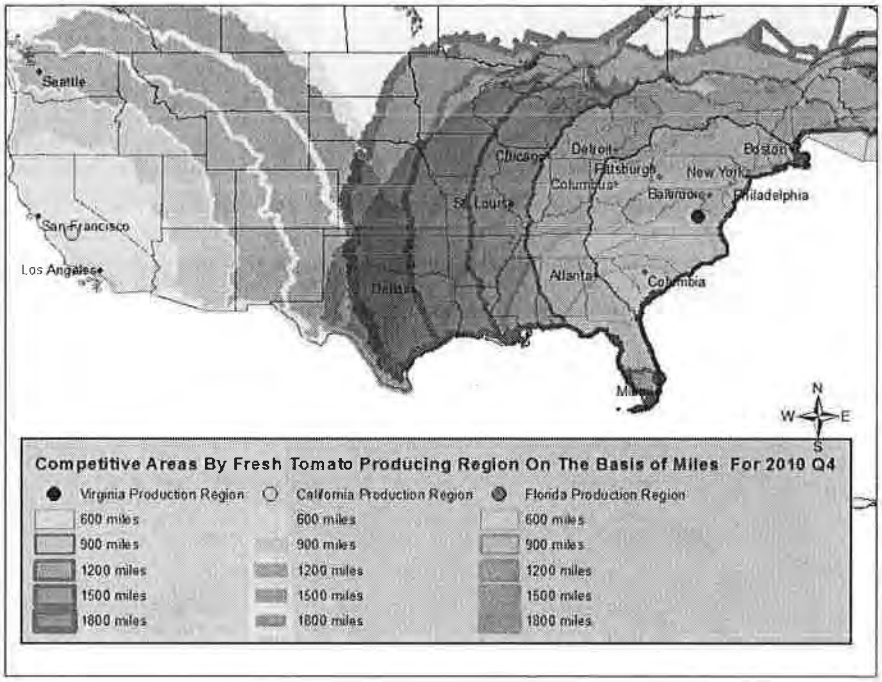

Figure B.13. Fresh Tomatoes Transportation Cost per Box by Production Region for 2010 Quarter 3

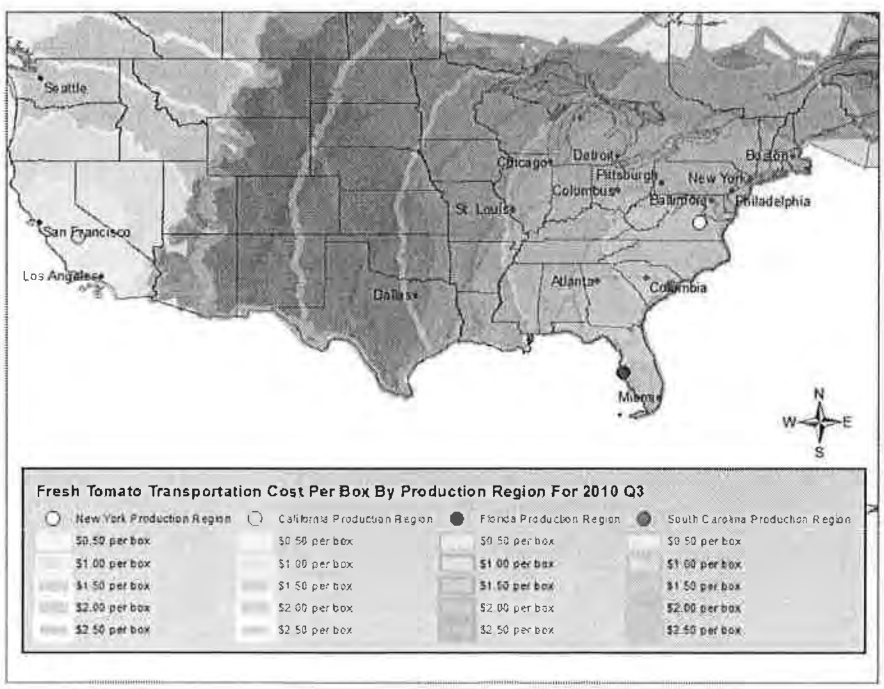

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Figure B.14. Fresh Tomatoes Transportation Cost per Box by Production Region for 2010 Quarter 4

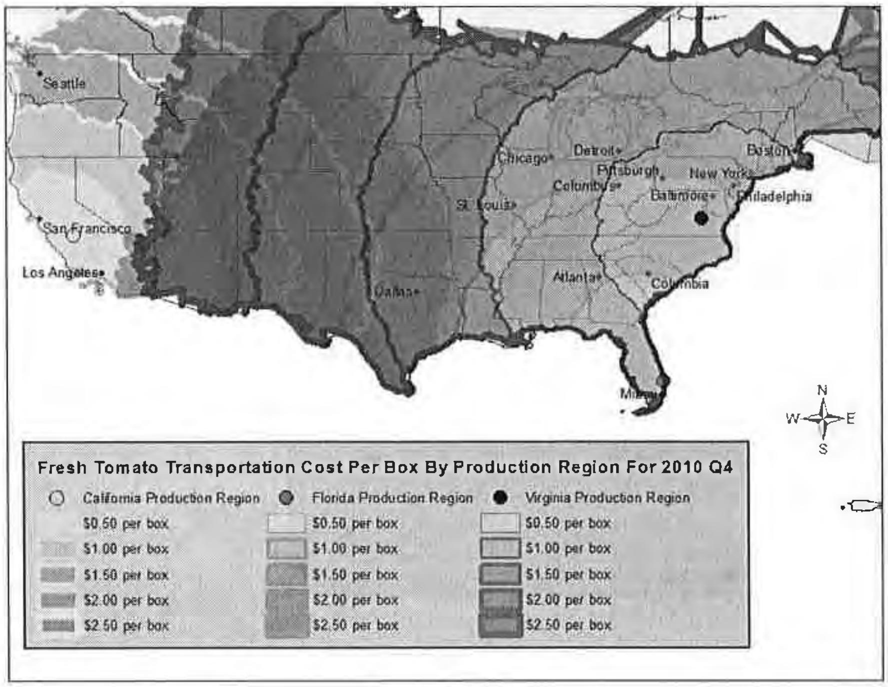

Figure B.15. Fresh Tomatoes Delivered Cost per Box by Production Region for 2010 Quarter 3

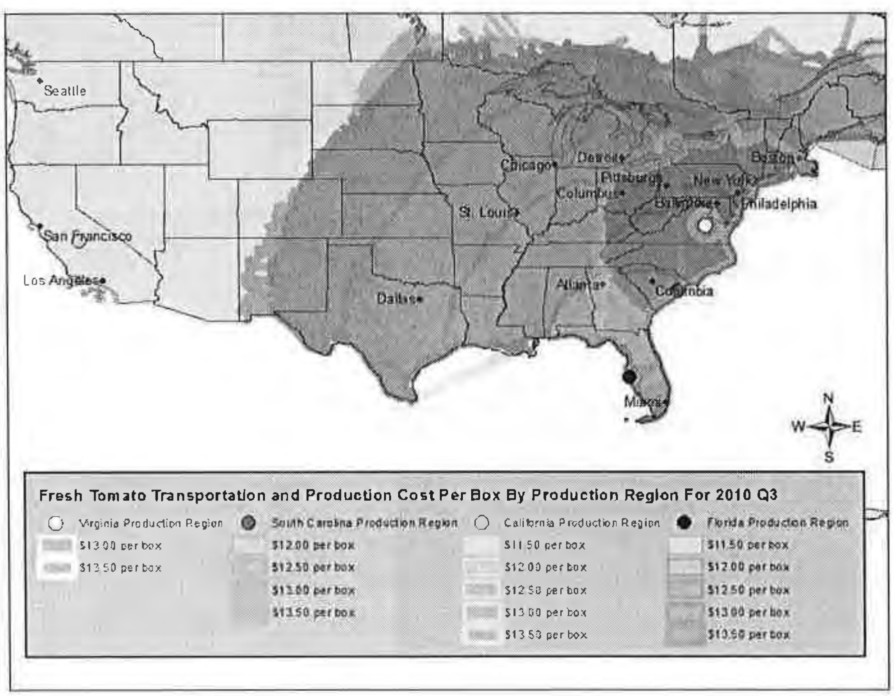

Figure B.16. Fresh Tomatoes Delivered Cost per Box by Production Region for 2010 Quarter 4

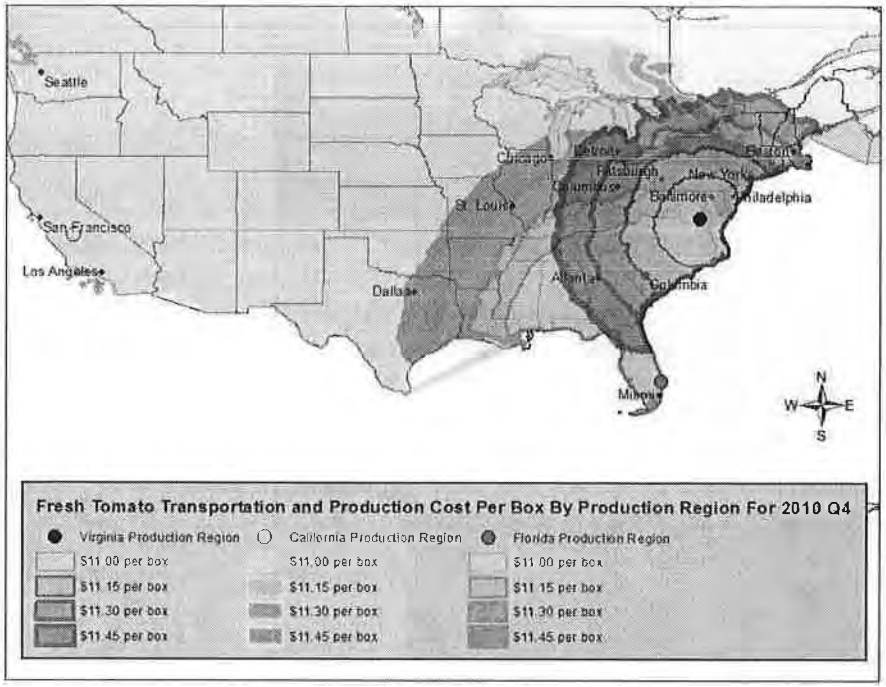

Figure B.17. Competitive Areas by Watermelon Producing Region on the Basis of Miles for 2010 Quarter 2

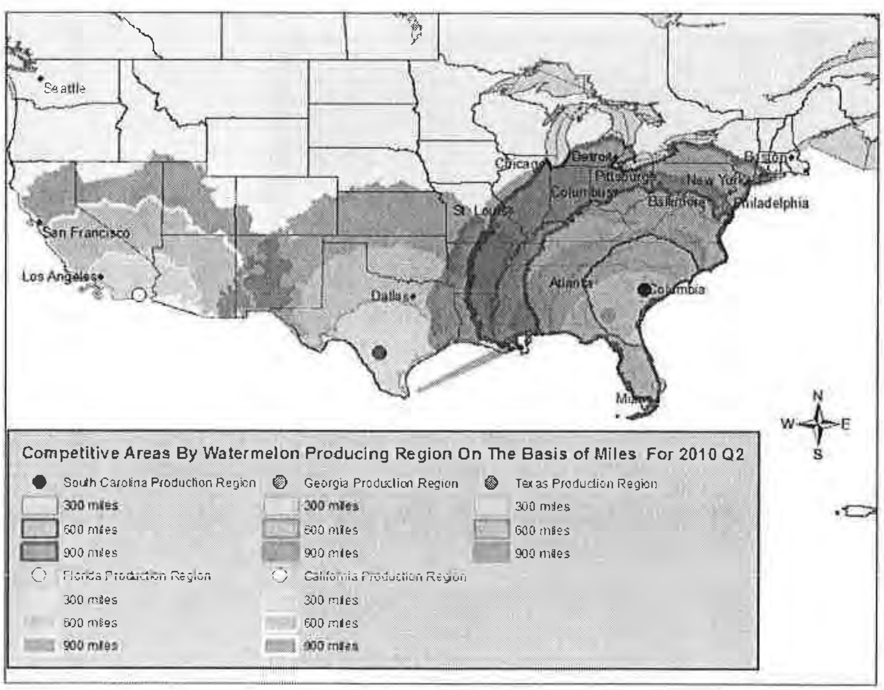

Figure B.18. Competitive Areas by Watermelon Producing Region on the Basis of Miles for 2010 Quarter 4

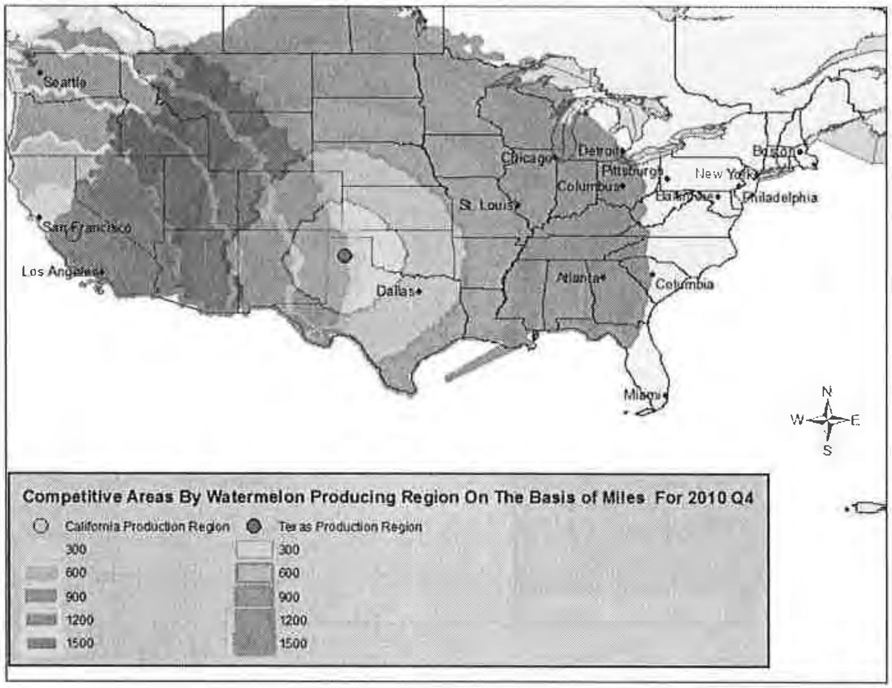

Figure B.19. Watermelon Transportation Cost per Box by Production Region for 2010 Quarter 2

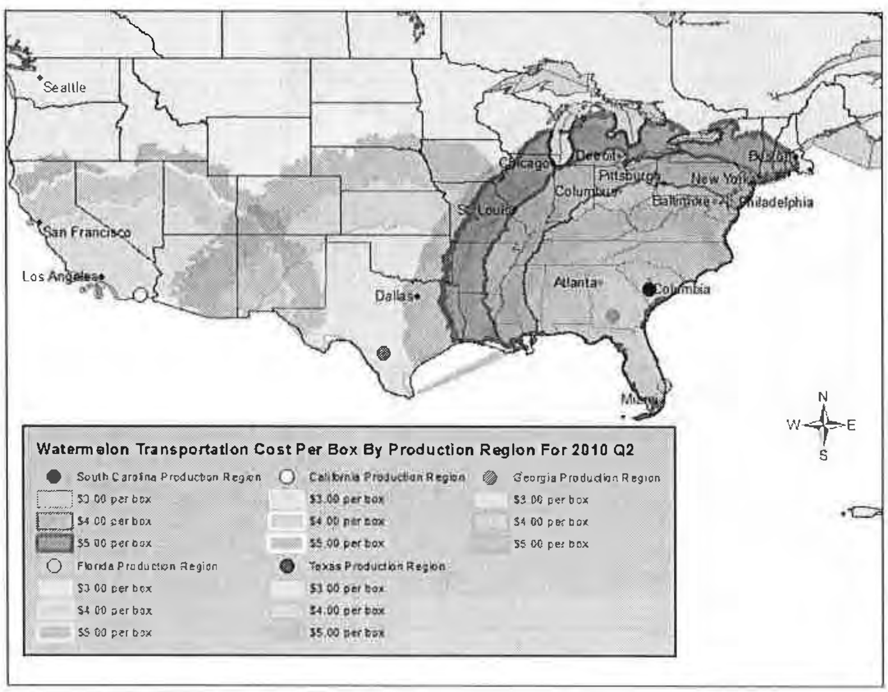

Figure B.20. Watermelon Transportation Cost per Box by Production Region for 2010 Quarter 4

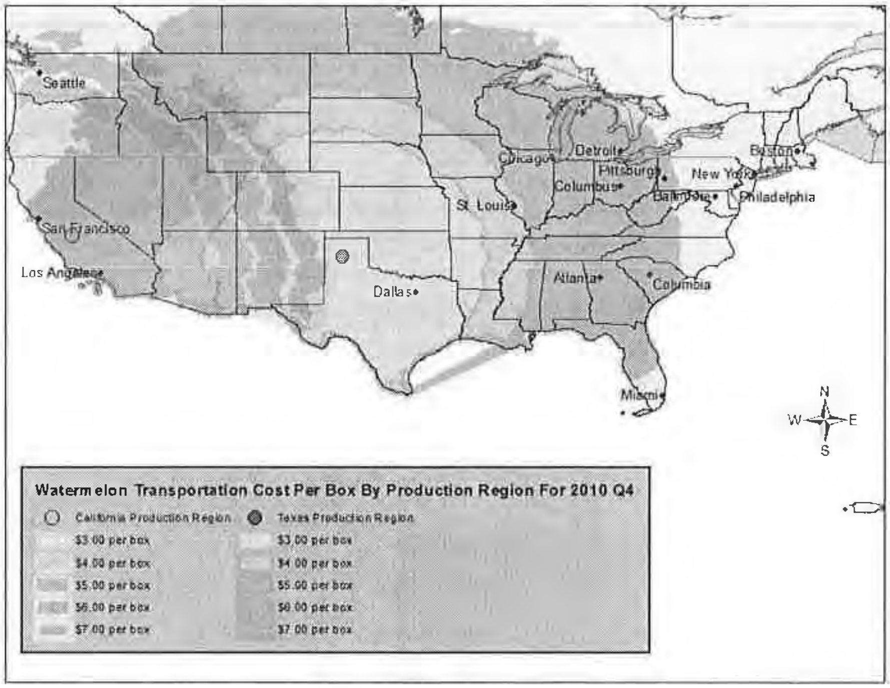

Figure B.21. Watermelon Delivered Cost per Box by Production Region for 2010 Quarter 2

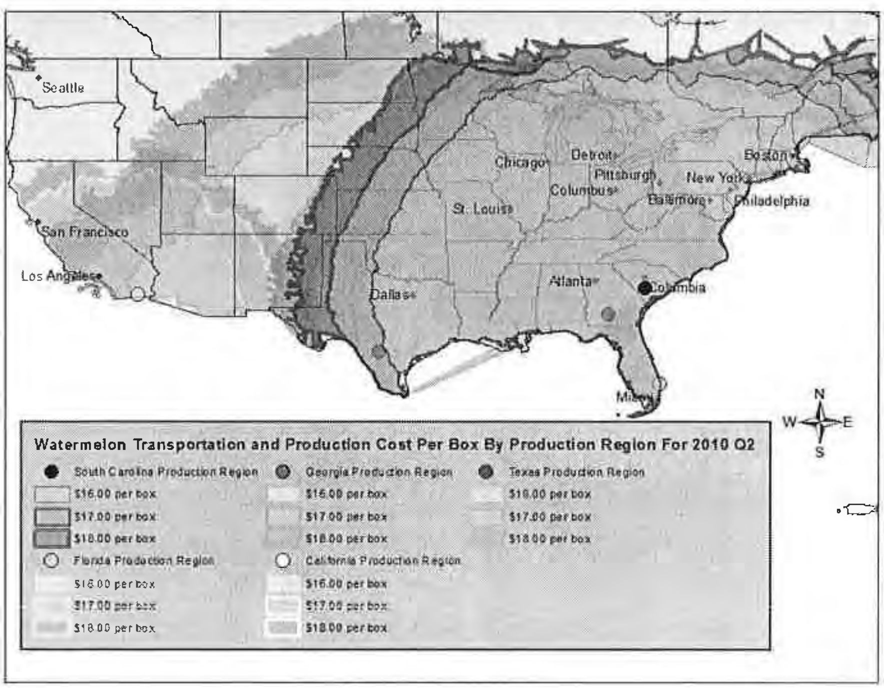

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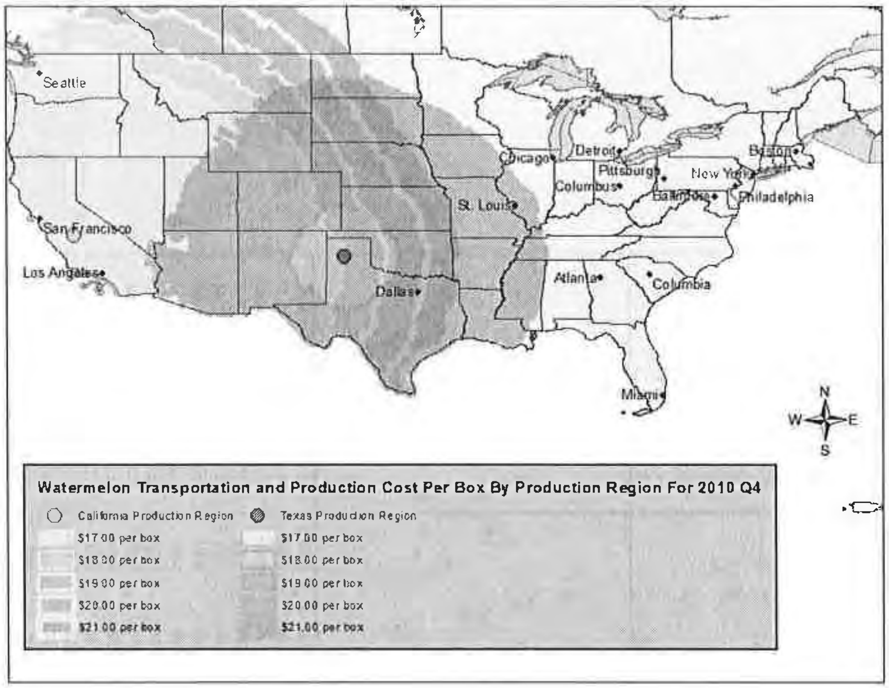
Figure B.22. Watermelon Delivered Cost per Box by Production Region for 2010 Quarter 4



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Appendix C

Table C.1. Shipping Point Price, Transportation Cost, and Delivered Cost Differentials between California and other Producing States for Celery

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Celery	Arizona	Seattle	0.19	-0.58	-0.39							-0.10	-0.71	-0.81
		San Francisco	0.19	-0.66	-0.47							-0.10	-0.81	-0.91
		Los Angeles	0.19	-0.46	-0.27							-0.10	-0.57	-0.67
		Dallas	0.19	0.73	0.92							-0.10	0.89	0.79
		St. Louis	0.19	0.60	0.79							-0.10	0.74	0.64
		Chicago	0.19	0.48	0.67							-0.10	0.59	0.49
		Detroit	0.19	0.52	0.71							-0.10	0.64	0.53
		Pittsburg	0.19	0.69	0.88							-0.10	0.84	0.74
		New York	0.19	0.65	0.84							-0.10	0.79	0.69
		Boston	0.19	0.64	0.82							-0.10	0.78	0.68
		Philadelphia	0.19	0.65	0.84							-0.10	0.79	0.69
		Baltimore	0.19	0.77	0.96							-0.10	0.95	0.85
		Atlanta	0.19	0.67	0.86							-0.10	0.82	0.72
		Miami	0.19	0.78	0.97							-0.10	0.96	0.86
		Columbus	0.19	0.63	0.82							-0.10	0.78	0.68
	Florida	Seattle	-2.47	-3.56	-6.03	-0.56	-5.85	-6.41						
		San Francisco	-2.47	-5.07	-7.54	-0.56	-7.59	-8.15						
		Los Angeles	-2.47	-5.05	-7.52	-0.56	-7.40	-7.96						
		Dallas	-2.47	1.12	-1.35	-0.56	0.78	0.22						
		St. Louis	-2.47	2.37	-0.10	-0.56	2.37	1.81						
		Chicago	-2.47	2.56	0.09	-0.56	2.53	1.97						
		Detroit	-2.47	3.26	0.79	-0.56	3.39	2.83						
		Pittsburg	-2.47	3.97	1.50	-0.56	4.35	3.79						
		New York	-2.47	4.64	2.17	-0.56	5.12	4.56						
		Boston	-2.47	4.80	2.33	-0.56	5.21	4.65						
		Philadelphia	-2.47	4.65	2.18	-0.56	5.17	4.61						
		Baltimore	-2.47	4.84	2.37	-0.56	5.46	4.90						
		Atlanta	-2.47	4.35	1.88	-0.56	5.05	4.49						
		Miami	-2.47	6.78	4.31	-0.56	8.26	7.70						
		Columbus	-2.47	3.50	1.03	-0.56	3.79	3.23						
	Michigan	Seattle							-3.65	-2.28	-5.93	-1.99	-2.06	-4.05
		San Francisco							-3.65	-4.89	-8.54	-1.99	-4.54	-6.53
		Los Angeles							-3.65	-5.50	-9.15	-1.99	-5.13	-7.12
		Dallas							-3.65	1.81	-1.84	-1.99	1.78	-0.21
		St. Louis							-3.65	4.85	1.20	-1.99	4.63	2.64
		Chicago							-3.65	6.22	2.57	-1.99	5.93	3.94
		Detroit							-3.65	7.09	3.44	-1.99	6.76	4.77
		Pittsburg							-3.65	6.91	3.26	-1.99	6.59	4.60
		New York							-3.65	7.16	3.51	-1.99	6.85	4.86
		Boston							-3.65	7.38	3.73	-1.99	7.07	5.08
		Philadelphia							-3.65	7.02	3.37	-1.99	6.72	4.73
		Baltimore							-3.65	7.18	3.53	-1.99	6.87	4.88
		Atlanta							-3.65	5.02	1.37	-1.99	4.82	2.83
		Miami							-3.65	5.01	1.36	-1.99	4.85	2.86
		Columbus							-3.65	6.52	2.87	-1.99	6.22	4.23

Table C.2. Shipping Point Price, Transportation Cost, and Delivered Cost Differentials between California and other Producing States for Sweet Corn

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Sweet Corn	Florida	Seattle				-3.68	-4.00	-7.68				-5.74	-2.23	-7.97
		San Francisco				-3.68	-5.13	-8.81				-5.74	-3.49	-9.23
		Los Angeles				-3.68	-4.91	-8.59				-5.74	-3.47	-9.21
		Dallas				-3.68	0.44	-3.24				-5.74	1.12	-4.63
		St. Louis				-3.68	1.58	-2.10				-5.74	2.18	-3.56
		Chicago				-3.68	1.71	-1.97				-5.74	2.40	-3.34
		Detroit				-3.68	2.29	-1.39				-5.74	2.97	-2.77
		Pittsburg				-3.68	2.89	-0.79				-5.74	3.48	-2.26
		New York				-3.68	3.44	-0.24				-5.74	4.08	-1.66
		Boston				-3.68	3.48	-0.20				-5.74	4.25	-1.50
		Philadelphia				-3.68	3.47	-0.21				-5.74	4.07	-1.67
		Baltimore				-3.68	3.56	-0.12				-5.74	4.11	-1.63
		Atlanta				-3.68	3.42	-0.26				-5.74	3.72	-2.02
		Miami				-3.68	5.39	1.71				-5.74	5.46	-0.28
		Columbus				-3.68	2.54	-1.14				-5.74	3.12	-2.63
	Michigan	Seattle							0.09	-1.83	-1.74			
		San Francisco							0.09	-3.59	-3.50			
		Los Angeles							0.09	-3.94	-3.85			
		Dallas							0.09	0.87	0.96			
		St. Louis							0.09	2.99	3.08			
		Chicago							0.09	3.93	4.02			
		Detroit							0.09	4.95	5.04			
		Pittsburg							0.09	4.82	4.91			
		New York							0.09	5.00	5.09			
		Boston							0.09	5.08	5.17			
		Philadelphia							0.09	4.91	5.00			
		Baltimore							0.09	4.90	4.99			
		Atlanta							0.09	3.43	3.52			
		Miami							0.09	3.41	3.50			
		Columbus							0.09	4.56	4.65			
	New York	Seattle							-1.10	-1.73	-2.83			
		San Francisco							-1.10	-3.48	-4.58			
		Los Angeles							-1.10	-3.86	-4.96			
		Dallas							-1.10	0.76	-0.34			
		St. Louis							-1.10	2.69	1.59			
		Chicago							-1.10	3.51	2.41			
		Detroit							-1.10	4.52	3.42			
		Pittsburg							-1.10	4.88	3.78			
		New York							-1.10	5.53	4.43			
		Boston							-1.10	5.90	4.80			
		Philadelphia							-1.10	5.37	4.27			
		Baltimore							-1.10	5.28	4.18			
		Atlanta							-1.10	3.23	2.13			
		Miami							-1.10	3.63	2.53			
		Columbus							-1.10	4.29	3.19			
	Georgia	Seattle				4.16	-3.29	0.87	1.67	-2.09	-0.42	-2.49	-1.72	-4.21
		San Francisco				4.16	-4.40	-0.24	1.67	-3.37	-1.70	-2.49	-2.96	-5.45
		Los Angeles				4.16	-4.36	-0.20	1.67	-3.46	-1.79	-2.49	-3.07	-5.56
		Dallas				4.16	1.22	5.38	1.67	1.68	3.35	-2.49	1.68	-0.81
		St. Louis				4.16	2.30	6.46	1.67	2.76	4.43	-2.49	2.70	0.21
		Chicago				4.16	2.43	6.59	1.67	2.98	4.65	-2.49	2.92	0.43
		Detroit				4.16	2.97	7.13	1.67	3.55	5.22	-2.49	3.47	0.98
		Pittsburg				4.16	3.42	7.58	1.67	3.98	5.65	-2.49	3.86	1.37
		New York				4.16	3.84	8.00	1.67	4.50	6.17	-2.49	4.37	1.88
		Boston				4.16	3.88	8.04	1.67	4.64	6.31	-2.49	4.54	2.05
		Philadelphia				4.16	3.87	8.03	1.67	4.49	6.16	-2.49	4.36	1.87
		Baltimore				4.16	3.96	8.12	1.67	4.54	6.21	-2.49	4.40	1.91
		Atlanta				4.16	4.14	8.30	1.67	4.43	6.10	-2.49	4.24	1.75
		Miami				4.16	4.70	8.86	1.67	5.16	6.83	-2.49	4.96	2.47
		Columbus				4.16	3.14	7.30	1.67	3.66	5.33	-2.49	3.55	1.06

Table C.3. Shipping Point Price, Transportation Cost, and Delivered Cost Differentials between California and other Producing States for Strawberries

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Strawberries	Florida	Seattle	-0.06	-0.72	-0.77	0.27	-1.15	-0.88				-11.33	-0.68	-12.01
		San Francisco	-0.06	-1.01	-1.07	0.27	-1.49	-1.22				-11.33	-1.04	-12.37
		Los Angeles	-0.06	-0.87	-0.93	0.27	-1.28	-1.01				-11.33	-0.90	-12.23
		Dallas	-0.06	0.32	0.26	0.27	0.29	0.56				-11.33	0.47	-10.86
		St. Louis	-0.06	0.56	0.50	0.27	0.60	0.87				-11.33	0.75	-10.58
		Chicago	-0.06	0.59	0.53	0.27	0.61	0.88				-11.33	0.79	-10.54
		Detroit	-0.06	0.71	0.65	0.27	0.77	1.04				-11.33	0.95	-10.38
		Pittsburg	-0.06	0.85	0.79	0.27	0.95	1.22				-11.33	1.10	-10.23
		New York	-0.06	0.97	0.91	0.27	1.09	1.36				-11.33	1.26	-10.07
		Boston	-0.06	0.77	0.71	0.27	0.82	1.09				-11.33	1.03	-10.31
		Philadelphia	-0.06	0.98	0.92	0.27	1.10	1.37				-11.33	1.26	-10.07
		Baltimore	-0.06	0.99	0.93	0.27	1.13	1.40				-11.33	1.27	-10.06
		Atlanta	-0.06	0.94	0.88	0.27	1.11	1.38				-11.33	1.18	-10.15
		Miami	-0.06	1.23	1.17	0.27	1.48	1.75				-11.33	1.52	-9.81
		Columbus	-0.06	0.70	0.64	0.27	0.77	1.04				-11.33	0.92	-10.41
	North Carolina	Seattle				-2.96	-1.02	-3.98						
		San Francisco				-2.96	-1.45	-4.41						
		Los Angeles				-2.96	-1.29	-4.25						
		Dallas				-2.96	0.29	-2.67						
		St. Louis				-2.96	0.70	-2.27						
		Chicago				-2.96	0.81	-2.15						
		Detroit				-2.96	1.02	-1.94						
		Pittsburg				-2.96	1.22	-1.74						
		New York				-2.96	1.39	-1.57						
		Boston				-2.96	1.13	-1.84						
		Philadelphia				-2.96	1.41	-1.56						
		Baltimore				-2.96	1.43	-1.53						
		Atlanta				-2.96	1.16	-1.80						
		Miami				-2.96	1.20	-1.76						
		Columbus				-2.96	1.05	-1.91						

Table C.4. Shipping Point Price, Transportation Cost, and Delivered Cost Differentials between California and other Producing States for Fresh Tomatoes

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Tomatoes	Florida	Seattle							-3.01	-1.94	-4.95	-3.24	-1.66	-4.90
		San Francisco							-3.01	-2.68	-5.69	-3.24	-2.38	-5.62
		Los Angeles							-3.01	-2.12	-5.13	-3.24	-1.87	-5.11
		Dallas							-3.01	1.05	-1.96	-3.24	1.07	-2.18
		St. Louis							-3.01	1.60	-1.41	-3.24	1.59	-1.65
		Chicago							-3.01	1.62	-1.39	-3.24	1.62	-1.63
		Detroit							-3.01	1.97	-1.04	-3.24	1.95	-1.29
		Pittsburg							-3.01	2.34	-0.67	-3.24	2.29	-0.95
		New York							-3.01	2.69	-0.33	-3.24	2.62	-0.62
		Boston							-3.01	2.77	-0.24	-3.24	2.71	-0.53
		Philadelphia							-3.01	2.71	-0.30	-3.24	2.64	-0.60
		Baltimore							-3.01	2.73	-0.28	-3.24	2.66	-0.58
		Atlanta							-3.01	2.65	-0.36	-3.24	2.55	-0.69
		Miami							-3.01	3.67	0.66	-3.24	3.51	0.27
		Columbus							-3.01	2.11	-0.90	-3.24	2.07	-1.17
	South Carolina	Seattle							-3.09	-1.75	-4.84			
		San Francisco							-3.09	-2.39	-5.48			
		Los Angeles							-3.09	-1.91	-5.00			
		Dallas							-3.09	1.28	-1.82			
		St. Louis							-3.09	1.92	-1.17			
		Chicago							-3.09	2.04	-1.05			
		Detroit							-3.09	2.42	-0.67			
		Pittsburg							-3.09	2.81	-0.29			
		New York							-3.09	3.09	0.00			
		Boston							-3.09	3.17	0.08			
		Philadelphia							-3.09	3.10	0.01			
		Baltimore							-3.09	3.13	0.04			
		Atlanta							-3.09	2.82	-0.28			
		Miami							-3.09	3.32	0.23			
		Columbus							-3.09	2.49	-0.60			
	Virginia	Seattle							-4.48	-1.62	-6.10	-3.80	-1.38	-5.18
		San Francisco							-4.48	-2.63	-7.11	-3.80	-2.34	-6.14
		Los Angeles							-4.48	-2.18	-6.66	-3.80	-1.93	-5.73
		Dallas							-4.48	0.95	-3.53	-3.80	0.98	-2.82
		St. Louis							-4.48	1.81	-2.67	-3.80	1.77	-2.03
		Chicago							-4.48	2.05	-2.43	-3.80	2.00	-1.80
		Detroit							-4.48	2.57	-1.91	-3.80	2.49	-1.31
		Pittsburg							-4.48	3.07	-1.42	-3.80	2.94	-0.86
		New York							-4.48	3.51	-0.97	-3.80	3.36	-0.44
		Boston							-4.48	3.59	-0.89	-3.80	3.45	-0.36
		Philadelphia							-4.48	3.53	-0.95	-3.80	3.37	-0.43
		Baltimore							-4.48	3.55	-0.93	-3.80	3.39	-0.41
		Atlanta							-4.48	2.59	-1.89	-3.80	2.50	-1.31
		Miami							-4.48	2.95	-1.53	-3.80	2.86	-0.94
		Columbus							-4.48	2.66	-1.82	-3.80	2.56	-1.24

Table C.5. Shipping Point Price, Transportation Cost, and Delivered Cost Differentials between California and other Producing States for Watermelon

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Watermelon	Delaware	Seattle							-4.13	-5.39	-9.52			
		San Francisco							-4.13	-9.54	-13.67			
		Los Angeles							-4.13	-9.94	-14.07			
		Dallas							-4.13	1.93	-2.20			
		St. Louis							-4.13	6.11	1.98			
		Chicago							-4.13	7.17	3.04			
		Detroit							-4.13	9.01	4.88			
		Pittsburg							-4.13	11.51	7.38			
		New York							-4.13	13.91	9.78			
		Boston							-4.13	14.22	10.09			
		Philadelphia							-4.13	13.89	9.76			
		Baltimore							-4.13	13.70	9.57			
		Atlanta							-4.13	8.54	4.41			
		Miami							-4.13	10.11	5.98			
		Columbus							-4.13	9.94	5.81			
	Florida	Seattle				-2.57	-9.41	-11.98	3.43	-6.36	-2.93			
		San Francisco				-2.57	-12.06	-14.63	3.43	-9.41	-5.98			
		Los Angeles				-2.57	-11.29	-13.86	3.43	-9.02	-5.59			
		Dallas				-2.57	1.74	-0.83	3.43	3.12	6.55			
		St. Louis				-2.57	4.36	1.79	3.43	5.72	9.15			
		Chicago				-2.57	4.60	2.03	3.43	6.15	9.58			
		Detroit				-2.57	5.90	3.33	3.43	7.53	10.96			
		Pittsburg				-2.57	7.31	4.74	3.43	8.84	12.27			
		New York				-2.57	8.59	6.02	3.43	10.30	13.73			
		Boston				-2.57	8.67	6.10	3.43	10.62	14.05			
		Philadelphia				-2.57	8.67	6.10	3.43	10.29	13.72			
		Baltimore				-2.57	8.88	6.31	3.43	10.40	13.83			
		Atlanta				-2.57	8.74	6.17	3.43	9.70	13.13			
		Miami				-2.57	12.56	9.99	3.43	13.48	16.91			
		Columbus				-2.57	6.40	3.83	3.43	7.88	11.31			
	Georgia	Seattle				3.39	-8.11	-4.72	2.18	-5.30	-3.12			
		San Francisco				3.39	-10.92	-7.53	2.18	-8.47	-6.29			
		Los Angeles				3.39	-10.51	-7.12	2.18	-8.39	-6.21			
		Dallas				3.39	3.01	6.40	2.18	4.15	6.33			
		St. Louis				3.39	5.76	9.15	2.18	6.86	9.04			
		Chicago				3.39	5.99	9.38	2.18	7.28	9.46			
		Detroit				3.39	7.30	10.69	2.18	8.67	10.85			
		Pittsburg				3.39	8.60	11.99	2.18	9.89	12.07			
		New York				3.39	9.57	12.96	2.18	11.10	13.28			
		Boston				3.39	9.64	13.03	2.18	11.41	13.59			
		Philadelphia				3.39	9.66	13.05	2.18	11.09	13.27			
		Baltimore				3.39	9.88	13.27	2.18	11.21	13.39			
		Atlanta				3.39	10.17	13.56	2.18	10.86	13.04			
		Miami				3.39	11.21	14.60	2.18	12.38	14.56			
		Columbus				3.39	7.81	11.20	2.18	9.02	11.20			

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Watermelon	Indiana	Seattle							-2.19	-4.52	-6.71			
		San Francisco							-2.19	-8.19	-10.38			
		Los Angeles							1.81	-8.21	-6.40			
		Dallas							-2.19	4.02	1.83			
		St. Louis							-2.19	8.93	6.74			
		Chicago							-2.19	9.54	7.35			
		Detroit							-2.19	10.19	8.00			
		Pittsburg							-2.19	10.62	8.43			
		New York							-2.19	10.92	8.73			
		Boston							-2.19	10.88	8.69			
		Philadelphia							-2.19	10.86	8.67			
		Baltimore							-2.19	10.83	8.64			
		Atlanta							-2.19	9.46	7.27			
		Miami							-2.19	9.47	7.28			
		Columbus							-2.19	10.47	8.28			
	Mississippi	Seattle							-0.95	-4.61	-5.56			
		San Francisco							-0.95	-8.06	-9.01			
		Los Angeles							-0.95	-8.10	-9.05			
		Dallas							-0.95	2.82	1.87			
		St. Louis							-0.95	5.29	4.34			
		Chicago							-0.95	5.96	5.01			
		Detroit							-0.95	7.11	6.16			
		Pittsburg							-0.95	8.16	7.21			
		New York							-0.95	9.20	8.25			
		Boston							-0.95	9.40	8.45			
		Philadelphia							-0.95	9.18	8.23			
		Baltimore							-0.95	9.27	8.32			
		Atlanta							-0.95	7.57	6.62			
		Miami							-0.95	8.55	7.60			
		Columbus							-0.95	7.42	6.47			
	North Carolina	Seattle							-3.43	-5.53	-8.96			
		San Francisco							-3.43	-9.29	-12.72			
		Los Angeles							-3.43	-9.20	-12.63			
		Dallas							-3.43	3.03	-0.40			
		St. Louis							-3.43	6.40	2.97			
		Chicago							-3.43	7.48	4.05			
		Detroit							-3.43	9.25	5.82			
		Pittsburg							-3.43	10.78	7.35			
		New York							-3.43	12.43	9.00			
		Boston							-3.43	12.74	9.31			
		Philadelphia							-3.43	12.42	8.99			
		Baltimore							-3.43	12.53	9.10			
		Atlanta							-3.43	10.06	6.63			
		Miami							-3.43	11.42	7.99			
		Columbus							-3.43	9.81	6.38			

Commodity	Origin	Destination	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
			Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered	Ship. Point	Transport	Delivered
Watermelon	South Carolina	Seattle				3.75	-8.51	-4.76	0.37	-5.63	-5.26			
		San Francisco				3.75	-11.28	-7.53	0.37	-8.77	-8.40			
		Los Angeles				3.75	-10.37	-7.12	0.37	-8.68	-8.31			
		Dallas				3.75	2.32	6.07	0.37	3.58	3.95			
		St. Louis				3.75	5.36	9.11	0.37	6.53	6.90			
		Chicago				3.75	6.11	9.86	0.37	7.38	7.75			
		Detroit				3.75	7.72	11.47	0.37	9.01	9.38			
		Pittsburg				3.75	9.27	13.02	0.37	10.43	10.80			
		New York				3.75	10.40	14.15	0.37	11.77	12.14			
		Boston				3.75	10.46	14.21	0.37	12.08	12.45			
		Philadelphia				3.75	10.48	14.23	0.37	11.76	12.13			
		Baltimore				3.75	10.70	14.45	0.37	11.88	12.25			
		Atlanta				3.75	9.81	13.56	0.37	10.56	10.93			
		Miami				3.75	10.89	14.64	0.37	12.12	12.49			
		Columbus				3.75	8.44	12.19	0.37	9.54	9.91			
	Texas	Seattle				3.12	-5.96	-2.84	0.97	-3.56	-2.59	-6.02	-2.84	-8.86
		San Francisco				3.12	-7.72	-4.60	0.97	-5.88	-4.91	-6.02	-5.15	-11.17
		Los Angeles				3.12	-6.93	-3.81	0.97	-5.48	-4.51	-6.02	-4.85	-10.87
		Dallas				3.12	4.80	7.92	0.97	5.60	6.57	-6.02	5.44	-0.58
		St. Louis				3.12	3.78	6.90	0.97	5.25	6.22	-6.02	5.26	-0.76
		Chicago				3.12	3.37	6.49	0.97	5.15	6.12	-6.02	5.23	-0.79
		Detroit				3.12	3.45	6.57	0.97	5.53	6.50	-6.02	5.65	-0.37
		Pittsburg				3.12	4.17	7.29	0.97	6.29	7.26	-6.02	6.37	0.35
		New York				3.12	4.59	7.71	0.97	7.05	8.02	-6.02	7.16	1.14
		Boston				3.12	4.65	7.77	0.97	7.36	8.33	-6.02	7.51	1.49
		Philadelphia				3.12	4.65	7.77	0.97	7.03	8.00	-6.02	7.12	1.10
		Baltimore				3.12	4.87	7.99	0.97	7.14	8.11	-6.02	7.21	1.19
		Atlanta				3.12	5.53	8.65	0.97	7.09	8.06	-6.02	7.00	0.98
		Miami				3.12	6.48	9.60	0.97	8.54	9.51	-6.02	8.48	2.46
		Columbus				3.12	4.11	7.23	0.97	6.02	6.99	-6.02	6.07	0.05
	Virginia	Seattle							-4.13	-5.32	-9.45			
		San Francisco							-4.13	-9.49	-13.62			
		Los Angeles							-4.13	-9.53	-13.66			
		Dallas							-4.13	2.53	-1.60			
		St. Louis							-4.13	6.38	2.25			
		Chicago							-4.13	7.69	3.56			
		Detroit							-4.13	9.77	5.64			
		Pittsburg							-4.13	11.59	7.46			
		New York							-4.13	13.44	9.31			
		Boston							-4.13	13.75	9.62			
		Philadelphia							-4.13	13.43	9.30			
		Baltimore							-4.13	13.54	9.41			
		Atlanta							-4.13	9.32	5.19			
		Miami							-4.13	10.70	6.57			
		Columbus							-4.13	9.95	5.82			

Project 23

Attachment

A

California Centers for International Trade Development
at State Center Community College District

CalAgX – California Agricultural Export Training Program

What Is CalAgX | CalAgX Benefits | Is CalAgX For You | Fees And Deadlines | Location

The California Agricultural Export Training Program (CalAgX) benefits the producers, processors and marketers of California grown or processed specialty crops. The program consists of 6 separate training sessions held at two-week intervals with each session lasting 4 hours. Each of the 6 sessions has been designed to meet the learning needs of new-to-export or non-exporting food and agriculture companies.

Apply Today!

More About The Program

- Participant Qualifications
- Curriculum Overview
- Session Descriptions
- Funding & Partners

Participant Eligibility

- Agriculture products are California grown
- Products are considered "Specialty Crops" as defined by the USDA
- Company must be based in California
- Company has less than two years of active exporting experience
- The company is a viable California business with an established domestic market and a registered Employer Identification Number (EIN)

CalAgX Lessons

- Session 01 – Introduction to Food & Agriculture Exporting
- Session 02 – International Marketing
- Session 03 – Logistics & Documentation
- Section 04 – Negotiation & Cultural Aspects
- Section 05 – Financing Exports & Getting Paid
- Section 06 – Foreign Regulations & Legal Aspects
- Class Materials & Resources

Archives

- August 2012 (6)
- June 2012 (1)
- March 2012 (1)

Contact

Center for International Trade Development
State Center Community College District
390 W. Fir Ave. Ste. 303
Clovis, CA 93611

Bus – (559) 324-6401

International Trade Topics

A New Beginning Booth Ranches Center for International Trade Development CIBER CITD Cuba Don Barton food safety Free Trade Agreement free trade agreements Gold River Orchards grow local International

February 2012 (1)

January 2012 (3)

October 2011 (1)

May 2011 (1)

March 2011 (1)

February 2011 (6)

Toll Free – (888) 638-7888
Fax – (559) 324-6492

international trade Kenkko Loren Booth Mark Benjamin Neil Galone Northern California Parr Rosson Richard G. Chriss sell global sell globally seminars supply chains Texas A&M Trade Barriers Trade Mission world ag expo WUSATA

Attachment

B

Cor ct Information

Center for International Trade Development,
State Center Community College District
390 W. Fir Ave., Ste. 303
Clovis, CA 93611
(559) 324-6401 Bus.
(888) 638-7888 Toll Free
(559) 324-6492 Fax

Statewide Coordinator: Frank M. Nuñez
Email: frank.nunez@scccd.edu

Training Locations

Northern California:
Port of Oakland
530 Water Street
Oakland, CA 94607
(510) 627-1100
http://www.portofoakland.com

Central California:
Center for International Trade Development
390 W. Fir Ave., Ste. 303
Clovis, CA 93611
(559) 324-6401
http://www.fresnocitd.org

Southern California:
Ventura Co Office Ed (Host: Port of Los Angeles)
5100 Adolfo Rd.
Camarillo, CA 93012
http://www.portoflosangeles.org

Supported By

U.S. Department of Agriculture
California Department of Food and Agriculture
Western U.S. Agricultural Trade Association
Centers for International Trade Development
California Agricultural Export Council
California Farm Bureau Federation
California Commodity Boards
Specialty Crops Trade Council
Port of Oakland
Port of Los Angeles

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90 W. Fir Ave., Ste. 303
lovis, CA 93611

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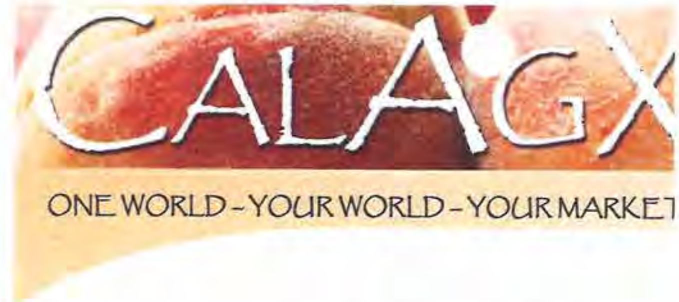

Going Global?

California Agricultural Export Training
Program May Be for You!

CalAgX 2012

"There is no time like the present to expor California agricultural Specialty Crops"

Registration Deadline:
February 24, 2012

For More Information, visit:
http://www.fresnocitd.org/calagx

The CalAgX program is funded by the 2009 Specialty Crop Block Gran program of the United States Department of Agriculture, and is presented by the Fresno Center for International Trade Development i

What can the CalAgX do for you?

- Develop the "next steps" for your company to expand your **specialty crop** sales on a global scale
- Understand the financial and promotional export assistance that is available
- Establish contacts with experienced professionals in international finance, logistics and trade
- Respond to international sales inquiries and trade leads
- Learn the details of moving your product overseas and getting paid
- Identify and resolve company barriers to exporting

Program Overview:

The CalAgX benefits the producers, processors and marketers of California grown or processed **specialty crops.** The program consists of 6 separate training sessions held at two-week intervals with each session lasting 4 hours. Each of the 6 sessions has been designed to meet the learning needs of new-to-export or non-exporting food and agriculture companies. Sessions consist of:

- **Session 1:** Introduction to Food & Agriculture Exporting
- **Session 2:** International Marketing
- **Session 3:** Negotiation & Cultural Aspects
- **Session 4:** Logistics & Documentation
- **Session 5:** Financing Exports & Getting Paid
- **Session 6:** Foreign Regulations & Legal Aspects

Class sessions will begin March 2012 and end May 2012.
Training sessions will be held in Oakland, Clovis and Camarillo, California.

Program Schedule 2012				
	Oakland	**Clovis**	**Camarillo**	**Time**
Session 1	03/06/12	03/07/12	03/08/12	9am–1pm
Session 2	03/20/12	03/21/12	03/22/12	9am–1pm
Session 3	04/03/12	04/04/12	04/05/12	9am–1pm
Session 4	04/17/12	04/18/12	04/19/12	9am–1pm
Session 5	05/01/12	05/02/12	05/03/12	9am–1pm
Session 6	05/15/12	05/16/12	05/17/12	9am–1pm

The CalAgX program is funded by the 2009 Specialty Crop Block Grant program of the United States Department of griculture, and is presented by the Fresno Center for International Trade Development in cooperation with the California

CalAgX Participant Qua[illegible]ications

Agricultural products are California grown

•

Products are "Specialty Crops" as defined by USDA

•

Company is based in California

•

Company has less than two years of active export experience

•

Viable California company with an established domestic market and an EIN

CalAgX 2012

Program Fee: $199 ($149 if Reg. before Jan 24th)
Add'l Representative: $75
Reg. Deadline: February 24, 2012

For More Information or to Apply Online, visit:
http://www.fresnocitd.org/calagx
(888) 638-7888

CalAgX Participant Quotes

"Well worth the time and money invested! I would highly recommend this class if you have any thought of export"
Dave Hamilton, Hamilton Ranches, Inc.

•

"The CalAgX program has given me the tools to be successful in International marketing"
Jeff Simonian, Simonian Fruit Company

•

"I did the original [CalAgX] training they offered in 2006, when we were doing some export business. In 2004, exports were 30% of our business. This year, we're projecting that 90% of our business will be export."
Don Barton, Gold River Orchards

•

"The CalAgX program has given me more confidence when making an export sale."
Michelle Carter, Meridian Nut Growers

CalAgX 2012

California Agricultural Export Training Program

"One World, Your World, Your Market"

Participant Application

Section I – Applicant Profile

A. Company Information

Company/Organization:
First Name:
Last Name:
Job Title:
Street Address:
City:
State:
Zip Code:
Phone: Ext:
Fax:
Mobile/Cell/Other:
Email:
Web Site:
Number of Employees:
Type of Business: Agent/Distributor
Gross Sales range: Under $100,000

B. Additional Company Participant

First Name:
Last Name:
Job Title:
Street Address:
City:
State:
Zip Code:
Phone: Ext:

Mobile/Cell/Other:

Fax:

Email:

Section II – Qualification Worksheet

A. What products do you have available to export?

B. What are your products Standard Industrial Classification (SIC) codes:

C. Do your products individually have 50 percent or more U.S. agricultural content by weight, excluding water and packaging? Yes

D. Check all that apply:

- ☐ Agricultural products are California grown.
- ☐ Products are considered "Specialty Crops" as defined by USDA.
- ☐ Company is based in California
- ☐ Company has less than two years of active export experience.
- ☐ Viable California Company with an established domestic market and an Employer Identification Number (EIN)

D. Is your company currently exporting? Yes If so, to what countries?

Section III – Preferred Training Location

The CalAgX training program aims to provide a training venue that is the most convenient to all class participants. Your selection below indicates the location preference for your company.

A. ☐ Oakland, CA – Port of Oakland
☐ Clovis, CA - Fresno CITD
☐ Camarillo, CA – Port of Los Angeles

Section IV – Criteria for Program Selection

A. Describe the product(s) your company has available for export.

B. Describe your company's domestic business experience to date.

C. Describe any export training or experience.

D. Provide an estimate of company's total export marketing budget in the coming year.

Section V – Expectations of Applicant

A. What are your expectations in participating in this training program?

Thank you for your interest in the CalAgX. You will be receiving monthly program updates via email. If you have any questions, please contact the statewide coordinator, Frank M. Nuñez, at (888) 638-7888 or frank.nunez@scccd.edu.

The CalAgX program is funded by the Specialty Crop Block Grant program of the United States Department of Agriculture, and is presented by the California Centers for International Trade Development at State Center Community College District in cooperation with the California Department of Food and Agriculture.

CalAgX 2012

Commitment Letter

(One must be received for every employee to be trained)

Name of Participant: ______________________________

Name of Company: ______________________________

As a term of my acceptance into the CalAgX program, I agree to adhere to the arranged program, to devote my time and attention to my practical training, and to conform to program regulations and procedures for the duration of my training. I will complete assigned tasks in the period required and undertake one export experience at the end of this program (e.g. host buying delegation, participate in trade mission, etc.) and participate in any follow-up or monitoring efforts.

Furthermore, I thoroughly understand the following policies of the CalAgX program:

I. <u>Conditions for Termination of Training Programs</u>:

A. Fail to show sufficient interest in or to pursue effectively the training program.
B. Conduct themselves in a manner prejudicial to the program or to the laws of the United States.
C. Have in any way falsified information on the application and/or supporting documents.

II. <u>Travel</u>:

A. The company assumes financial responsibility for travel to and from the training site.

______________________________ ______________

Participant's Signature Date

Attachment

C

International Market-Entry Plan / Customize Market Research

Authorization Statement

In the following weeks, our market development team consisting of CITD staff, consultants and international business/marketing students will be developing either an International Market-Entry Plan or Customized Market Research for CalAgX 2012 participants.

Development of International Market-Entry Plans or Customize Market Research will need to select **1 of your specialty crop products** and **1 country** you would like a plan developed for. If you choose an international market-entry plan, you will need to provide data on your company which may be seen as sensitive but will be held in the strictest of confidence. We will need your assistance in providing the following:

- A designated contact person and approximately 3 to 4 hours of their time.
- "Ballpark" figures on current sales, recent sales growth, domestic vs. export sales, and company projections on future sales (primarily where it concerns the export market)
- Provide current marketing strategy (domestic or export) – such as market positioning, pricing strategy, etc.

____________________ Product HS Code

____________________ Country

Please **one option** below to indicate your commitment level.

☐ Company wants to participate in the development of a *confidential* International Market-entry Plan.

☐ Company wants to participate in the development of Customized Market Research.

☐ Company <u>**does not**</u> want to participate in the development of a *Confidential* International Market-Entry Plan or Customized Market Research.

____________________ Date

____________________ Authorized Representative - Signature

____________________ Company Name

____________________ Authorized Representative - Print

____________________ Contact Person

Center for International Trade Development
390 W. Fir Ave., Bldg B, Ste. 303, Clovis, CA 93611
Tel: 559-324-6401 • Fax: 559-324-6492 • Toll Fee: 888-638-7888 • www.fresnocitd.org
One World... Your World... Your Market!

State Center Community College District, Center for International Trade Development

CalAgX 2012

Reece Farms

Walnuts in Hong Kong

Market Report

Market research prepared by
Anmmar Alsaggaf | International Trade Marketing Assistant

Marketing Research Source:
EUROMONITOR INTERNATIONAL

Center for International Trade Development
390 W. Fir Ave., Bldg B, Ste. 303, Clovis, CA 93611
Tel: 559-324-6401 • Fax: 559-324-6492 • Toll Fee: 888-638-7888 • www.fresnocitd.org
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Table of Contents

This market research report has been funded and supported through the Specialty Crop Block Grant program of the USDA, and is presented in cooperation with the CDFA and the California CITDs.

Foreign Market Selection - Hong Kong

Schedule B number - 0802.31.0000 WALNUTS, FRESH OR DRIED, IN SHELL

Source 1: (US Census Bureau, 2012) http://www.census.gov/foreign-trade/schedules/b/

CIA world fact book demographics

Nationality:

noun: Chinese/Hong Konger
adjective: Chinese/Hong Kong

Ethnic groups:

Chinese 95%, Filipino 1.6%, Indonesian 1.3%, other 2.1% (2006 census)

Languages:

Cantonese (official) 90.8%, English (official) 2.8%, Putonghua (Mandarin) 0.9%, other Chinese dialects 4.4%, other 1.1% (2006 census)

Religions:

eclectic mixture of local religions 90%, Christian 10%

Population:

7,153,519 (July 2012 est.)

Age structure:

0-14 years: 11.6% (male 431,728/female 394,898)
15-64 years: 74.8% (male 2,573,929/female 2,757,095)
65 years and over: 13.5% (male 452,278/female 512,580) (2011 est.)

Source 2: (CIA World Fact Book 2012) https://www.cia.gov/library/publications/the-world-factbook/geos/hk.html

International Marketing

Trends

Walnuts

Traditionally, domestic walnuts are used as an ingredient for soup. California walnuts have gained popularity, especially in affluent regions, due to aggressive marketing efforts and competitive prices. Walnuts are consumed as in-shell snacks, as well as in confectionary and baked products. Chinese consumers prefer the taste of U.S. walnuts over domestically produced ones, which are slightly bitter in taste depending on the variety.

Source 3: (Tree Nuts Annual, 2009)
http://gain.fas.usda.gov/Recent%20GAIN%20Publications/TREE%20NUTS%20ANNUAL_Beijing_China%20-%20Peoples%20Republic%20of_9-21-2009.pdf

Walnuts are healthy and affordable

The walnuts retail market reached 2,000 tonnes and 3,900 tonnes respectively in 2009 and 2010, accounting for about 29% of the domestic market. The retail demand is expected to grow quickly in forthcoming years, and reach over 20,000 tonnes in 2013.

According to trade sources, the significant increment of walnut retail consumption is related to their health value. The Chinese generally believe walnut are beneficial to brain development, and have less oil and fat then pistachios or peanuts.

Opportunities and Challenges

Opportunities

Hong Kong is one of the top markets in the world for food and beverages, processed, fresh and frozen gourmet products. U.S. exports of high value food and beverage (HVFB) products to Hong Kong reached US$2.56 billion, consolidating Hong Kong's position as the 5th largest market for the U.S. in 2011.

Hong Kong is a major trading hub where buyers make purchasing decisions for hundreds of millions of dollars of consumer oriented products that are transshipped to China and other parts of Asia.

U.S. food products enjoy an excellent reputation among Hong Kong consumers, as they are renowned for high quality and food safety standards. Technical barriers to imports of U.S. products are generally very low. There is a wide variety of U.S. products available to Hong Kong consumers (over 30,000 different items).

The link between the Hong Kong Dollar (HKD) to the U.S. Dollar help insulate the HKD from currency fluctuations.

In general, implementation and application of regulations is transparent and open.

Demand is increasing most rapidly for "healthy" and gourmet foods, market segments where the U.S. is especially strong.

Hong Kong concerns over food safety have made U.S. food products as a top choice for quality and safety.

Hong Kong's modern and efficient port terminal and free port status make it an attractive destination and for re-exports.

Challenges

U.S. food products are not always price competitive. China is the largest competitor of U.S. food products.

Lengthy transportation time and availability of product due to seasonality (e.g. fresh produce) associated to importing U.S. food and beverage products to Hong Kong can make them less competitive than products available in the region or from China, Australia New Zealand (favorable in terms of location).

The importance of Hong Kong as a transshipment point and buying center for China and elsewhere is not widely known to U.S. exporters.

Hong Kong labeling and residue standards differ in some cases, which can impede trade. Numerous HK food regulations are not in line with Codex, which can complicate import clearances. While Hong Kong has one of the busiest container terminals in the world, it also has the most expensive port handling charges.

Hong Kong's top supermarkets are a duopoly that often request slotting fees.

Inflation is on the rise in Hong Kong. The increase in food prices may cause some consumers to turn to more lower-price lower-quality food products where U.S. products do not enjoy strong competitive advantage.

Competitive landscape

US imports accounted for only a 57.9% share of imports in 2005, but reached 92.8% and 95.3% in 2009 and 2010 respectively. This upward trend will likely continue. The US should further increase exports to Hong Kong.

Table 1 Country Source: Walnuts to Hong Kong 2010

Partner	'000 tonnes	% share
USA	33.100	95.3
China	0.732	2.1

Table 1 Country Source: Walnuts to Hong Kong 2010		
Partner	'000 tonnes	% share
Ukraine	0.366	1.1
Mexico	0.187	0.5
India	0.109	0.3
Pakistan	0.106	0.3
Vietnam	0.045	0.1
Cyprus	0.021	0.1
Iran	0.020	0.1
Canada	0.020	0.1
Others	0.018	0.1
World	34.724	100.0

Market Size

Table 2 Retail Market Size for 2008-2013 Hong Kong	2008	2009	2010	2011e	2012f	2013f
Market size in US$ million	0.3	46.2	94.1	191.7	390.6	796.0
Market size in HK$ million	2.0	360.0	733.6	1,495.0	3,046.6	6,208.5
Market size in tonnes ('000)	0.0	2.0	3.9	7.5	14.8	28.9

Source: Euromonitor International from trade sources

Pricing

Most walnuts sell from US$25.70-45.00 per kg. Some are priced below US$12.90 per kg. Independent food stores and supermarkets of smaller size have fewer varieties. The walnuts sold in these channels are usually cheaper. Supermarket with large selling space will include some rare varieties, which are usually more expensive.

Summary 1 Summary of Main Varieties for Walnuts			
Variety	Country of origin	Availability	Price range (US$/Kg)
Raw, no shell	USA	Year-round	25.00-33.00
Raw, no shell, boxed	USA	September-November	44.00

Summary 2 Summary of Main Varieties for Walnuts

Variety	Country of origin	Availability	Price range (US$/Kg)
Raw	Indonesia	September-February	19.00
Raw (special promotion at convenience store)	China	Year-round	4.00
Raw	China	Year-round	27.00-31.00
Raw	Australia	September-February	38.00
Raw	Japan	Year-round	31.00

Source: Euromonitor International from trade sources

Walnuts in Hong Kong

Most walnuts found in the market are shelled. Some are raw and some roasted. About half are loosely packed. Similar to the presentation of other nuts products, retailers try to create an image of freshness and naturalness for their walnuts. This is achieved by storing walnuts in clear cases or jars which allows customers to see the product. Walnuts have very long shelf life and can be stored in the loose format as well.

About half of the walnuts are the private labels of the retailers. In some supermarkets or independent food store with large selling space, walnuts are put into large transparent boxes of an independent panel or even counter. Consumers can order an approximate quantity and shop staff will place the walnuts into bags, which are weighed and zipped immediately. These panels or counters sell various types of nuts usually labeled with the country of origin, such as a US flag sticker affixed to the transparent boxes. The purpose of these independent panels or counters is to give consumers the impression the walnuts are "fresh" and "natural" from the US.

Distribution

Table 3 Sales of Walnuts by Distribution Format 2007/2010/2013

% retail volume	2007	2010	2013F
Supermarkets/hypermarkets	25.3	29.6	33.2
Independent food stores	31.6	30.0	28.5
Convenience stores	5.4	4.9	4.2
Discounters	-	-	-
Open markets	25.3	21.7	18.8
Others	12.4	13.9	15.2
Total	100.0	100.0	100.0

Entry Method

Supply chain dynamics

As walnuts only account for small sales on the retail floor, it is difficult for retailers to approach producers directly. Retailers, such as independent food stores, are usually not experts in walnuts.

Wholesalers/distributor, therefore, play an important role. This type of dry fruit wholesalers/distributor is called "hang". They are usually located in Sheung Wan on the Hong Kong Island, a district with a good reputation in dry fruits. Many "hang's" are family owned and have operated for decades.

Some are linked by non-profit organization such as The Chinese General Chamber of Commerce. The Chinese General Chamber of Commerce, as an example, is an organization with over a century of history. One of the main objectives of the Chinese General Chamber of Commerce is to facilitate trading and assist its team members to enjoy more benefits via their network. The presence of online portals, such as Alibaba, would benefit the communication between wholesalers to retailers. "Hang's" have been established for a long time and 'word of mouth' is important. Therefore, getting network referrals from the chambers are important as well.

Source: Euromonitor International from trade sources

Key Companies

Summary 8 Summary of Key Companies for Walnuts

Company name	Type	Location(s)	Website
On Tak Lung	Distributor	Sheung Wan	www.ontaklung.com/
Healthy Food	Distributor	Tsim Sha Tsui	www.healthyfoodltd.com/
Man Shun Cheong	Distributor	n/a	n/a
Three Sixty	Retailer	Central and Kowloon	www.threesixtyhk.com/
Market Place	Retailer	Nationwide	www.marketplacebyjasons.com/
Wellcome	Retailer	Nationwide	www.wellcome.com.hk

Documentation

As a standard procedure, importers must submit relevant documentation at the point of entry, such as the certificates of origin and import permits. Imports of food products into Hong Kong are subject to control in regards to fulfillment of bacteriological or microbiological standards, preservatives and food colors used, metal and mineral oil content, and contamination by harmful substances (such as hormone residues).

Imported fruits, nuts and vegetables are exempt from duties, import quotas and the value-added tax (VAT). Administrative fees apply.

Food labeling regulations

All imported food and beverage products, irrespective of whether they are directed to retail or food service sectors, must comply with the local composition and labeling regulations set by the Center for Food Safety (CFS). These regulations require that all packaged food be labeled with the name or designation of the product; a list of ingredients in descending order of weight or volume; a statement of special storage conditions or instructions for use; the numerical count, net weight or net volume; the name and address of the manufacturer or packager; a nutritional panel in the prescribed format in relation to calories, protein, carbohydrates, total fat, saturated fat, trans fat, sodium and sugar, plus any other nutrients for which nutritional claims are made on the packaging or label; and an expiration date for the product (in both English lettering and Chinese characters). All packaged fruit, vegetable and nut products must comply with these regulations.

Taxes, Duties, and other fees

Hong Kong is a free port and does not impose any tariff, VAT rates, import duties or quotas to walnuts.

Source 4: (GAIN Report, Hong Kong Exporter Guide 2012)
http://www.chilealimentos.com/medios/Servicios/Normas_internacionales/Norma_otros_paises/Normativa_Hong_Kong/Exporter_Guide_Hong_Kong_3_21_2012.pdf

Source5: Euromonitor International

Appendix

Trade Shows

Date	Name of Show	Website
May 29-31, 2012	Vinexpo Asia Pacific	http://www.vinexpo.com/en/
Aug 16-20, 2012	HKTDC Food Expo	http://www.hktdc.com/fair/hkfoodexpo-en/HKTDC-Food-Expo.html
Aug 23-25, 2012	Natural Products Expo Asia	http://www.naturalproductsasia.com
Sep 5-7, 2012	Asia Fruit Logistica*	http://www.asiafruitlogistica.com/en
Sep 11-13, 2012	Restaurant and Bar	http://www.restaurantandbarhk.com
Sep 11-13, 2012	Asian Seafood Exposition	http://www.asianseafoodexpo.com
Sep 11-13, 2012	Frozen Food Asia	http://www.frozenfoodasia.com
Nov 8-10, 2012	5th Hong Kong Int'l Wine & Spirits Fair	http://hkwinefair.hktdc.com
Dec 5-7, 2012	Agri-Pro Expo Asia	http://www.AgriProAsia.com

Key Contacts (GAIN and FAS, FOS)

Agricultural Trade Office

American Consulate General
18th Floor, St. John's Building 33 Garden Road, Hong Kong Tel: (852) 2841-2350 Fax: (852) 2845-0943 E-Mail: ATOHongKong@fas.usda.gov Web site: http://www.usconsulate.org.hk http://www.usfoods-hongkong.net

Importer Lists

ATO provides Hong Kong importer lists to U.S. exporters and assists to arrange meeting appointments, provided adequate lead-time is given. Please contact the ATO via Atohongkong@fas.usda.gov for further information and other business tips.

Sources and references

1 US Census Bureau, 2012 http://www.census.gov/foreign-trade/schedules/b/

2 CIA World Fact Book 2012 https://www.cia.gov/library/publications/the-world-factbook/geos/hk.html

3 Tree Nuts Annual, 2009
http://gain.fas.usda.gov/Recent%20GAIN%20Publications/TREE%20NUTS%20ANNUAL_Beijing_China%20-%20Peoples%20Republic%20of_9-21-2009.pdf

4 GAIN Report, Hong Kong Exporter Guide 2012
http://www.chilealimentos.com/medios/Servicios/Normas_internacionales/Norma_otros_paises/Normativa_Hong_Kong/Exporter_Guide_Hong_Kong_3_21_2012.pdf

5 Euromonitor International 2012

Attachment

D

Having trouble viewing this email? Click here

Dear Frank,

The California Centers for International Trade Development, in cooperation with the California Department of Food and Agriculture and Western United States Agricultural Trade Association, is pleased to announce the upcoming trade activities in California. Reserve you space today!

WUSATA Branded Program Seminars

Los Angeles - July 11, 2012
San Francisco - July 12, 2012

Is your product ready for export? Need help funding international marketing activities and promotions? Thinking about attending an international or domestic Is your product ready for export? Need help funding international marketing activities and promotions? Thinking about attending an international or domestic trade show? If so, then the Branded Program Seminar is for you!

Attend one of WUSATA's Branded Program Seminars to learn how the federally funded USDA's Market Access Program (MAP) can help your business expand your worldwide marketing reach.

Who should attend?

Eligible food and agricultural companies currently exporting or have plans to enter the international marketplace! Visit the Services section to learn about program basics and how to qualify.

Why attend?

- Our seminars will explore WUSATA programs and how we can financially assist your company's exporting journey.
- The Branded Program is an intricate system and we are here

Mexico & Central America Fresh Produce Inbound Mission

A delegation of importers and retail buyers will travel to California for meetings and facility tours. The delegation will be comprised of importers and retailers from Mexico and Central America. This will be an excellent opportunity for companies to network and establish contacts with key buyers from Mexico and Central America. These buyers will be available for meetings with companies on the following dates: July 11th and 12th in California. Meeting times are limited and are offered on a first-come first served basis, so we encourage you to register early.

For more information and registration, visit: Mexico/Central Fresh

Registration Deadline: July 7, 2012

to help you navigate.
- Personnel changes often occur, and this is a great way to train or re-train your staff on the program's fundamentals.

Join Our Mailing List!

***NOTE: PRE-REGISTRATION FOR THIS EVENT IS REQUIRED.**
Our registration process is now online. Companies will need to create an account with WUSATA Web (different from your Branded Program Application login) before signing up for events. Please visit the Tutorials section or contact us directly for information on how to register for our website.

Participation Fee is $25 per person (includes lunch)

REGISTER FOR LOS ANGELES - JULY 11, 2012
REGISTER FOR SAN FRANCISCO - JULY 12, 2012

Registration Deadline: July 5, 2012

California Centers for International Trade Development,
State Center Community College District

Forward this email

Center for International Trade Deve. 390 W. Fir Ave., Ste. 303 Clovis CA 93611

WUSATA

wusata.org

Western US Agricultural Trade Association

USATA Products of the U.S.A

Branded Program Seminar

July 11, 2012

Los Angeles, California

Event Benefits:

- Learn how to double your company's international marketing budget
- Explore state and federal exporting resources

WUSATA and the 13 Western U.S. Member States announce participation and registration for the following activity description:

Is your product ready for export? Need help funding international marketing activities and promotions? Thinking about attending an international or domestic Is your product ready for export? Need help funding international marketing activities and promotions? Thinking about attending an international or domestic trade show? If so, then the ***Branded Program Seminar*** is for you!

Attend a Branded Program Seminar to learn how the federally funded USDA's Market Access Program (MAP) can help your business expand your worldwide marketing reach.

Products of Interest*:

Open to food and agriculture based businesses that are eligible for WUSATA's Branded Program. Visit www.wusata.org to learn about how to qualify.

**Products must be at least 50% U.S. agricultural origin by weight, excluding added water and packaging.*

Registration Deadline:

July 04, 2012

Participation Fee:

$25 per person

Managing States:

Josh Eddy
CA Dept. of Food and Ag.
916-403-6731
Josh.eddy@cdfa.ca.gov

Meuy Saeteurn
WUSATA
360-693-3373
meuy@wusata.org

To Register: login to your *My WUSATA* account at WUSATA Web, or visit www.wusata.org and create one today!

Western U.S. Agricultural Trade Association: 4601 NE 77th Avenue, Suite 240, Vancouver, WA 98662 USA
(P) 360-693-3373 • (F) 360-693-3464 • events@wusata.org • www.wusata.org
To view WUSATA's non-discrimination and privacy policies please visit our website .

Attachment

E

Specialty Crop Trade Mission to China & South Korea

June 10-16, 2012

The California Specialty Crop Trade Mission to China and Korea will include customized one-on-one meetings with foreign buyers (Shanghai and Seoul), market briefings by U.S. Embassy staff, as well as retail market visits to assist California small businesses with export sales and foreign market expansion.

Trade Mission Schedule:

June 10 – Arrive Shanghai

June 11 – U.S. Embassy Briefing
Match Making Meetings

June 12 – Match Making Meetings
Product Showcase

June 13 – Retail Market Visits
Travel to Seoul

June 14 – U.S. Embassy Briefing
Match Making Meetings

June 15 – Match Making Meetings
Product Showcase

June 16 – Market Visits
Depart to U.S.

Activity Information:

This trade mission is designed to assist California specialty crop companies with entering and expanding export sales to China and Korea. Program staff will work with participating companies to schedule one-on-one business meetings with appropriate foreign buyers. Companies will also receive in-depth market briefings from U.S. Department of Agriculture officials and visit a variety of retail market outlets to better understand the sales and distribution channels in the market. In addition, companies will have the opportunity to showcase their products to importer/distribution representatives.

Participation Fee: $500.00 *(Participation is limited)*

California Specialty Crop Companies will be provided:

- Customized one-on-one appointments in Shanghai and Seoul
- Market briefings by U.S. Officials
- Hotel accommodations in Shanghai and Seoul
- Travel assistance/reimbursement of international airfare available – restrictions apply.
- California specialty crop requirements must be met to receive trade mission travel assistance.
- California entities that do not meet specialty crop requirements can participate in the trade mission at their own expense.

Specialty Crop Trade Mission to China & South Korea

June 10-16, 2012

Registration Form: (Please complete at fax to **559-324-6492** or e-mail citd@scccd.edu)
Registration Deadline: May 1, 2012

Company Name: ______________________________

Contact Name: ______________________ Title: ______________

Address: ______________________________

City: ______________ State: ________ ZIP: ______________

Phone: ______________ Fax: ______________

E-mail: ______________ Website: ______________

Products/Brand: ______________________________

Signature: ______________________________

Specialty Crop Certification:

- Products are considered "Specialty Crops" as defined by USDA
- Agricultural products are California grown.
- Company is based in California.
- Company has less than two years of active export experience.
- Viable California Company with an established domestic market and an Employer Identification Number (EIN)

Participation Information:

* Eligible for travel assistance (one individual)
* Will provide specialty crop verification
* Will participate in all scheduled activities/events
* Travel assistance based on U.S. travel requirements
*$500.00 Participation Fee

Trade Mission Contact:
Candy Hansen – Gage
Center for International Trade Development
Phone: 559-324-6401
E-mail: candy.hansen-gage@scccd.edu

The California Specialty Crop Trade Mission is funded by the 2009 Specialty Crop Block Grant program of the United States Department of Agriculture, and is presented by the Fresno Center for International Trade Development in cooperation with the California Department of Food and Agriculture.

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE
Karen Ross, Secretary

CITD Center for International Trade Development

China – Specialty Crop
Mission Evaluation & Contribution Form

Activity Name: ______________________________

Dates of Activity: ______________________ Industry Served: ______________________

*Please complete this form in its entirety; print and **sign**; then send or fax to CITD. Company data is collected for aggregate statistical reporting purposes only. Your feedback assists CITD to plan future promotions. Proprietary information provided will be maintained as business confidential unless otherwise indicated. Please contact Alicia Rios at (559) 324-6401 or alicia.rios@scccd.org with questions.*

Company Information

Company: ______________ Contact Person: ______________ Title: ________

Address: ______________ City: ______________ State: ______ Zip: ______

Telephone: ______________ Fax: ______________ Email: ______________

Web Site: ______________

- Is your company a first-time exporter? Yes ☐ No ☐
- Has your company exported to this country before? Yes ☐ No ☐
- Is this your first CITD trade mission activity? Yes ☐ No ☐

Activity Evaluation

1. What was the Value of export sales booked during this activity? $________
2. Were any export purchase orders signed as a result of this activity? Yes ☐ No ☐
3. What sales do you expect within the next 12 months from this activity? $________
4. How many new products did you introduce to this market during this activity? ________
5. How many new international buyer contacts resulted from this activity? ________
6. How many new international distributorships are likely to result from this activity? ________

Please rate this activity on the following:	Poor	Fair	Average	Good	Excellent
7. Cost / benefit returns to your company	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
8. Quality of contacts or information	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

9. Would your company participate in this activity next year? Yes ☐ No ☐

Company Contributions *(i.e., non-reimbursable participation expenses paid by your company)*

Value of staff time for planning, participation & follow up:	
• OK to use total amt only. Example: person(s) x $ x # of day(s) =	$
Direct costs of planning, participation & follow up:	
• Travel, transportation, lodging, meals	$
• Participation fees, freight, equipment rental, translator / host(ess)	$
Other costs associated with participation in activity:	
• Sample product value, communication costs, POS materials, meals hosted	$

Additional comments or questions: ______________________________

I certify the above contributions information to be accurate:

______________________ ______________________ ______________
Company Representative Signature **Title** **Date**

Please fax completed form to **CITD** at **(559) 324-6492**

California First:
Spotlight on California Wine Regions

SCBG Review with Faye Ison

April 17, 2012

California Wine Background

- California produces 90% of all U.S. wine
- California is the 4th leading wine producer worldwide
- California wine accounts for two-thirds of all wine sales in the U.S. ~ $19.9 billion retail value in U.S.
- 3,600 bonded wineries in CA; 4,600 winegrowers
- California wine quality tied directly to ideal climate, soil, and long mountainous coastline
- World leader in sustainably grown and made wines

California Wine Competition

- Extremely competitive with producers from every traditional and emerging winegrowing country, and other U.S. states, targeting U.S. consumers

- Most countries, especially EU, provide significant subsidizes and support for local wine industry (Example, Bordeaux, one region of France, will spend $4 million in marketing to U.S. consumers in 2012

- Other U.S. states also recognizing the value of wineries to local economies, tourism and rural preservation

- 2011 U.S. became world's largest wine market

CALIFORNIA FIRST GRANT

California First Grant:

- Umbrella campaign for California wine
- Promote diversity of California's wine regions
- Coordinate efforts of regional associations
- September California Wine Month celebration
- Tools and resources to promote CA regions to trade, media, consumers, esp. millennials
- Opportunities: Collaborate with Visit California on wine and food tourism, WI International Marketing and CSWA

CALIFORNIA FIRST GRANT

WINE INSTITUTE

WI & CAWG Regional Marketing Survey:

- Survey of 36 regional winery & grower associations
- Goal to assess marketing skills and needs with 14 questions on marketing priorities and activities
- Responses from 22 organizations around the state
- Consumer & media activities high priority
- Tools: tasting events, brochures, maps, websites
- Wine trade, millennials and social media of interest but lacked resources/expertise to pursue
- **Survey results shared at May workshops and used to implement multi-pronged program**

CALIFORNIA FIRST GRANT

WINE INSTITUTE

California Wine Trade Research 2010:

- In-depth focus groups conducted with top sommeliers around the state in March 2010 with Master Sommelier Evan Goldstein
- Recommendations for California to maintain and grow dominance
- Show diversity beyond the three main varietals (Chardonnay, Cabernet & Pinot) from Napa and Sonoma and bold California wine style
- Emphasize the value in California wines at different price points.
- Reach out to Millennials, the fastest-growing consumer segment, who may favor imports over California (with the encouragement of sommeliers)

Presented recommendations and plans for implementing on winery, grower, regional and statewide level at May workshops

CALIFORNIA FIRST GRANT

May 2010 Workshops:

- Best practices workshops in Paso Robles, Lodi, Sonoma
- 150 vintner & growers
- Region Survey Results
- California First Messages
- Finding & recommendations from Sommelier Research
- California Wine Month Panel & Toolkit

California First Grant

California Wine Month 2010

WINE INSTITUTE

TRADE PARTNERS

TAVISTOCK GROUP

SAFEWAY Ingredients for life.™

joie de vivre

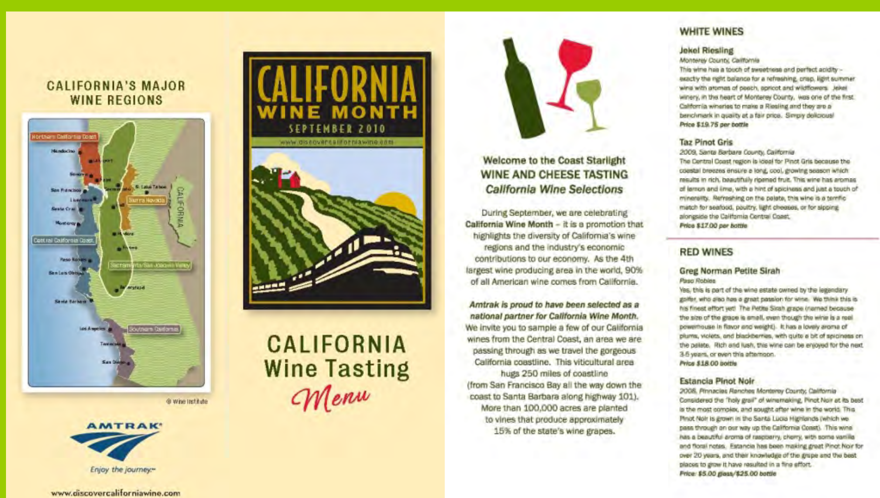
KIMPTON hotels & restaurants

PATINA RESTAURANT GROUP

AMTRAK

California First Grant

California Wine Month 2010



California First Grant

California Wine Month 2010

California Restaurant Association

CALIFORNIA WINE MONTH 2010

September will mark the sixth annual California Wine Month, as proclaimed by Gov. Arnold Schwarzenegger. Check back often for information from the California Restaurant Association, as well as the Wine Institute of California, on marketing opportunities during California Wine Month. For more information, go online at www.discovercaliforniawine.com.

Best California Wine List Competition

In honor of California Wine Month, the California Restaurant Association presents the Best California Wine List Competition. In its third year, the competition celebrates the quality and diversity of California's renowned wines and the restaurants that best showcase them. The competition is open to any interested restaurant or restaurant company and is divided into four wine catergories. Full entry guidelines are available here. To enter, complete the entry form and mail with your restaurant's physical wine list c/o the California Restaurant Association, 621 Capitol Mall, Suite 2000, Sacramento, CA 95814. For more information e-mail bestcawinelist@calrest.org.

California First Grant

California Tourism CWM Promotion

Communications platform to promote California's wine and food product.

Encouraging consumers to visit with more than 100 special hotel deals celebrating California wine and wine country activities.

Promoted www.visitcalifornia.com/winemonth via a national press release and targeted media pitching.

Press release distributed via PR Newswire picked up by 200+ online media.

Release reached audience of nearly 1.8 million

California First Grant

California Wine Month 2010

Wall Street Journal Sept. 10

Special Advertising Section

CALIFORNIA WINES

PRODUCED IN COOPERATION WITH

The Flavors of Wine Country

By Jeff Morgan

With nearly 3,000 wineries producing 90 percent of all U.S. wine, California's global impact on drinking and dining is enormous. Two out of every three wine bottles sold in America are made in California. Outside the U.S., some 120 nations import California wines. And each year, 20 million visitors from around the globe visit the state's wine regions for a closer look at what makes California a leader in great taste.

With varied microclimates and topography, California's wine regions each harbor their own distinctive traits and wine styles. The state's winegrowers also produce wine from 117 different grape varieties, which adds a significant measure of diversity to what we find so delicious to drink in our glass. Some of the wine regions are quite warm, while others are comparatively cool. A number of them are large — with surface areas that can be measured in hundreds of thousands of acres. Others fit neatly into the small, bucolic, country villages that form their boundaries. In all, California's viticultural areas unfold across the state in a puzzle-like pattern that holds the key to wine quality.

Photographs by Charles O'Rear

During the growing season, sunshine is fairly constant. But temperature and other important considerations are not. As we visit California's wine regions, which stretch from the Pacific Coast moving east to the center of the state, we see they are marked by low-lying valleys and vertiginous mountain ranges. The striking geography creates unique and diverse growing conditions that are ultimately reflected in the taste of the wines.

Closest to the ocean are such regions as Sonoma and Mendocino counties, as well as the Central Coast. These areas host smaller viticultural areas as well. Among them are places with names like Santa Lucia Highlands, Santa Cruz, Russian River Valley, Carneros and the Dry Creek and Anderson valleys. They benefit from morning fog and maritime breezes that produce a cooling effect favoring certain grape varieties like Chardonnay and Pinot Noir. Other grapes, such as Zinfandel, are well suited to these areas, too.

Still coastal, but slightly farther inland and less affected by sea breezes, are warmer regions such as Napa Valley, Sonoma Valley, Alexander Valley, PasoRobles and Livermore Valley. Cabernet Sauvignon, Merlot, Zinfandel, Chardonnay and Sauvignon Blanc are among the most widely planted grape varieties here.

Even further east, California's impressive Central Valley is actually two valleys, the Sacramento and San Joaquin, extending nearly 400 miles through the middle of the state. The Central Valley hosts appellations that include Lodi and Madera. This large swath of land is known as the "breadbasket of the West." East of the Central Valley are the Sierra Foothills, where Zinfandel has been grown since the days of the Gold Rush in Amador, El Dorado and Calaveras counties.

© Wine Institute

Geography notwithstanding, it's easy to fly to many of California's vineyard-draped wine communities. Northern California's three main airports — San Francisco, Oakland and Sacramento — provide easy access to many of the northern portions of the state. Visitors to the south will discover the gateway to wine country is only about an hour away from Los Angeles' two major airport hubs: LAX and Orange County.

Without exception, California wine travelers will be treated to a vine-studded vision in green that blankets the countryside and follows the lay of the land. The vineyards wind along valley floors, hug rolling hillsides and climb steep mountain slopes. In the fall, their plump clusters of dark purple and golden-hued grapes foretell a taste of things to come as winemakers make ready for the harvest.

Making Fine Wine

Only ripe grapes yield the flavors that make great wines. Sunshine is the most important of all the quality factors, and today's vineyards are trained to allow the right amount of sunshine to penetrate the vine canopies. As a result, grapes benefit from increased photosynthesis, the process that allows them to capture the sun's energy and ripen effectively.

Winemakers typically wait until their grapes are at the peak of ripeness before picking them. How do they know when the grapes are ripe? Sugar development and other indicators can be measured in the laboratory, but ultimately the best winemakers generally rely on their sense of taste. They walk the vineyards prior to harvest, tasting and waiting for the moment when the flavors are "right." It's a skill that comes with experience. And it's part of the winemaker's art.

Once the grapes are harvested, winemakers must finish what began in the vineyard. "The science behind winemaking is very important," says Jeff Meier, director of winemaking for J. Lohr Vineyards & Wines, in Paso Robles. "But science only takes us to a certain point. It can't replace what we winemakers learn over time through hands-on experience. That experience gives us the ability to translate the flavors of the vineyard most effectively to your glass."

Today's grapes are handled in a far more gentle way than ever before — a technique that produces great elegance and finesse during fermentation. White grapes are often "whole-cluster pressed" to retrieve the

The bounty of California's wine regions offers an exceptional tasting experience

LA Times Magazine Sept. 5

ADVERTISING SUPPLEMENT

WINES of California

"PETITE SIRAH IS LIKE A 300-POUND FOOTBALL PLAYER NICKNAMED "TINY" – IT'S A HUGE RED WITH AN INKY PURPLE COLOR AND A MOUTH-COATING POWER!" – Leslie Sbrocco

What's next?

WINE EXPERT PREDICTS WHICH VARIETALS WE WILL BE ENJOYING SOON

Choosing a California wine used to be simple. You picked up a bottle of Chardonnay at the store, or a Cabernet if you wanted something different. But with the international influence of overseas wines on California (and vice versa), a dizzying selection of once-obscure varietals are now making waves. The trend is what is old is new again. The state is producing great old-world varietals like Tempranillo, Albariño and Grenache. Meanwhile, old standards like Chardonnay, Riesling and even rosé are reinventing themselves by way of the Golden State.

Grenache grapes, grown in Paso Robles and Santa Barbara County, produce a hearty red wine.

To sort it all out, we turned to wine consultant and author Leslie Sbrocco, whose first book on the subject, "Wine for Women: A Guide to Buying, Pairing, and Sharing Wine" (William Morrow 2003) won the Georges Duboeuf Best Wine Book of the Year award. Sbrocco is also a winner of a James Beard Foundation award (the Oscars of the food and wine world), as well as three Emmys for her work on the PBS restaurant show "Check, Please!" She just launched a member-driven online community TheThirstyGirl.com.

Here, she exposes to us the latest insider trends in the ever-evolving California wine world.

What varietals are you seeing as the next wave of California wines?

I think it's so rewarding to see the attention that Riesling [has been] getting in the past five years. We've been seeing what we call the "Riesling renaissance." California is never going to produce a ton of Riesling, but producers and consumers are taking it seriously here. Most people drink it young because it's refreshing and crisp, with no oak aging. You uncork it in the fall, and it's an immediate pleasure to drink.

Riesling has such a natural affinity for spicy cuisine, like curries and Chinese food. And it's my favorite pairing with burritos. It's also a gorgeous stand-alone wine. Riesling's the most flexible food wine, period. People think of Riesling as sweet, but it's not. You can have bone-dry Riesling all the way up to very sweet. In California, we have more of the dry to off-dry styles of Rieslings, as opposed to the dessert Rieslings.

With the wine market being more global and different countries influencing one another, what outside influences are you seeing on the California industry?

I'm excited by little esoteric things like tempranillo and albarino, which are red and white Spanish varieties.... Tempranillo is a red grape variety that is the signature grape of Spain, and rarely have we seen it doing well outside of that country. Now there's some small-scale production in California, specifically in Santa Ynez. And Napa is making some great Albariño. Then there [are] the Rhône-style wines like Syrah and Grenache.

California Grenache is getting a lot of attention lately. What regions are turning out the best?

Worldwide from Spain to France to Australia, grenache [illegible] is known for producing hearty, spicy reds. In California, where it has a rich history, the grape is just getting its due now as wine drinkers look for more adventurous offerings. Thriving in warmer spots of Santa Barbara County and Paso Robles on the Central Coast, it's often used as a blender for Rhône-style wines and as a base for many top rosés.

You won't see a huge amount of pure Grenache bottles flooding store shelves like Syrah did, but there are some almost cult-like California versions. I'm a fan of bold Grenache. The bigger the better for me, as long as there's a kick of freshness, especially alongside grilled sausages smothered in mushrooms. Grenache is a good summer pick for barbecue meats, but also works just as well with fall and winter soups and braised dishes.

Continued on page [illegible]

California First Grant

California Wine Month 2010

2010 EVENTS

- **CALIFORNIA FOCUS: events in SF and Los Angeles**
- **THEME: “Unexpected Grapes from Unexpected Places”**
- **EDUCATION: Trade & media educational seminars**
- **CONSUMER ELEMENT: Regional association grants**

California First Grant

California Wine Month 2010

Master Classes for Trade and Wine & Lifestyle Media

California First Grant

California Wine Month 2010

WINE INSTITUTE

San Francisco Grand Tasting
Hotel Vitale

California First Grant

California Wine Month 2010

WINE INSTITUTE

Los Angeles Grand Tasting
Hotel Palomar

California First Grant

California Wine Month 2010

WINE INSTITUTE

full circle
wine solutions

Seminar Evaluation Results Summary

Attendees were asked to check one of five boxes: Strongly agree, agree, neutral, disagree and strongly disagree. These answers were then scored against a 5-point scale with 5 given for any "Strongly Agree" responses. Overall, the scores were very high across all four questions.

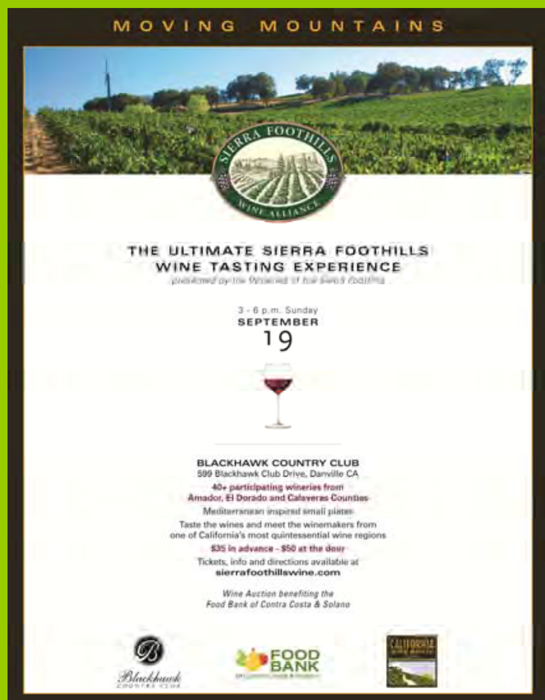
Trade Seminar Results	**SF 1:30 PM**	**SF 3:30 PM**	**LA 1:30 PM**	**LA 3:30 PM**	**Average**
# of Responses	47	46	39	44	NA
The speaker was	4.9	4.9	4.9	4.8	4.9
This seminar enhanced my knowledge about the diversity of California wines and regions.	4.5	4.5	4.6	4.6	4.6
This seminar reinforced that the fact that California has new options for my wine list/shelf.	4.4	4.4	4.5	4.5	4.4
seminar to others.					

Media Seminar Results	**SF**	**LA**	**Average**
# of Responses	31	20	NA
This seminar enhanced my knowledge about the diversity of California wines and regions.	4.2	4.6	4.4
This seminar reinforced that the fact that California offers interesting options for pairing food and wine.	4.4	4.5	4.4
seminar to others.			

California First Grant

California Wine Month 2010

Regional Association Activities



Celebrate California Wine Month At Two Bay Area Events

The Paso Robles and San Luis Obispo wine regions have teamed up to offer you two exclusive opportunities to taste their award winning wines paired with the cuisine of two premier restaurants in the Bay Area - Mortons in San Jose and Spruce in San Francisco.

Join us as we celebrate California Wine Month. Cheers!

Morton's The Steakhouse San Jose
Monday, September 13
6-8 p.m.
The wines of Paso Robles and San Luis Obispo team up with Morton's San Jose for a walk around tasting featuring 14 wineries. Enjoy bites of Morton's USDA prime aged steak, seafood and signature flavors from Morton's.

California First Grant

California Wine Month 2010

RESULTS

- 18+ regions active in events and promos
- 100+ vintners, growers, regions at events
- 200 trade and media attended seminars
- 400 trade and media at SF & LA events
- 2800+ retail and restaurants outlets
- 97 million consumer impressions
- $850 thousand in advertising value

California First Grant

Website - CAWG

california-vineyards.com

California First Grant

Social Media - CAWG

E-Newsletter

Facebook

Twitter

###

Last Updated on Tuesday, 12 October 2010 19:57

Gov. Schwarzenegger Proclaims September 2010 CA Wine Month

Celebrate California's Signature Beverage with Dozens of Consumer Events Across the State

SACRAMENTO, Calif. – To help celebrate September 2010 as California Wine Month, proclaimed by Governor Arnold Schwarzenegger for the sixth consecutive year, many of the Golden State's wineries, winegrape growers and regional associations are hosting special consumer events surrounding the state's signature beverage.

"California has long been known for our production of superior, award-winning wines," said Governor Schwarzenegger in his proclamation. "The Judgment of Paris in 1976 brought California wine to the world stage and established our wine producers as respected masters of their craft. This month is dedicated to celebrating our rich history of wine-making and the bright future of this important industry." For a copy of the proclamation, go to: www.discovercaliforniawine.com/learn/governors-proclamation.

Last Updated on Thursday, 26 August 2010 18:27

Read more...

New Logos for U.S. and International

WINE INSTITUTE

CALIFORNIA WINES

U.S.

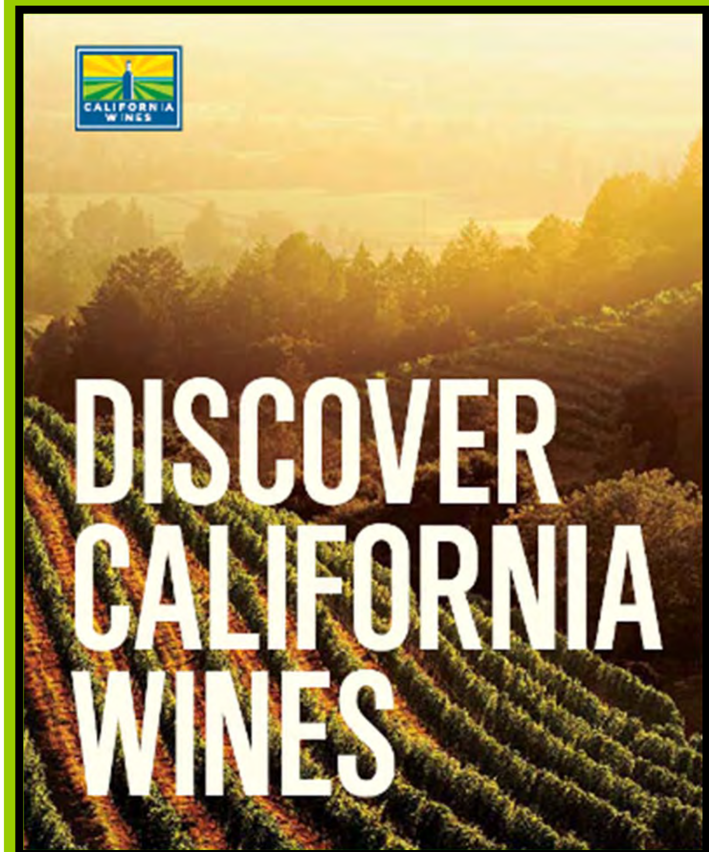
International

WINE INSTITUTE
THE VOICE FOR CALIFORNIA WINE

California WINES

Brochure

Highlights the diversity, quality and value of California Wines by focusing on winegrowing regions, varietals, sustainability, and food & wine pairings.



AVA Map

Highlights winegrowing regions, AVAs and California landmarks

CALIFORNIA FIRST GRANT

WINE INSTITUTE

New York Wine Trade Research 2011:

- In-depth focus groups conducted with 24 top sommeliers and retailers in New York City in February 2011 by Full Circle Wine Solutions/Master Sommelier Evan Goldstein
- Insights on CA wine perceptions and recommendations to address them
- New York wine trade views California as best American wine region and and important part of lists
- Lack of knowledge of region, style and price diversity
- Less loyalty with strong representation of European imports
- Need to cultivate ambassadors for California in New York wine trade

Presented recommendations and plans for implementing on winery, grower, regional and statewide level at May workshops

CALIFORNIA FIRST GRANT

WINE INSTITUTE & CAWG
CORDIALLY INVITE YOU TO

Marketing for California Wineries & Growers

Workshops - May 13, 25 & 26, 2011

Join us for morning workshops in **Napa, Monterey, SF** and **Sacramento**. Learn how to tell your story to full advantage in "The Breakthrough Message." Hear the results of our 2011 New York Sommelier Survey presented by Evan Goldstein, M.S., of Full Circle Wine Solutions. Get the latest on social media best practices and how to put them in action in separate sessions geared to wineries and winegrape growers.

Registration & Breakfast 8:30 | Program 9 am – Noon

SESSIONS

NAPA
May 13, 2011
Meritage Hotel
875 Bordeaux Way
Napa, CA 94558

MONTEREY
May 25, 2011
Constellation Offices
800 South Alta Street
Gonazales, CA 93926
"Event Room"

SAN FRANCISCO & SACRAMENTO
May 26, 2011
Two Locations
SF – Wine Institute Offices (Vintners)
Sacramento – AdFarm Offices (Growers)
These sessions also offered as webinars

RSVP or questions to communications@wineinstitute.org or Sharlene@cawg.org. Please indicate which sessions you wish to attend (in person or webinar for SF & Sacramento) and include full name of attendee and affiliation. Space is limited.

PROGRAM

GENERAL SESSION:

THE BREAKTHROUGH MESSAGE
Susan Orenstein, Storytelling Specialist, Communications Consultant, Former Journalist
How to tell your story in a cluttered, competitive world
Does your story need a refresh? Are you conveying your uniqueness to full advantage? It can be surprisingly hard to see your own true story and even harder to tell it in a concise, compelling and authentic way. Learn how to get to the heart of your story and build a deeper connection with your customers.

VINTNER TRACK:

SOMMELIER SURVEY 2011: NEW YORK
Evan Goldstein, MS, Educator/Author, Full Circle Wine Solutions
What top New York sommeliers have to say about California wine
Learn the results of in-depth focus groups held with two dozen of New York's most influential sommeliers and delivered with recommendations on how wineries and regional associations can enhance perceptions and relationships with these important gatekeepers.

SOCIAL MEDIA 101 FOR WINERIES
Mia Malm, Malm Communications, Jeremy Benson, Benson Marketing Group
These experts share best practices and case studies of successful campaigns to show how you build consistent brand equity, streamline your workload, reach your audience and navigate the social world to benefit your winery. You'll receive an update on the Wine Institute's upcoming social strategy as well as a Best Practices handout.

GROWER TRACK:

SOCIAL MEDIA FOR FARMERS
Libby Hall and Brandon Souza, AdFarm
New this year, we have a break out session designed just for the winegrape grower. This hands-on social media training session will provide learning opportunities for everyone from the seasoned social media expert to those still trying to figure out the meaning of a #hashtag. You will leave this session with the ability to tell your unique story using social media.

The session is presented by the Know a California Farmer campaign, a campaign born out of a need for California agriculture to come together to speak with a unified voice on behalf of its contributions. The purpose of www.knowacaliforniafarmer.com is to create a conversation with consumers and give growers the tools to use social media in a way that will make a positive difference for themselves and all of California agriculture.

May 2011 Workshops:

- Best practices workshops in Napa, Monterey, SF & Sacto
- 175 vintner & growers
- Messaging training
- Recommendations from NY Sommelier Research
- Social Media Sessions for wineries and growers

California Wine Month 2011

- Proclamation
- Trade Partners
- Media Partners
- Region & Winery Activity
- Events – NYC and SF
- Publicity Campaign

California Wine Month 2011

Seventh Year for Governor's Proclamation, first for Jerry Brown

Executive Department
State of California

PROCLAMATION

BY THE GOVERNOR OF THE STATE OF CALIFORNIA

California is uniquely blessed with geographic characteristics conducive to the production of fine wines. The state's latitudinal span, topographical variations, and diverse geology create a variety of soils and micro-climates that allow us to grow an unparalleled range of fine wine grapes. Our Mediterranean climate has attracted winemakers since the 18th century, when Spanish missionaries planted California's first grapevines. Today, the winemaking traditions brought by European immigrants are enhanced by more than a century of modern innovation in cultivation and fermentation techniques, areas in which California's industry, assisted by partnerships with our research universities, is the undisputed world leader.

As an industry, California wine brings innumerable benefits to the state. Our scenic and historic wine-growing regions, a renowned cuisine based on food and wine pairings, and the opportunity to taste and purchase our world-famous wines bring an estimated 20.7 million tourists to our state each year. Our state's wineries create jobs for 330,000 Californians and revenue from retail sales of $18.4 billion, including $1.14 billion in export sales to 122 countries.

California's wineries and wine grape growers are primarily family businesses whose commitment to the industry's economic and environmental sustainability reflects their intention to remain in operation for many generations to come. The Code of Sustainable Winegrowing Practices reflects the industry's commitment to preserving the land and human capital that make possible the continuing bounty of California wine.

NOW THEREFORE I, EDMUND G. BROWN JR., Governor of the State of California, do hereby proclaim September, 2011, as "California Wine Month."

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 2nd day of August 2011.

EDMUND G. BROWN JR.
Governor of California

ATTEST:

DEBRA BOWEN
Secretary of State

California Wine Month 2011

WINE INSTITUTE

TRADE PARTNERS

MORTON'S THE STEAKHOUSE

california PIZZA KITCHEN CPK

SAFEWAY Ingredients for life.

VONS Ingredients for life.

KIMPTON hotels & restaurants

TAVISTOCK RESTAURANTS

AMTRAK

VINO VOLO discover great wines

P.F. CHANG'S

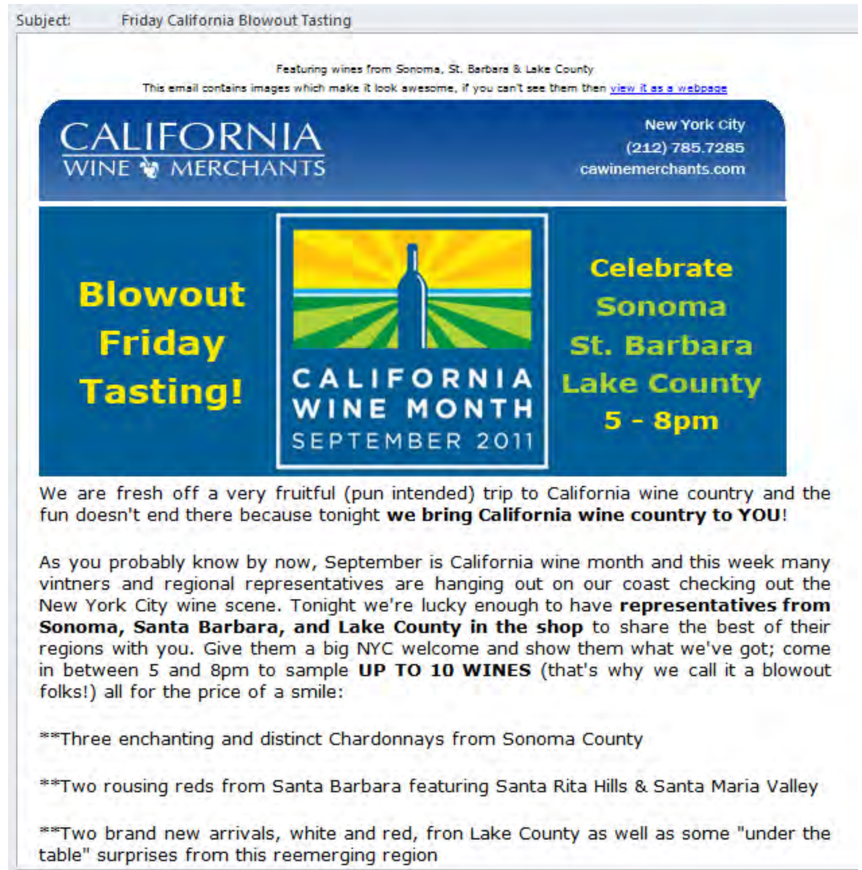
California Wine Month 2011

DISPLAY:
Vino Volo
Dulles Airport,
Washington, D.C.

California Wine Month 2011

WINE INSTITUTE

WEBSITE:
California Wine Merchants
New York, NY


Subject: Friday California Blowout Tasting

Featuring wines from Sonoma, St. Barbara & Lake County
This email contains images which make it look awesome, if you can't see them then view it as a webpage

CALIFORNIA WINE MERCHANTS
New York City
(212) 785.7285
cawinemerchants.com

Blowout Friday Tasting!

CALIFORNIA WINE MONTH SEPTEMBER 2011

Celebrate Sonoma St. Barbara Lake County 5 - 8pm

We are fresh off a very fruitful (pun intended) trip to California wine country and the fun doesn't end there because tonight **we bring California wine country to YOU**!

As you probably know by now, September is California wine month and this week many vintners and regional representatives are hanging out on our coast checking out the New York City wine scene. Tonight we're lucky enough to have **representatives from Sonoma, Santa Barbara, and Lake County in the shop** to share the best of their regions with you. Give them a big NYC welcome and show them what we've got; come in between 5 and 8pm to sample **UP TO 10 WINES** (that's why we call it a blowout folks!) all for the price of a smile:

**Three enchanting and distinct Chardonnays from Sonoma County

**Two rousing reds from Santa Barbara featuring Santa Rita Hills & Santa Maria Valley

**Two brand new arrivals, white and red, fron Lake County as well as some "under the table" surprises from this reemerging region

California Wine Month 2011

Regional Association websites

California Wine Month 2011

New York Trade and Media Tasting

- September 15th 2 – 5 pm
- Grand Central Terminal
- 125 trade and media
- Regions –Lake, Lodi, Monterey, Napa, Paso Robles, Sonoma, WI, CAWG
- Wines: six best of region, vintners offered mini-verticals
- Sommelier & retailer hosted tables
- Regional events at 11 wine shops
- Taxi Video Campaign

California Wine Month 2011

WINE INSTITUTE

By-the-glass at restaurants

Boutique retailer favorites

California Wine Month 2011

Breakfast with Josh Greene
Wine and Spirits Magazine

Tour of Brooklyn Retailers

California Wine Month 2011

WINE INSTITUTE

New York Regional Pouring Events

67 WINE SINCE 1941

MORRELL WINE BAR & CAFE

CALIFORNIA WINE MERCHANTS
WINES & SPIRITS
15 BRIDGE ST, NYC CAWINEMERCHANTS.COM (212) 785-7285

BEDFORD WINE MERCHANTS

Fermented Grapes wines (& spirits)

BROOKLYN WINE EXCHANGE

Custom AMERICAN WINE BAR

RYE BROOK wine & spirit SHOP

CHELSEA WINE VAULT

Red White & Bubbly BROOKLYN, NEW YORK

California Wine Month 2011

Over a million views in New York taxis during a one-week period.

California Wine Month 2011

San Francisco Consumer Tasting

- September 17, Noon – 3
- Ferry Building Grand Concourse
- 250 consumers, media
- Marketplace & Farmer's Market
- 10 regions + WI, CAWG, CSWA, CUESA, Ferry Plaza Wine Merchants
- Remote broadcast on KGO Radio *Dining Around with Gene Burns*

California Wine Month 2011

WINE INSTITUTE

KGO NEWSTALK AM810

DININGAROUND.COM

California Wine Month 2011

WINE INSTITUTE

Publicity Results

100 Stories = Over 200 million impressions

California First Grant

California Wine Month 2011

RESULTS

- 15 regions active in events and promos
- 50 + vintners, growers, region execs
- 150 trade and media at NYC event
- 200 consumers at SF event
- 2500+ retail and restaurants outlets
- 200 million impressions from publicity

New California Wines Website *(Home P*

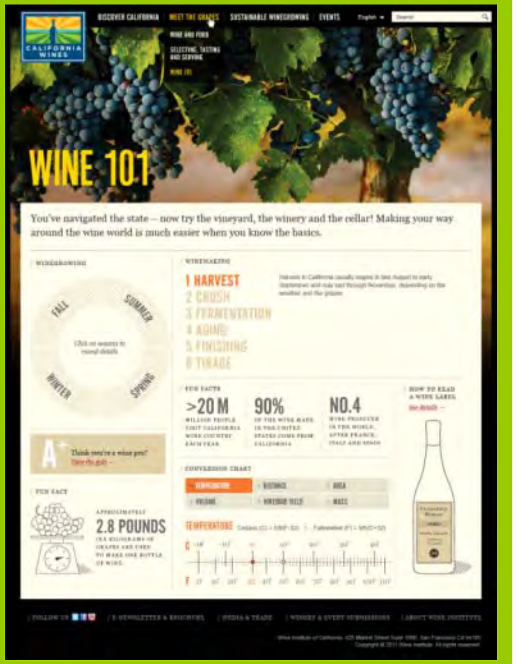
Highlights the diversity, quality and value of California Wines by focusing on winegrowing regions, varietals, sustainability, and food & wine pairings. Will be translated into multiple languages.

California Wines Website

Regional Features include a map with AVAs, "factoids" about the region, winery listings, and event profiles

California Wines Website

"Meet the Grapes" section includes our California wines and cuisine – varietals, food & wine pairings, Wine 101 section, etc.

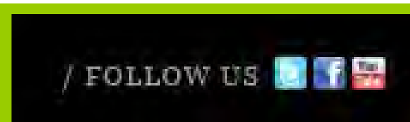


Social Media

Launched integrated social media campaign via Facebook, Twitter and YouTube in Summer 2011

Social Media

New Facebook Timeline Page Design Launched March 30th



Social Media

California Wines Twitter Account

Additional Opportunities from CA First Grant

California Wines Videos

Additional Opportunities from CA First Grant

California Wines: Down to Earth Campaign

California Wine Sales

Wine Sales in the U.S.

from all production sources

Year	Millions of Cases	Retail Value
2011	347	$32.5 billion
2010	329	$30.0 billion
2009	321	$28.7 billion
2008	314	$30.0 billion
2007	314	$30.4 billion
2006	312	$27.8 billion
2005	291	$25.8 billion
2004	280	$24.0 billion
2003	269	$22.3 billion
2002	260	$21.8 billion

Appendix 1.

Figure 1. Historical consumer price index for urban consumers

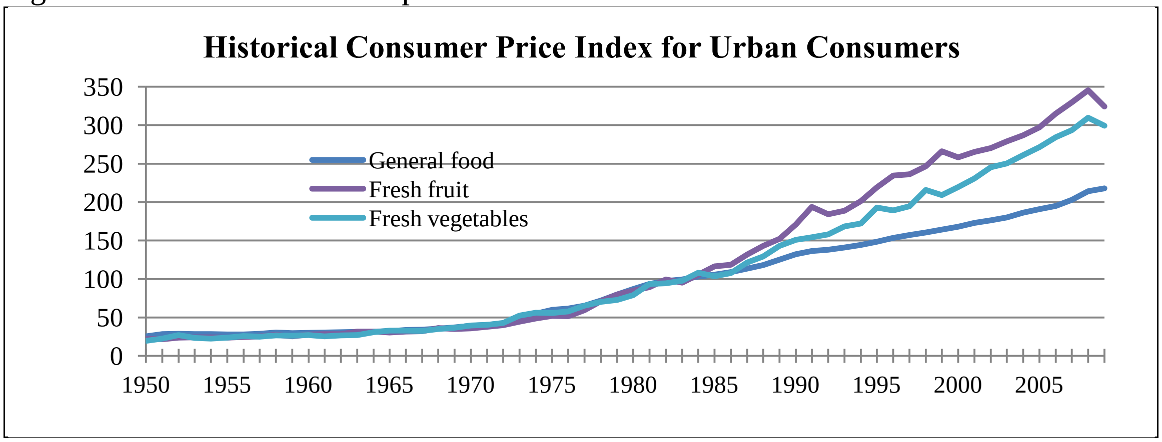
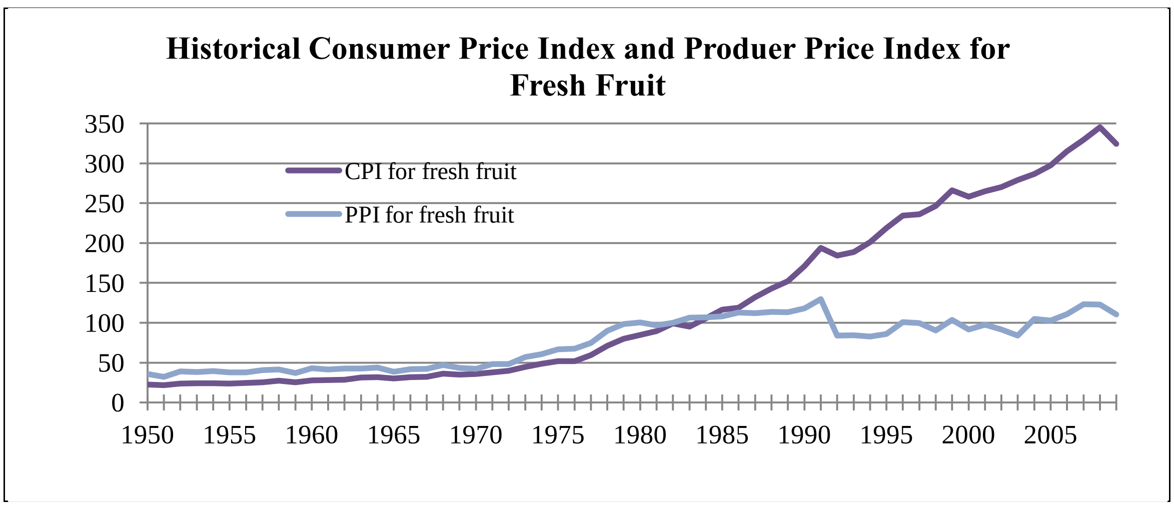


Figure 2. Historical consumer price index and producer price index for fresh fruit



Data source: BLS http://data.bls.gov/PDQ/servlet/SurveyOutputServlet

Table 1. Farm share (%) in retail price for fresh fruit and for major commodity groups (2008-2010)

Farm share in retail value for fresh fruit, 1997-2010

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
17.7	17.3	16.5	15.7	15.8	16.4	16.7	19.3	16.6	17.6	16.6	15.8	14.9	15.9

Table 2. Farm share in retail value for commodity groups, 2008-2010

	2008	2009	2010
Market basket			
Farm value-retail cost (%)	22.9	19.8	22.5
Meat products			

Farm value-retail cost (%)	31.2	28.8	31.6
Dairy products			
Farm value-retail cost (%)	33.2	25.3	31.9
Poultry			
Farm value-retail cost (%)	41.4	38.4	42.3
Eggs			
Farm value-retail cost (%)	46.3	38.0	40.0
Cereal and bakery products			
Farm value-retail cost (%)	9.6	6.9	7.1
Fresh fruit			
Farm value-retail cost (%)	15.8	14.9	15.9
Fresh vegetables			
Farm value-retail cost (%)	18.7	19.0	21.1
Processed fruits and vegetables			
Farm value-retail cost (%)	17.0	15.3	15.9

Source: Agricultural Outlook: Statistical Indicators, January 2011
http://www.ers.usda.gov/publications/agoutlook/aotables/

Appendix 2. Literature review

Previous studies attempted to explain how marketing margins may be determined within the setting of vertical marketing chains or upstream and downstream market structure. Among one of the first papers on this topic, Waugh (1934) discussed the measurement of marketing margins and the changes in margins over time. He suggested that the study of efficiency in marketing may be even more important than the study of production efficiency, and that the problem might require a dynamic explanation.

While Waugh emphasized the importance of marketing aspects in the integrated farm production system, formal modeling work was not provided much later. One of the earliest papers modeling the interactions among the vertically related markets is by Gardner (1975). In his paper on the farm-retail price spread in a competitive industry, Gardner developed a model, following Flyod (1965), to explain equilibria observed in the retail food, farm output, and marketing sectors. The primary focus of the paper is how the price spread responds to various shocks in the market system including shifts in demand, farm supply, or the demand or supply of marketing inputs. Wohlgenant (1985, 1989) further extended the empirical framework and examined retail-to-farm demand linkages. For fresh produce, he argued that the empirical results likely do not match the model prediction because of problems in aggregating such heterogeneous products into a single commodity. Even if Wohlgenant had obtained reliable results for fruits and vegetables, we would want disaggregated results for fruit and vegetables to use in any study focused on the price-retail spread of fruits and vegetables.

In an attempt to explain marketing margins, a series of studies on marketing margins devoted on the subject of market power Past studies on the market power hypothesis indicate that empirical evidence is mixed, depending on the industry studied. Holloway (1991), using the model used by Gardner (1975) tested for perfect competition in food industries. He failed to reject the hypothesis that food marketing sectors, including eggs, fresh fruits, fresh vegetables, and processed fruits and vegetables, are perfectly competitive on the basis of the price spreads in those industries. Kinnucan and Nelson (1993) examined the relationship between vertical control and price spread in the egg industry. Capps et al. (1995) also found the similar results in the U.S. lamb industry, concluding that increases in packer market power (as measured by the four-firm concentration index) had a positive effect on farm-retail price spreads.

Among this literature on marketing margins and market structure, some focused exclusively on perishable products such as fresh produce, which are known for their characteristic of inelastic short run supply. Sexton and Zhang (1996) modeled the short-run determination of farm prices for California iceberg lettuce. They characterize the industry as one in which there is imperfect competition in procurement, meaning that supply and demand does not determine a unique price and that monopsonistic buyers may extract surplus. They employed a switching regression framework, in which wholesale price is set equal to harvest cost at some times, and set above harvest cost at some value depending on the bargaining power of buyers. Their study results did not support either hypothesis that the wholesale market was perfectly competitive or that it is collusive. They found that, 30% of the time, the crop was sold at the harvest cost, and that the remainder of the time, the crop was sold at a marked-up price.

Similar to Sexton and Zhang, Richards and Patterson (2003) analyzed retailers' ability to set noncompetitive prices in fresh apples, table grapes, fresh California oranges, and Florida grapefruits. They showed that retail prices for semi-perishable fresh produce are mostly determined at the shipping point; that retail prices respond more rapidly to wholesale price increases than to decreases; and that retail prices are fixed relative to shipper prices, indicating that retailers possess bargaining power and control over prices. Sexton, Zhang and Chalfant (2003, 2005) extended Sexton and Zhang (1996)'s earlier study by applying their extended model to the iceburg lettuce industries and fresh tomato industries. This study examines supermarket retailer behavior in the procurement of iceberg lettuce from California and Arizona, vine-ripe and mature-green tomatoes from California, and mature-green tomatoes from Florida. The analysis relies upon both a reduced-form specification of farm-retail price spreads and a structural model of procurement for a perishable commodity with inelastic supply. The evidence supports a conclusion that buyers have been able to exercise oligopsony power in procuring iceberg lettuce from grower-shippers in California and Arizona. The evidence regarding buyer market power is more mixed for fresh tomatoes. The apparent success of the Florida mature-green tomato industry in enforcing a price floor and capturing a significant share of the surplus in excess of the price floor demonstrates the potential benefits to producers from coordinated behavior.

As Wohlgenant (2001) indicated in his chapter in the *Handbook*, marketing margins have attracted much attention and public scrutiny, but with little consensus. Some of the questions asked include: Are they too large? How have they changed? What variation is systematically explicable? How do they relate to market power? What is the incidence of marketing costs on retail and farm prices? What is the transmission for shocks to marketing costs to reach retail and farm prices? Does the concentration of middlemen help or hurt farmers? In his chapter, Wohlgenant addressed determinants of marketing margins, and modeling them in the context of fixed and variable proportions and markup pricing, concluding that none of these modeling approaches works perfectly. He also discussed lags in food price determination, with particular attention to the model of Wohlgenant (1985) in which any direction of changes in price spreads is theoretically possible.

Taking a more descriptive approach, some recent studies related issues on marketing margins to problems associated with data construction. More specifically, current low farm shares of fresh produce are partly due to the outdated method of data construction. Stewart (2006) examined the price indices published by the Bureau of Labor Statistics, focusing on aggregation processes used in price index calculations for fresh fruits and vegetables. He claimed that the composition of constant basket used to define an aggregate for fresh fruit or fresh vegetables was outdated. Unless these baskets are modified to take into account changes in consumers' preference or market place, the use of current price indices would undermine the studies conducted using these price indices. When he used the adjusted price indices, the updated estimates showed larger farm shares than the ones estimated using the current, unadjusted data series. The unadjusted data series estimated the 2004 farm share at 19 percent for fresh vegetables and 20 percent for fresh fruit; the updated consumer baskets yielded farm shares of 23.5 percent for fresh vegetables and 26.6 percent for fresh fruit. His study indicated that the existing (unadjusted) series overstated the decrease in farm share.

Some other studies attempted to explain marketing margins in the context of the recent emergence of discount stores. Leibtag (2006, 2010) investigated the relationship between the emergence of large discount food stores and retail food prices. Nontraditional stores, such as mass merchandisers, supercenters, club warehouses and dollar stores have increased their presence over the past decades and often present lower priced alternatives to conventional supermarkets. According to Martinez (2007), the U.S. food system has the increasing presence of nontraditional grocery retailers, and these developments have contributed to sharp increases in concentration in the grocery retail sector, changing conventional relationships among retailers, wholesalers, and manufacturers. The share of food retail by type of outlet indicates that nontraditional retail has increased 17% of its share in consumer food retail purchase in 1994 to 32% in 2005. He pointed out that the current CPI for food does not fully take into account the lower price option of nontraditional retailers and thus a gap exists between price changes as measured using scanner data versus the CPI estimate. Comparisons of identical items, at the Universal Product Code level, show an expenditure-weighted average price discount of 7.5 percent, with differences ranging from 3 to 28 percent lower in nontraditional stores than in traditional stores.

A more comprehensive review of the literature and an annotated bibliography are provided below.

Annotated Bibliograph

Frederick V. Waugh, 1934. "Margins in Marketing." *Journal of Farm Economics*, Vol. 16, No. 2, pp. 233-245.

In one of the first papers on the topic, Waugh discussed the measurement of marketing margins and the changes in margins over time. He suggested that the study of efficiency in marketing may be even more important than the study of production efficiency, and that the problem might require a dynamic explanation, a precedent for Wohlgenant (1985). He noted problems in gathering data, e.g., that the heterogeneity in cuts of beef and in dairy products makes determination of the farm-retail spread for beef and milk difficult. He also dealt with the regulation of marketing, writing that any regulatory limitation of competition should result in lower consumer prices, higher producer prices, or both.

Bruce L. Gardner, 1975. "The Farm-Retail Price Spread in a Competitive Food Industry." *American Journal of Agricultural Economics,* Vol. 57, No. 3, pp. 399-409.

In his paper on the farm-retail price spread in a competitive industry, Bruce Gardner developed a model to explain equilibria observed in the retail food, farm output, and marketing sectors. The primary focus of the paper is how the price spread responds to shifts in demand, farm supply, or the demand or supply of marketing inputs. He noted the importance of substitution within the marketing sector, which implies in a change of prices for both farm inputs and non-farm inputs when demand for food increases or supply of farm inputs increases. His conclusions are broad: no simple markup pricing rule can accurately represent the farm-retail price spread, because shifts may occur in any of the three sectors. He showed that (a) the effect of demand shifts on the retail-farm price ratio depends on the relative elasticity of supply of farm products and marketing inputs; (b) increased supply of farm products increases the ratio; (c) increased supply of marketing inputs decreases the ratio. He also derived results regarding the response of the price ratio to price ceilings and floors, and results that depend on the value of the elasticities of farm and retail demand and on the elasticity of substitution.

Michael K. Wohlgenant, 1985. “Competitive Storage, Rational Expectations, and Short- Run Food Price Determination.” *American Journal of Agricultural Economics*, Vol. 67, No. 4, pp. 739-748.

To explain farm-retail price spreads and price stickiness for food commodities, Wohlgenant developed a dynamic model in which producers derive price expectations according to the rational expectations hypothesis, and applied the model to estimate the implications of inventories on price spreads. In this model, the short-run market rental rate depends on anticipated gains or losses from holding inventories; that is, on the next period’s expected retail prices. Inventory costs consist of both (1) the physical costs of holding inventory, which increase with inventory; and (2) the costs of set-up and stocking out, which decline as inventory rises, for a given sales rate. Producers maximize the expected present discounted value of net revenue. He concluded that the estimating equation for retail price depends on the nature of the stochastic process by which next period’s wholesale price is determined. He also noted that by including overidentifying restrictions in his model, he could test the rational expectations hypothesis, and disentangle the effects of realized price from the effects of realized price on farm-retail price spreads.

Michael K. Wohlgenant and John D. Mullen, 1987. “Modeling the Farm-Retail Price Spread for Beef.” *Western Journal of Agricultural Economics*, Vol. 12, No. 2, pp. 119-125.

The authors used a relative price spread model, in which the price spread is calculated only relative to the industry output price and marketing input price, both deflated by the retail price. As Gardner (1975) noted, the common approach is to assume that price spread is determined as a combination of proportional and absolute markups, but this only works if shocks affect either supply or demand, and not both simultaneously. Wohlgenant and Mullen tested the relative price spread model using an application to beef, and showed that it performed better, empirically, than the common markup approach.

Michael K. Wohlgenant, 1989. “Demand for Farm Output in a Complete System of Demand Functions.” *American Journal of Agricultural Economics*, Vol. 71, No. 2, pp. 241-252.

Developed a new conceptual and empirical framework on retail-to-farm demand linkages. He showed that, except for fresh fruit, increases in retail demand are positively related to both retail and farm prices. These results are consistent with constant-returns-to-scale production technology. For two categories, (1) fresh fruits and (2) processed fruits and vegetables, he argued that the empirical results likely do not match the model prediction because of problems in aggregating such heterogeneous products into a single commodity. Even if Wohlgenant had obtained reliable results for fruits and vegetables, we would want disaggregated results for fruit and vegetables to use in any study focused on the price-retail spread of fruits and vegetables.

Garth J. Holloway, 1991. “The Farm-Retail Price Spread in an Imperfectly Competitive Food Industry.” *American Journal of Agricultural Economics*, Vol. 73, No. 4, pp. 979-989.

Used the model of Gardner (1975) to test for perfect competition in food industries. He failed to reject the hypothesis that food marketing sectors, including eggs, fresh fruits, fresh vegetables, and processed fruits and vegetables, are perfectly competitive on the basis of the price spreads in those industries.

Henry W. Kinnucan and Robert G. Nelson, 1993. “Vertical Control and the Farm-Retail Price Spread for Eggs.” *Review of Agricultural Economics*, Vol. 15, No. 3, pp. 473-482.

Examined whether increased vertical control in the egg industry hurts welfare, because market power enables price markups, or helps welfare through increased farm-to-retail co- ordination (i.e., efficiency in the marketing sector). Over the period 1973-1983, the farm-retail price spread decreased by 42% as vertical control—contracts and vertical integration—increased. Using OLS and modeling production technology as constant-returns-to-scale, the authors found a highly significant negative relationship between price spread and vertical control, and concluded that vertical control improves welfare because of improved coordination. This is in the context of a product with fixed-proportions technology, with very little processing between farmgate and retail. They estimated that 58% of the decrease in price spread is attributable to increased vertical control. Thus, their result is consistent with the results of Holloway (1991): vertical control is not anti-competitive. They do not use any variation in quality (considering only large Grade A eggs); but they do use variation in seasonality on a quarterly basis.

Oral Capps, Jr., Patrick J. Byrne, and Gary W. Williams, 1995. “Analysis of Marketing Margins in the U.S. Lamb Industry.” *Agricultural and Resource Economics Review*, Vol. 24, Issue 2, pp. 232-240.

Showed that in the lamb industry, increases in packer market power (as measured by the four-firm concentration index) had a positive effect on farm-retail price spreads. Augmented the relative price spread method of Wohlgenant and Mullen (1987).

Richard J. Sexton and Mingxia Zhang, 1996. “A Model of Price Determination for Fresh Produce with Application to California Iceberg Lettuce.” *American Journal of Agricultural Economics*, Vol. 78, No. 4, pp. 924-934.

Modeled the short-run determination of farm prices for fresh produce that has in- elastic short-run supply, with an empirical application to the iceberg lettuce industry in California. They characterize the industry as one in which there is imperfect competition in procurement, meaning that supply and demand do not determine a unique price and that monopsonistic buyers may extract surplus. They employed a switching regression frame- work, in which wholesale price is set equal to harvest cost at some times, and set above harvest cost at some value depending on the bargaining power of buyers. Under perfect competition, farmers would receive all existing rents, and Sexton and Zhang tested the null hypothesis that farmers’ bargaining power was inversely related to the volume of lettuce on the market. They rejected both the hypotheses that the wholesale market was perfectly competitive and that it is collusive; they found that, 30% of the time, the crop was sold at the harvest cost, and that the remainder of the time, the crop was sold at a marked-up price.

Michael K. Wohlgenant, 2001. “Marketing Margins: Empirical Analysis.” Chapter 16 in *Handbook of Agricultural Economics*, Volume 1. B. Gardner and G. Rausser, eds. Elsevier Science B.V.

In this *Handbook* chapter, Wohlgenant wrote that marketing margins have attracted much public scrutiny, but little consensus. Among the questions commonly asked are: Are they too large? How have they changed? What variation is systematically explicable? How do they relate to market power? What is the incidence of marketing costs on retail and farm prices? What is the transmission for shocks to marketing costs to reach retail and farm prices? Does the concentration of middlemen help or hurt farmers? In the chapter, Wohlgenant addressed determinants of marketing margins, and modeling them in the context of fixed and variable proportions and markup pricing, concluding that none of these modeling approaches works perfectly. He also discussed lags in food price determination, with particular attention to the model of Wohlgenant (1985) in which any direction of changes in price spreads is theoretically possible.

Timothy J. Richards and Paul M. Patterson, 2003. “Competition in Fresh Produce Markets: An Empirical Analysis of Marketing Channel Performance.” USDA-ERS Contractor and Cooperator Report No. 1.

This paper analyzed retailers’ ability to set noncompetitive prices in fresh apples, table grapes, fresh California oranges, and Florida grapefruits. Similar to Sexton and Zhang (1996), this analysis employed a switching regression framework. They showed that retail prices for semi-perishable fresh produce are mostly determined at the shipping point; that retail prices respond more rapidly to wholesale price increases than to decreases; and that retail prices are fixed relative to shipper prices, indicating that retailers possess bargaining power and control over prices. They also found evidence of tacit collusion, using an econometric specification developed by Green and Porter (1984). Their tests showed that retailers exhibit market power in both buying and selling of fresh apples and grapefruit, and market power in the sale of fresh oranges. Finally, they showed that retailer power falls as the quantity of commodity sold increases.

Richard Sexton, Mingxia Zhang, and James Chalfant, 2003. “Grocery Retailer Behavior in the Procurement and Sale of Perishable Fresh Produce.” USDA-ERS Contractor and Cooperator Report No. 2.

In this publication, the authors applied the model of Sexton and Zhang (1996) to new industries, tested for changes in farm-retail spread as a function of production volume and shipping costs, and tested for any overall trends in farm-retail spread in these industries. Under perfect competition, the variations in the spread would be fully explained by variations in sellers’ marginal cost. Under competition, an increase in volume should decrease the farm-retail spread, if an increased volume gives sellers more bargaining power. On the other hand, if the spread increases as a function of volume, then buyers are acting as oligopsonists. They conclude that, in the California and Arizona iceberg lettuce and fresh tomato industries, there is strong evidence that increases in marketed volume increase the farm-retail price spread, and that, in Florida, a high degree of industry coordination helps protect mature-green tomato growers from price fluctuations. Further, they found that retail chains tended to stabilize retail prices, a strategy that reduces total surplus and therefore farm-sector income. Inelastic demands for produce, driven partly because consumers are unwilling to shop at multiple grocery stores, enables retail markups over marginal cost, and harms upstream producer welfare. Finally, they find that there is no consistent relationship between the prices of bagged iceberg salads and the farmgate price of iceberg lettuce.

Julian M. Alston, Daniel A. Sumner, and Stephen A. Vosti, 2006. "Are Agricultural Policies Making Us Fat? Likely Links between Agricultural Policies and Human Nutrition and Obesity, and Their Policy Implications." *Review of Agricultural Economics* Vol. 28, No. 3, pp. 313–322.

Showed that over 1960–2003, there has been a clear downward trend in commodity prices, with an exception in beef cattle, which has had several temporary price increases. Over somewhat shorter periods within 1960–2003 for which data are available, the farmgate price of tomatoes, broccoli, potatoes, and apples fell significantly, while the farmgate price of lettuce, asparagus, and table grapes increased; oranges showed no trend after 1970. Meanwhile, the authors showed that consumer prices for food had no strong relationship with farm prices. Part of the lack of correlation was attributed to quality improvements not seen in the data, such as improved packaging or processing, and also to increased seasonal availability of items such as strawberries. These quality improvements cannot be easily measured, so changes in marketing margins for fresh fruits and vegetables over time are also difficult to estimate.

Hayden Stewart, 2006. "How Low Has the Farm Share of Retail Food Prices Really Fallen?" USDA-ERS Economic Research Report Number 24.

Conventional analysis showed that the farm share of the consumer's food dollar, in produce, decreased from 34% to 19% for fresh vegetables and from 33% to 20% for fresh fruits over 1982–2004. However, the conventional analysis is problematic because it uses the same basket of goods in 1982 and 2004. Stewart revised this analysis using the current basket of goods, and showed that the farm share of the consumer's food dollar is somewhat higher than the conventional analysis, but still lower than in 1982: 23.5% for fresh vegetables and 26.6% for fresh fruits.

Ephraim Leibtag, 2006. "The Impact of Big-Box Stores on Retail Food Prices and the Consumer Price Index." USDA-ERS Economic Research Report Number 33.

Explored the effects of the expansion of big-box retailers on retail food prices. While the price of food has increased annually by less than 3% per year (according to the CPI), prices at any one point in time vary by approximately 10% across store formats, i.e., between conventional supermarkets and big-box retailers such as Wal-Mart, Target, and Costco. Leibtag showed that previous price comparisons across store formats overestimated the price difference, by not controlling for differences in package-size or quality. In an earlier paper, Hausman and Leibtag showed that, by not accounting for a shift in store formats from conventional supermarkets to big-box retailers, the CPI overestimated the inflation rate by up to 15%. This study improved estimates further, by accounting for variation in package weight, using ACNielsen Homescan data. He showed that less-processed products show more variation in prices, and argued that entry of big-box stores forces other retailers to lower prices. Overall, he concluded that consumer welfare increased because of the entry of big-box stores, but did draw conclusions about producer (farmer) welfare.

Fred Kuchler and Hayden Stewart, 2008. "Price Trends Are Similar for Fruits, Vegetables, and Snack Foods." USDA-ERS Economic Research Report Number 55.

This paper built on Alston, Sumner, and Vosti (2006). The authors selected 11 fresh pro- duce commodities for which there has been relatively little change in quality over the period analyzed (1980–2006, for six commodities, and a shorter period for five other commodities). They showed that for 9 of 11 fresh produce commodities considered, the consumer price fell by 0.5–1.6% per year. For the other two commodities, broccoli and field-grown tomatoes, there was significant change in processing (e.g., broccoli florets) and in technology and product attributes (for field-grown tomatoes) over the period. The authors also discussed how produce departments in grocery stores nearly doubled the number of SKUs available over 1987–1997, and consumers tended to spend more on partially-processed products at the end of the period.

Sunil P. Dhoubhadel, Sergio C. Castillo, and Oral Capps, Jr., 2009. "Analysis of Marketing Margins under Food Recalls and BSE Outbreaks in the U.S. Beef Industry." Selected Paper prepared for presentation at the Agricultural & Applied Economics Associations 2009 AAEA & ACCI Joint Meeting, Milwaukee, WI, July 26-28.

Found that BSE announcements in the USA and Canada increase marketing margins, whereas recalls do not increase farm-to-retail margins. Severe recalls do have a positive effect on marketing margins from farm-to-wholesale, but decrease the margin from wholesale-to-retail. Used the augmented relative price spread method of Capps et al. (1995).

Timothy J. Richards, Ram Acharya, and Ignacio Molina, 2009. "Retail and Wholesale Market Power in Organic Foods." Selected Paper prepared for presentation at the Agricultural & Applied Economics Association 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29.

Showed that the supply of organic apples is limited by the standards that must be met to attain organic certification; while demand for organic apples (and other fruits and vegetables) continues to grow, supply has been slow to adjust. They wrote that it is unclear whether the high premium paid at retail for organic fruits and vegetables is attributable to additional producer costs or to demand. They used a random coefficients, mixed logit model with a generalized extreme value distribution of the error term to tease out supply effects from demand effects, and modeled the retailer as a Stackelberg follower, and upstream producers as a Stackelberg leader. They showed that the upstream producers' margin was higher for organics than for non-organics, and upstream producers capture most of the rents for organics, although their share has been decreasing over time. Conversely, retailers captured most of the rent for non-organic fresh produce.

Timothy Woods, Sayed Saghaian, and Lucia Ona, 2009. “Will Higher Shipping Costs Drive the U.S. to Source More Localized Produce?” Selected paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Atlanta, Georgia, January 31-February 3.

Explored the effects of increased shipping costs on retail prices and discussed a possible shift in consumption toward local produce. The authors used OLS to examine the change in consumer prices of three fresh produce commodities with different values and different degrees of perishability. They showed that, at “peak diesel prices,” the price of high-value, highly perishable strawberries increased by $2.8 - 5.4\%$; the prices of lower-value, less-perishable lettuce and low-value, even-less-perishable potatoes increased by $10.8 - 22.1\%$ and $10.8 - 29.0\%$, respectively. However, I doubt that the effects of diesel price on retail prices of fresh produce can be accurately determined using OLS, because of the endogeneity of supply and demand effects.

Byeong-Il Ahn and Daniel A. Sumner, 2009. “Political Market Power Reflected in Milk Pricing Regulations.” *American Journal of Agricultural Economics*, Vol. 91, No. 3, pp. 723-737.

Developed a model of price differentials allowing, simultaneously, for local monopolies in fluid milk retail and a Nash equilibrium in the national market for manufacturing milk products. They simulated the price differentials for fluid and manufacturing-use milk that would be sought by a monopolist, and specified by U.S. milk marketing orders, and find that the actual price differentials are only about 7% of those that maximize monopolist profit. Second, they simulate the policies that would be set by regional regulators under different welfare weights and find that the political power of milk producers is also only about 7% of that of a monopolist.

Celine Bonnet, Pierre Dubois, Sofia B. Villas Boas, and Daniel Klapper, 2011. “Empirical Evidence on the Role of Non Linear Wholesale Pricing and Vertical Restraints on Cost Pass-Through.” Working paper.

Showed that in the German ground coffee market, the use of retail price maintenance— in which retail price is specified by the manufacturer—increases the pass-through rate of price shocks in the supply chain, because retailers have limited capability of performing strategic price markup.

Dale M. Heien, 1980. “Markup Pricing in a Dynamic Model of the Food Industry.” *American Journal of Agricultural Economics*, Vol. 62, No. 1, pp. 10-18.

Developed a dynamic model of farm and retail pricing. Tested the hypothesis that price changes are transmitted from wholesale-to-retail using 24 commodities. Among produce commodities, the results supported the hypothesis for oranges, frozen orange juice, potatoes, and frozen French fries; the results suggested bidirectional causality for fresh orange juice and canned tomatoes; and they suggested independence between wholesale and retail prices for eggs, apples, tomatoes, and lettuce.

Ronald W. Ward, 1982. “Asymmetry in Retail, Wholesale, and Shipping Point Pricing for Fresh Vegetables.” *American Journal of Agricultural Economics*, Vol. 64, No. 2, pp. 205-212.

Analyzed price linkages in fresh vegetables between retail, wholesale, and shipping point. Tested the hypothesis that there should be strong linkages between the three points, because fresh vegetables require minimal processing. He found that both retail and shipping point prices generally lagged wholesale prices, and offered the hypothesis that wholesale markets were more concentrated as the explanation. Further, he tested for asymmetry in price transmission from wholesale to retail and shipping point and found that retail prices tended to respond more quickly to wholesale price increases than to decreases. (The asymmetry was observed in celery, cabbage, corn, green peppers, potatoes, and tomatoes, while symmetry was observed only in carrots and cucumbers.) Finally, he found that the farm-retail price spread had widened over time.

J.S. Shonkwiler and T.G. Taylor, 1988. "Food Processor Price Behavior: Firm-Level Evidence of Sticky Prices." *American Journal of Agricultural Economics*, Vol. 70, No. 2, pp. 239-244.

Used an empirical friction model to show that the indirect costs of changing prices, for a major processor of frozen, concentrated orange juice, caused price rigidity. Found that prices are equally rigid in response to increases and decreases in indirect costs.

Daniel H. Pick, Jeffrey Karrenbrock, and Hoy F. Carman, 1990. "Price Asymmetry and Marketing Margin Behavior: An Example for California—Arizona Citrus." *Agribusiness*, Vol. 6, No. 1, pp. 75-84.

Estimated the extent and timing of retail price changes for lemons and Navel oranges in response to changes in FOB price. Also estimated changes in marketing margins, which the authors expected to increase in response to increases in FOB price. Employed a method similar to Heien (1980) and Ward (1982). First, they determined that for lemons, the retail price was more volatile than the FOB price; however, there was no similar relationship that held for oranges across all four markets studied. For lemons, the authors found that retail markets responded more to FOB increases than decreases in two of the four markets, and could not reject symmetric response in the other two markets. For oranges, three markets showed asymmetric responses to FOB price increases and one showed a symmetric response. About one of the four markets (depending on the test) showed the expected response of marketing margins to FOB price changes. Finally, they conclude that there was a direct relationship between responsiveness of retail price to FOB price changes and responsiveness of marketing margins to FOB price changes.

Nicholas J. Powers, 1995. "Sticky Short-Run Prices and Vertical Pricing: Evidence from the Market for Iceberg Lettuce." *Agribusiness*, Vol. 11, No. 1, pp. 57-75.

Used the approach of Heien (1980) to examine the transmission of price changes in California iceberg lettuce, from farmgate to wholesale to retail. Found that the response of wholesale prices to FOB prices was symmetric (to increases and decreases), that the price changes fully passed through, and responses were also symmetric to trucking cost changes. Found that retail prices responded more slowly to wholesale price changes than wholesale prices responded to FOB price changes. Retail prices responded at least as fast, and with greater magnitude, to increases in wholesale prices than to decreases, but the price changes exhibited only partial pass-through.

Finally, the author simulated the effects of offering constant FOB price for a month, and found that the consumer price should be lower under such a buyer policy.

Other papers on marketing margins in beef—all cited in Doubhadel, Castillo and Capps (2009):

Armah. S. 2007. “An Empirical Analysis of Recent Changes in U.S. Beef Marketing Margins.” Selected paper prepared for presentation at the American Agricultural Economics Association annual meetings, Portland, Oregon, 29 July - 1 August.

Brester, G. W., and J. M. Marsh. 2001. "The Effects of U.S. Meat Packing and Livestock Production Technologies on Marketing Margins and Prices." *Journal of Agricultural and Resource Economics* 26:445-462.

Hall, L., A. Schmitz, and J. Cothern. 1979."Beef Wholesale-Retail Marketing Margins and Concentration." *Economica* 46:295-300.

Lloyd, T. A., McCorriston, S, Morgan, C. Wyn, and Rayner, A. J. 2006. "Food Scares, Market Power and Price Transmission: The UK BSE Crisis”. *European Review of Agricultural Economics* 33(2):119-147.

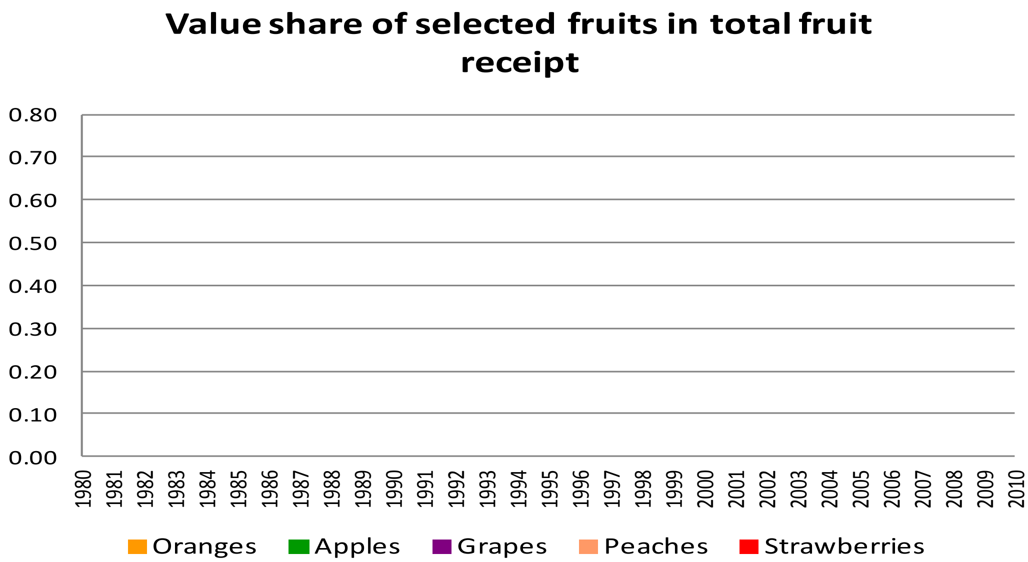
Marsh, J., and G. Brester. 2004: “Wholesale-Retail Margin Behavior in Pork and Beef,” *Journal of Agricultural and Resource Economics* 29:45–64.

Appendix 3.

We have selected five representative fruits as our focus commodities. Those are oranges, apples, grapes, peaches and strawberries. These five fruits represent between 60%-70% of cash receipts for all fruits received by U.S. fruit farmers.

Table. Value share for selected fruits in total cash receipt from all fruits

Year	oranges	apples	grapes	peaches	strawberries	sum of shares
1980	0.23	0.12	0.23	0.06	0.04	0.69
1981	0.22	0.13	0.22	0.07	0.05	0.70
1982	0.22	0.14	0.23	0.04	0.07	0.70
1983	0.24	0.13	0.19	0.05	0.07	0.69
1984	0.23	0.16	0.16	0.05	0.07	0.67
1985	0.22	0.14	0.15	0.05	0.07	0.64
1986	0.19	0.14	0.18	0.05	0.08	0.64
1987	0.19	0.15	0.19	0.04	0.08	0.66
1988	0.22	0.12	0.20	0.05	0.07	0.65
1989	0.22	0.12	0.22	0.04	0.07	0.67
1990	0.20	0.13	0.20	0.05	0.07	0.65
1991	0.17	0.18	0.20	0.04	0.07	0.67
1992	0.16	0.18	0.21	0.04	0.08	0.67
1993	0.17	0.16	0.23	0.04	0.08	0.68
1994	0.18	0.15	0.21	0.04	0.09	0.68
1995	0.18	0.16	0.21	0.04	0.09	0.68
1996	0.17	0.18	0.23	0.04	0.07	0.69
1997	0.16	0.13	0.28	0.04	0.08	0.69
1998	0.21	0.13	0.24	0.04	0.09	0.72
1999	0.14	0.13	0.28	0.04	0.11	0.70
2000	0.16	0.13	0.28	0.04	0.09	0.70
2001	0.15	0.12	0.28	0.05	0.10	0.69
2002	0.15	0.13	0.26	0.04	0.11	0.68
2003	0.14	0.15	0.23	0.04	0.12	0.68
2004	0.12	0.14	0.25	0.04	0.11	0.66
2005	0.14	0.13	0.26	0.04	0.10	0.66
2006	0.14	0.14	0.23	0.04	0.11	0.66
2007	0.12	0.14	0.23	0.03	0.12	0.64
2008	0.13	0.17	0.21	0.03	0.12	0.66
2009	0.12	0.13	0.23	0.04	0.14	0.66
2010	0.12	0.13	0.21	0.04	0.13	0.63



Source: Fruit and tree nut yearbook 2011 Economic Research Service, USDA

Appendix 4. BLS price and index aggregation:

The primary issue regarding price data in the context of grower margins concerns aggregation issues surrounding retail prices. Commodity level prices and price indexes are available at the grower as well as retail levels mostly from USDA and BLS. USDA collects and provides market level price data for many major agricultural products. Even though USDA provides data at all marketing levels, their data effort especially focuses on grower level. For the retail level, USDA does not provide a comprehensive data base, and often relies on BLS sources. For example, grower margins provided by USDA are based on BLS retail price data. Thus, in understanding and interpreting these values, it is very important to understand how these BLS price data are generated.

All prices or indexes published by BLS (as well as other places) are the products resulting from some type of aggregation process. Publicly accessible data are usually generated from initially much disaggregated data information. That is, monthly prices can be created by aggregating weekly or daily prices, or in the case of spatial aggregation, urban prices in a region, for example, can be created by aggregating prices collected from designated urban locations in that region. In general, the data collection agency initially collects data on a daily, weekly or monthly basis (depending on the transaction of commodity) at many locations of the country for a given commodity. In general, this initially very detailed data information is further summarized (or aggregated) over time and locations, which then is published as monthly or annual data for the nation or a region as a whole.

BLS usually uses the simple average method to construct annual data, rather than the quantity weighted method. USDA uses both weighted average and simple average methods in the construction of annual grower received prices. (Shipment quantities are supplied from USDA's Agricultural Marketing Services.) During the peak season, market quantities tend to be high and prices are low, and during the early or late season, market quantities tend to be small and prices are high. A similar situation extends even to off-seasons. In the past decades, imports of fresh fruit have continued to increase and fresh fruits have been more readily available during the off-season. Naturally, off-season products consist mostly of imports, and off-season prices are typically higher than the season price. This implies that the annual consumer prices generated using seasonal as well as off-seasonal prices are expected to be higher than the typical price that would prevail during the season. The consequence of the simple average (say, a simple average of monthly prices) method used in generating annual retail prices is the upward bias of the price compared to say, the weighted average.

USDA relies on BLS for retail price information in their analysis of price including marketing margins. For instance, the Economic Research Service obtains retail data on national average prices (U.S. city-average price data) from the BLS and uses in their calculation of grower margins (published in the USDA yearbook for fruits and nuts). (For documentation for data collection descriptions, refer to the website *ERS*/data sets/price spreads from farm to consumer/documentation, http://www.ers.usda.gov/Data/FarmToConsumer/pricespreadsdoc.htm*)* The implication of these higher retail prices in farm share calculation may lead to a consistently biased number, in this case, a lower farm share.

Another issue concerning BLS retail prices relates to the compatibility with farm price data in the calculation of farm share in the retail price. With increasing globalization, products at the retail level, even for fresh produce, are increasingly more available during the domestically off-season period. This implies that retail prices are available for a much longer period than farm prices. It is also likely that retail prices collected during the off season are relatively high. Longer season in retail markets: Even in the absence of constant pricing, falling farm shares can be realized as fresh produce is increasingly more available to consumers (increase in off-season imports). Retail price data include non-season prices which may be relatively high compared to the season price. However, producer prices include the value only in the season.

Due to the BLS's retail pricing calculation, retail prices are overestimated, which results in widening marketing margins over time. The possibility of retail prices being overestimated is based on the following facts. Retail prices are mostly collected from BLS. Grower received prices are collected from USDA. Increased imports during the off-season and the wider availability of early and late fruit varieties expand the availability of fruits at the retail level beyond the period that is considered traditionally as a season for each fruit. Thus, retail prices are collected over the span that expands beyond the season.

Prices of imported products sold at retail during non-season are likely higher than the domestic season price. Thus, the inclusion of off-season prices in the calculation of average prices likely result in a higher unweighted average retail price than the one calculated using only in-season prices. This will lead to the overestimated margin between retail to farm prices. The fact that farm prices are available only during the domestic in-season implies that the retail prices used in farm share calculation should also include in-season prices.

Appendix 5. Data Sources

Price data for individual commodities
http://www.nass.usda.gov/QuickStats/

Select Quick stat 1.0, then US & State-Prices
Agricultural crop prices: Monthly and annual prices of selected crops. Prices are provided in many different forms-received, paid, fob, etc. Annual prices go back many decades but monthly prices go back at most 1997.

Note that Quick Stat 2.0 also has lots of data.

Trade data

http://www.fas.usda.gov/gats/default.aspx
USDA, Foreign Agricultural Service, Global Agricultural Trade System. Crop specific trade data include import and export quantities and values of fresh fruits including peaches, apples, nectarines, strawberries, kiwis, avocadoes, oranges for 1989-2009

California Production Data
-Shorter time series (some include monthly level)
http://www.nass.usda.gov/Statistics_by_State/California/Publications/Fruits_and_Nuts/index.asp#
This site offers alphabetically indexed California production data at monthly level (from 2001) for selected crops and at annual level (from 1990s) for most major crops.

-Longer time series
http://www.nass.usda.gov/Statistics_by_State/California/Historical_Data/index.asp
this site provides longer historical California data for acreage, production, unit value by crop. For major field crops, data goes back to 1920 and for many specialty crops data goes back to 1987.

Comprehensive specialty crop data:
http://usda.mannlib.cornell.edu/MannUsda/viewTaxonomy.do?taxonomyID=6
Includes comprehensive data from NASS, FAS, ERS for individual specialty crops and selected value added products. This site also has links to various USDA regular publications.

USDA data released in regular publications

ERS fruit and tree nut year book (spreadsheet files)
Yearbook for the most recent year, 2011. Links to yearbooks for other years are also provided.
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377

Agricultural prices summary
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003
Publication dates: Jun 01, 1964 To Nov 30, 2009. Beginning in 2010, the Agricultural Prices Summary is no longer published. All price data series are available from NASS' online Quick Stats database. These data are updated monthly by commodity with the most current estimates available. So, it seems that QuickStats has all the information, but it is possible some of old data may not have been transferred and for old data this site may be useful.

NASS Noncitrus Fruits and Nuts
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1113
Publication dates: Jan 14, 1974 To Jul 07, 2011
Not in excel form

Agricultural Marketing News price data (go to the end)

Bureau of Labor Statistics
http://www.bls.gov/data/
Types of data available: CPIs, PPIs and actual retail price data

Various CPIs for urban consumers (not seasonally adjusted):

- CPI food index monthly and annually (1913-2010),
- CPI fresh fruit price index for monthly and annually (1947-2010) (apples1939-2010, bananas 1939-2010, fresh citrus 1998-2010, oranges 1939-2010, other fruits 1998-2010) ,
- CPI fresh vegetable price index, monthly and annually (1947-2010)

Various Producer Price Index:

- PPI farm products, monthly and annually (1948-2010)
- PPI fresh fruits and melons, monthly and annually (1947-2010)
- PPI fresh oranges (1947-2010), PPI fresh apples (1947-2010)

Retail data: http://data.bls.gov/cgi-bin/dsrv?ap either monthly or semi-annual data are provided.

- Area options: US city average, Northeast urban, Midwest urban, South urban, West urban, City size A (further divided into city regions)
- Commodity options: using six digit commodity code (for example, 711415 strawberries, dry pint, per 12oz)
- Data availability depends on area options and commodity options, and data goes back as old as 1980.

Agricultural Marketing Service of USDA

Fruit and Vegetable Market News

The first *Market News* was published in 1915 by the Department of Agriculture at Hammond, Louisiana, on the price and movement of local strawberries. Subsquently, more fruit and vegetable market information at six terminal markets (New York City, Chicago, Saint Louis, Kansas City, Buffalo and Baltimore) and at seven seasonal shipping point stations throughout the country were added to *Market News*.

The Fruit and Vegetable Market News Service collects information on the current supply, demand and prices on nearly 400 domestic and 70 international fruits, vegetables, nuts, ornamental and specialty crops. Data are collected via interviews in person and telephone survey with salespersons, brokers and buyers. Market News data are available through the Fruit and Vegetable Market News Portal, where users can access current and historical price and movement information. The Portal offers customized views and downloads of data back to 1998 for terminal prices, shipping point prices, movement and specialty crop information.

Agricultural Market News reports publish daily, weekly and seasonal price aggregates for the shipping point (or FOB), terminal (or wholesale) and retail markets. We have examined weekly prices in some detail. The prices at the shipping point were provided in most detail, classified by product variety, size, grade, container, and districts where products were originated. Terminal prices also include these product/container information for each terminal market location. Retail prices were reported in less detail; they are classified by variety, size (depending on the fruit), and broadly defined region.

USDA Market News Portal: http://www.marketnews.usda.gov/

USDA Fruit and Vegetable Market News portal: http://www.marketnews.usda.gov/portal/fv

Retail data details

Fruit and Vegetable Market News surveys more than 200 retailers, comprising roughly 17,000 individual stores, with online weekly advertised features. Information represents advertised prices for fruits and vegetables at major retail supermarket outlets. Weighted Averages are simple weighted averages and prices are in dollars per pound unless otherwise stated.

Region categories: Regions in the US are grouped into six areas, Northeast US, Southeast US, Midwest US, South Central US, Southwest US, and Northwest US. Data are available for National or each of these regions separately.

Types of retail prices available are: weighted average price, high and low prices among the surveyed prices on a weekly basis. These prices are available by region, variety, organic vs. conventional.

Terminal price data details

The term of terminal market refers to a physical location in a metropolitan area where produce is sold by wholesalers to retailers or other large users in wholesale lots. Market reporters gather information on terminal markets sales primarily through personal interviews with sellers and buyers.

Terminal markets for which terminal market prices are available are:

Market	Dates available
Atlanta	01/02/1998 - Current
Baltimore	01/02/1998 - Current

Boston	01/02/1998 – Current
Chicago	01/02/1998 – Current
Columbia	01/02/1998 – Current
Dallas	01/02/1998 – Current
Detroit	01/02/1998 – Current
Los Angeles	01/02/1998 – Current
Miami	01/02/1998 – Current
New york	01/23/1998 – Current
Philadelphia	01/05/1998 – Current
Pittsburgh	01/02/1998 – Current
San Francisco	01/02/1998 – Current
Seattle	01/02/1998 – Current
St.Louis	01/02/1998 – Current

Each price is provided with following description:

Terminal (Wholesale) Market: Location where the product is sold.

Container: Container or package in which the product is sold. Example: Cartons Tray Pack

Variety/Subvariety: The name of the variety pertaining to the commodity. For example, on apples the variety might be Red Delicious. Sometimes a variety has additional details and this is shown as a sub variety.

Grade: The grade that applies to the product. Generally this is a U.S. or State grade. Example for Washington apples: WA ExFcy – Washington Extra Fancy

Organic: Refers to product that has been grown organically, according to the Organic Foods Production Act (OFPA) of 1990.

Date: Date of Report

Low-High Price: Primary price range showing low price and high price.

Origin: State or Country from which the product originated (Pennsylvania and Washington in the example shown)

Origin District: The district within the state or country from which the product originated. Sometimes the district is spans several states, as in “New England” or “Klamath Basin.”

Item Size: The size of the items within the container (or unit). For example apples in cartons tray pack may have 88 apples or 100 apples in the same size container, and they would be listed as 88s and 100s respectively. 88s designate a larger apple than 100s. Examples of other sizes are "large" or "small" as in the case of bell peppers, "standard," an industry determined size for asparagus, and 10-oz minimum or Size A for potatoes.

Environment: These values signify the environment conditions under which a commodity is grown. Environment types are: Greenhouse, Greenhouse Hydroponic, Greenhouse Including Hydroponic, and Field Grown.

Color: The specific color for a particular commodity or variety

Unit of Sale: The unit at which the product is sold. Examples include “per pound” and “per melon”

Storage: Storage or other external factors affecting the product. Examples are “Controlled Atmosphere Storage,” “Regular Storage, “ and “Unwashed.”

Trans Mode: The transportation mode at which the product arrived on the market. Examples are ”Truck,” “Air,” “Boat,”,“Rail”, “Piggyback”, and “Import”.

Shipping point price details

The term of shipping point refers to the point (location) of production or port of entry from which the produce is originally shipped. The shipping point is included in a geographical area often referred to in *Market News* reports as a “district” in which several shippers are located. Market reporters gather information on shipping point sales primarily through telephone interviews with sellers and buyers. Shipping point reporters also collect information on the volume of product sold and this is shown in shipment or movement reports.

Each price is described with following characteristics:

District: Region where product originated. This may be a region within a state, or a port of entry for a foreign commodity or a general area covering two or more states.

Container: Container or package in which the product is sold. Example: Cartons Tray Pack

Variety/Subvariety: The name of the variety pertaining to the commodity. For example, on apples the variety might be Red Delicious. Sometimes a variety has additional details and this is shown as a sub variety.

Grade: The Grade that applies to the product. Generally this is a U.S. or State grade. Example for Washington apples: WA ExFcy “WA ExFcy - Washington Extra Fancy ”.

Organic: Refers to product that has been grown organically, according to the Organic Foods Production Act (OFPA) of 1990.

Date: Date of Report

Low-High Price: Primary price range showing low price and high price

Season: The crop-year of the commodity, based on the harvest start date. For example, if the apple harvest begins in August, the season begins in August and runs until the product is sold. For apples the season 2009 may include sales from August 2009 to July 2010. Each commodity has its own season, based on the area where it is produced.

Item Size: The size of the items within the container (or unit). For example apples in cartons tray pack may have 88 apples or 100 apples in the same size container, and they would be listed as 88s and 100s respectively. 88s designate a larger apple than 100s. Examples of other sizes are "large" or "small" as in the case of bell peppers, "standard," an industry determined size for asparagus, and 10-oz minimum or Size A for potatoes.

Environment: These values signify the environment conditions under which a commodity is grown. Environment types are: Greenhouse, Greenhouse Hydroponic, Greenhouse Including Hydroponic, and Field Grown.

Color: The specific color for a particular commodity or variety

Unit of sale: The unit at which the product is sold. Examples include “per pound” and “per melon”

Storage: Storage or other external factors affecting the product. Examples are “Controlled Atmosphere Storage,” “Regular Storage,” and “Unwashed.”

Import/Export: Indicates whether the sale is for domestic consumption or for exporting

Appendix 6

Asymmetric transmission between terminal and shipping point prices for selected fruits

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Asymmetric transmission between terminal and shipping point prices for selected fruits

Price transmission has drawn widespread interest from economists. Previous studies analyzed price relationships in both input and output markets, among different links along the supply chain, and across nodes in spatially disperse markets. A variety of products—from agricultural commodities to petroleum products—has been the subject of empirical work.

One common assumption used in studies of price transmission is symmetry of responses to shocks. That is, the magnitude of price transmission across markets or nodes does not depend on the direction (up or down) of the initial price shock (Wohlgenant, 2001). A few studies applied to agricultural commodities have attempted to investigate empirically this assumption using a more general framework that separates the regimes by the direction of initial price shock and allows the possibility of non-symmetric transmission (Karrenbrock, 1991; Azzam, 1999; Meyer and von Cramon-Taubadel, 2004; Kaufmann, 2005; Ahn and Kim, 2008). Following this line of literature, commonly referred to as asymmetric price transmission, the present study adds to the price transmission literature on specialty crops by investigating the structure of price transmission in the context of the vertical market chain for fruit markets in the United States. Focusing on the initial shipping point and terminal (wholesale) links in the marketing chain, we examine short-term as well as cumulative price responses of terminal prices to changes in shipping point prices.

In addition to providing empirical evidence related to asymmetry, previous studies on asymmetric price transmission explored the interpretation of asymmetric price transmission. If the markets were efficient, (and some additional conditions are met) a price shock in one market affects the price of the related market in a symmetric fashion. This suggests that the test of asymmetry could be used to investigate market efficiency, and the evidence of asymmetry would be consistent with a market with asymmetric transaction costs, market power or some other deviation from perfect competition (Meyer and v. Cramon-Taubadel, 2004; Carmen and Sexton, 2005; Koutroumanidis et al., 2009**).** A number of studies of agricultural commodities suggested that the main driver of asymmetric price transmission in a vertical marketing chain is market power (McCorriston et al., 1998; Azzam and Schroeter, 1995; Chen and Lent, 1992; Bunte and Peerlings, 2003; Carmen and Sexton, 2005). A party with market power can influence the price

to increase profits. Under such a situation, market participants with market power exploit the situation differentially depending on the direction of the initial price shock.
Evidence of asymmetry does not necessarily imply market power. Carlton (1989) suggests that unless the change in marginal cost (the procuring price from upstream marketing chain) is sufficiently large, retailers do not implement a price change due to a menu or re-pricing cost. Bettendorf and Verboven (2000) supported this claim empirically in the context of vertical markets for coffee. Other explanations include Ball and Mankiw (1994) who focused on asymmetric adjustment of nominal prices during the time of inflation, and Reagan and Weitzman (1982) who showed how the competitive industry results in asymmetric price transmission through their inventory holding behavior. Bailey and Brorsen (1989) also pointed out that asymmetric (or imperfect) information about costs may cause asymmetric price transmission.[1]

We formally test the asymmetry of price transmission between the shipping point and terminal prices of fresh fruits, apples, table grapes, peaches, and strawberries, using weekly price data spanning from 1998 to 2011. The model separates the two regimes of the initial price shock and incorporates time lags of both explanatory and dependent variables, which enables us to investigate the price adjustment process between prices in different stages of the marketing chain. The empirical models are discussed in the next section. Data description and preliminary tests on data and model specification, including the tests on lag order, unit-root, causality and cointegration follow. We then report the model estimation results, and conclude the paper with summary and implications.

Empirical Model

The key features of the models used in testing asymmetric price transmission involve the segmentation of the regimes differentiated by the sign of the initial price shock. Early studies adopting regime segmentation include Wolffram (1971) and Houck (1977).[2] Allowing the possibility of non-instantaneous price adjustments, Ward (1982) and Boyd and Brorsen (1988) extended Houck's model by incorporating lagged explanatory variables in the vertical marketing

[1] For more discussion, see Peltzman (2000) who investigated various plausible causes for price asymmetries such as market concentration, inventories, inflation-related asymmetric "menu costs" of price changes, or the fragmentation of the marketing chain. His study supports none of these causes, except for the level of fragmentation of the marketing chain.
[2] Even though the typical asymmetric specification originates from Wolffram and Houck, the basic conceptualization of asymmetric price transmission goes back to Farrell (1952), who first investigated empirically the irreversibility behavior of the demand function of habitual consumption goods.

chains of fresh vegetables and pork in the United States.[3] The length of lags in this framework corresponds to the duration of the price adjustment, and the coefficients on the lagged explanatory variables indicate the magnitude of their impacts on the dependent variable.

The main drawback of this approach relates to the time series properties of the data. Recognizing that this simple approach is not consistent with common time series properties of the data, Borenstein et al. (1997) and v. Cramon-Taubadel (1998) applied a cointegration method to the tests of asymmetric transmission between the crude oil and retail gasoline prices and between producer and wholesale prices in the German pork market, respectively. As a more comprehensive time-series approach, Krivonos (2004) adopted an error correction model and characterized the long-run equilibrium price transmission in the world versus producing-county coffee markets.

Developing the empirical model starts with defining the relationship between the current and lagged prices in a marketing chain simply composed of the downstream and upstream markets. Let P_t^d , denoting the downstream price at time *t*, depend on its own lagged values and the upstream prices, P^u , both contemporaneous and lagged. Then, a typical autoregressive distributed lag (ADL) model with the lag length of *n* can be specified as: $P_t^d = a_0 + \sum_{i=1}^{n} a_i P_{t-i}^d + \sum_{i=0}^{n} b_i P_{t-i}^u + \varepsilon_t$. This equation assumes a symmetric relationship between the changes in explanatory variables and the dependent variable. This symmetric relationship is more immediate when the equation is expressed in differences, $\Delta P_t^d = \sum_{i=1}^{n-1} a_i \, \Delta P_{t-i}^d + \sum_{i=0}^{n-1} b_i \, \Delta P_{t-i}^u$, where Δ signifies a change from the value of the previous period. To incorporate the possibility of asymmetric transmission, we need to separate the explanatory variables depending on the direction of the change, which can be specified using binary variables, A_i^+ A_i^- B_i^+ and B_i^-:

(1) $$\Delta P_t^d = \gamma + \sum_{i=1}^{n-1} a_i^+ A_i^+ \Delta P_{t-i}^d + \sum_{i=1}^{n-1} a_i^- A_i^- \Delta P_{t-i}^d + \sum_{i=0}^{n-1} b_i^+ B_i^+ \Delta P_{t-i}^u + \sum_{i=0}^{n-1} b_i^- B_i^- \Delta P_{t-i}^u + e_t$$

[3] Houck's (1977) model was developed to test the asymmetry in supply response in the U.S. milk and pinto beans markets by extending the basic model concept by Wolffram (1971), who segmented the initial price shock into increasing and decreasing phases.

$$A_i^+ = \begin{cases} 1 & if \quad \Delta P_{t-i}^d > 0 \\ 0 & otherwise \end{cases}, \; A_i^- = \begin{cases} 1 & if \quad \Delta P_{t-i}^d < 0 \\ 0 & otherwise \end{cases} B_i^+ = \begin{cases} 1 & if \quad \Delta P_{t-i}^u > 0 \\ 0 & otherwise \end{cases}, \; B_i^- = \begin{cases} 1 & if \quad \Delta P_{t-i}^u < 0 \\ 0 & otherwise \end{cases}$$

Equation (1) allows two types of asymmetric price transmission tests. First, we can test for short-term asymmetric price transmission between ΔP_{t-i}^u and ΔP_t^d. If ΔP_{t-i}^u were symmetrically transmitted to ΔP_t^d, estimated coefficients b_i^+ and b_i^- would be the same. Thus, asymmetric price transmission exists with respect to the ith lagged upstream price if two coefficients are significantly different from one another. The second test is for cumulative asymmetric price transmission. If the influences of $\sum_{i=0}^{n-1} B_i^+ \Delta P_{t-i}^u$ and $\sum_{i=0}^{n-1} B_i^- \Delta P_{t-i}^u$ on the dependent variable are symmetric, the cumulated coefficients $\sum_{i=0}^{n-1} b_i^+$ would be same as $\sum_{i=0}^{n-1} b_i^-$. Thus the hypothesis of symmetric cumulative price transmission would be rejected if these sums were significantly different from one another. The short-term symmetry implies cumulative symmetry, but not vice versa. Further, the short-term asymmetry does not imply cumulative asymmetry. Similar tests between the contemporaneous and lagged dependent variables apply. That is, the short-term price adjustment is said to be asymmetric if the data reject $H_0: \; a_i^+ = a_i^-$ and the cumulative price adjustment is asymmetric if the data reject $H_0: \; \sum_{i=1}^{n-1} a_i^+ = \sum_{i=1}^{n-1} a_i^-$.

Note that tests on asymmetric price transmission provide information about market efficiency (or inefficiency) and market inefficiency is indicated by the asymmetry on the coefficients *b*'s. Further, asymmetry confirmed with further statistical evidence of $\sum_{i=1}^{n-1} b_i^+$ being significantly greater than $\sum_{i=1}^{n-1} b_i^-$ is termed positive asymmetry, which is consistent with the fact that higher profits are earned by downstream participants than what they could have earned under the efficient market (Carman and Sexton, 2005).

Another alternative model specification relates to the time series nature of the price variables. Although equation (1) can capture the cumulative effects in price transmission, these models essentially do not consider the effects of price transmission when price variables deviate from their long run path. In general, differenced variables (such as ΔP_t^d, ΔP_{t-i}^d and ΔP_{t-i}^u) tend to be stationary, however, the original price variables may meander without showing the constant mean or variance over time. Although the prices are not stationary, if a linear relationship between these price variables is stable and the residual from this linear relationship is white-noisy, we say there exists cointegration between these variables (Anders, 1995). If the existence of cointegration is identified, the asymmetric price transmission model can be extended to specify the long-run adjustments by introducing the error-correction terms as in von Cramon-Taubadel and Loy (1996). Given the error correction model can be extended based on the results of the cointegration test, the presentation of the error correction model will be deferred until we perform the cointegration test.

Data

One distinct characteristic of fresh fruits is perishability, which surely contributes to short term fluctuation of market prices. This implies that price transmission can be relatively in short term and the data used to examine price transmission necessarily have to reflect such short terms. In light of this, we searched for time series price data with short intervals. The Agricultural Marketing Service at the U.S. Department of Agriculture provides weekly prices of major agricultural commodities at various marketing channels. We have chosen fresh strawberries, apples, table grapes and fresh peaches as representative fruits and for each of these fruits, we collected weekly prices at the shipping point and terminal market. Obivously, the upstream and downstream markets in the model are represented by the terminal market and shipping point, respectively. In terms of selecting the location of the shipping point and terminal market, we picked the shipping point in the region that is associated with major production and the terminal market that likely handles this volume. While our data period spans from 1998 to 2011, depending on its season the data series for each fruit begins and ends in different months. Data details are provided in appendix.

Figure 1 presents the time series of terminal and shipping point prices for each fruit considered. Except for fresh apples, these prices are discontinuous each year because these prices are mostly available only for the domestic season (fresh apples have a long season in the US). Nevertheless, we tend to have larger observations for terminal prices than FOB prices because terminal markets in general handle larger volume than FOB markets, in addition to the fact that they often handle imported products as well. For each fruit, the two price series tend to move together, and fluctuate considerably over the years investigated. Price fluctuations are larger in the second half of the period for both series. The time pattern of the price fluctuation suggests the possibility of non-stationarity of price series, which violates the time series property of constant mean and variance. The co-movement of these series further suggests the possibility of cointegration, as is often manifested by the parallel pattern of non-stationary variables. The time properties of the data will be formally investigated next.

Preliminary tests

In this section we first consider the choice of lag orders and causality and then investigate time series properties of the data. We select appropriate lag orders based on statistical criteria, and perform the causality tests to identify the relationship between shipping point and terminal prices. We conduct unit root tests on the variables used in empirical equations to avoid spurious regression and erroneous interpretation of estimated results. We also test for cointegration between the terminal and FOB prices for the possibility of including long-run relations of these time series vectors in the empirical estimation.

Lag order choice and causality tests

The following vector autoregressive (VAR) model is used to determine the lag orders and conduct the causality test:

$$\begin{bmatrix} P_t^T \\ P_t^S \end{bmatrix} = \begin{bmatrix} \gamma^T \\ \gamma^S \end{bmatrix} + \begin{bmatrix} a_1^T \, b_1^T \\ a_1^S \, b_1^S \end{bmatrix} \begin{bmatrix} P_{t-1}^T \\ P_{t-1}^S \end{bmatrix} + \begin{bmatrix} a_2^T \, b_2^T \\ a_2^S \, b_2^S \end{bmatrix} \begin{bmatrix} P_{t-2}^T \\ P_{t-2}^S \end{bmatrix} + \ldots + \begin{bmatrix} a_k^T \, b_k^T \\ a_k^S \, b_k^S \end{bmatrix} \begin{bmatrix} P_{t-k}^T \\ P_{t-k}^S \end{bmatrix} + \begin{bmatrix} e_t^T \\ e_t^S \end{bmatrix}$$

where superscripts T and S denote terminal and shipping point (which correspond to downstream and upstream respectively) and the subscript denotes time. Within the VAR formulation expressed as above, the optimum lag order is selected using the Akaike's information criterion (AIC) and Schwartz Bayesian Information Criterion (SBIC). We considered up to the fifth lag and the lag order that produces the minimum information criteria is selected (Anders, 1995). Table 1 presents the values obtained under the two information criteria for each order of lags considered. Using these criteria, we selected the lag order one for apples, lag order four for table grapes, lag order three for strawberries, and lag order four for peaches.[4]

In specifying the empirical equations, our underlying assumption is that the current terminal price is influenced by the shipping point prices, consistent with the usual assumption that

[4] Due to the space limitation, we do not present the full estimation results of the VAR model.

downstream prices are affected by upstream prices.[5] However, this is not always the case, and has to be verified empirically. To check the causality between prices, we used the estimation results from the VAR model. From the first equation of the VAR model ($P_t^T = \gamma^d + \sum_{i=1}^{k} a_i^d P_{t-i}^T + \sum_{i=1}^{k} b_i^d P_{t-i}^S$), we can say that P^S causes P^T if we reject the null hypothesis H_0: $b_1^d = b_2^d = ... = b_k^d = 0$. Likewise, using the results of the second equation of the VAR model ($P_t^S = \gamma^u + \sum_{i=1}^{k} a_i^u P_{t-i}^T + \sum_{i=1}^{k} b_i^u P_{t-i}^T$), P^T is said to cause P^S, if we reject the null hypothesis H_0: $a_1^u = a_2^u = ... = a_k^u = 0$.

Table 2 shows the causality test results. The test results show that except for strawberries, shipping point prices cause terminal prices, which is consistent with the underlying assumption upon which our model specification is based. However, for strawberries, the causality of both directions is strongly rejected. This implies that the direction of price causality is inconclusive, which invalidates the specification of our VAR equation. Therefore, the strawberry equation will be eliminated from our asymmetric estimation.

Unit-root tests

Unit-root tests are essential in checking the spurious regression and the existence of cointegration. For the regression to be statistically meaningful, all the variables in the regression have to be stationary. Specification tests concerning equation (1) include spurious regression. For each variable used in equation (1), we conduct a unit root test by adopting the Augmented Dickey-Fuller (ADF) test. The ADF test with an intercept and trend is based on the following form of regression: $\Delta Y_t = \alpha_0 + \alpha_t t + \rho Y_{t-1} + \sum_{i=1}^{n} \beta_j \Delta Y_{t-j} + u_t$, where Y is the variable that is subjected to the unit-root test. The null hypothesis for testing the unit root is $\rho = 0$. If the absolute value of ADF test statistic is greater than the absolute value for the critical point, the hypothesis of unit root is rejected. Test results are provided in appendix. The hypothesis of unit root is rejected at 1% significance for every variable tested, strongly indicating little possibility of spurious relationships for regression equation (1). (UNIT ROOT TEST RESULTS TO BE AVAILABLE LATER)

[5] The opposite direction of causality is, of course, plausible as in Koutroumanidis et al., which deals with a market where imports represent a large share of domestic consumption, and the import price leads the consumer price. They find that under such market conditions, causality is from downstream to upstream markets, i.e., the consumer price affects the producer price.

Note that our asymmetric transmission model as expressed in equation 1 can be further expanded using the error correction approach under certain assumptions. The validity of an error correction model requires a cointegration test on time series P^u and P^d, which involves stationarity tests on P^S and P^T and then a cointegration test upon the evidence of non-stationarity. Our test results reject the null hypotheses of unit root process for both variables.[6] Having obtained the evidence of stationarity, we did not proceed with the Engle-Granger cointegration test, which thus precludes in the context of modeling the error correction model approach.

Estimation results of asymmetric price transmission

Table 4 reports the results obtained from estimating model (1). All coefficients related to shipping point prices are positive, while all own lagged price effects except those for apples are negative. Positive shipping point price effects indicate that the terminal price moves together with shipping point prices both current and lagged, meaning a rise (fall) in shipping point price induces an increase (reduction) in terminal price. While this finding is consistent with our intuition, negative lagged own price effects are interesting. Except apples, previous terminal prices affect the current terminal price in an opposite direction. Combined with the findings on positive shipping point price effects, the significance of negative lagged own price effects is that the lagged own prices work as a dampening factor even though positive shipping point price effects may dominate.

We have found distinct patterns of lagged price effects for each fruit. The lagged price effects we obtained do not conform to the usual expectation that prices effects taper down as the order of lag increases. For apples, one period lagged shipping price effect associated with a negative price change is much larger than the current price effect (0.08 vs. 0.34). For peaches, the second lagged shipping point price has the largest price effects among all lagged effects for both positive and negative changes. For own price effects, lagged price effects tend to get larger as the lag increases.

F-test statistics for asymmetry tests are reported in Table 4 and the summary interpretation of the test results is provided in Table 5. The null hypothesis that the effect of the current shipping point price is symmetrically transmitted to the current terminal price is rejected for apples and peaches but not for table grapes. These asymmetry effects are, however, positive for apples and

[6] We first apply the augmented Dickey-Fuller (ADF) test to each of time series P^S and P^T using the same regression form employed in the previous unit root tests.

negative for peaches, meaning that for apples the terminal price responds with a larger margin to a shipping point price increase than to a decrease and the reverse is true for peaches. Nevertheless, as indicated by the magnitude of the estimated coefficients for b_0^+ and b_0^-, positive asymmetry for apples is substantial while the negative asymmetry for peaches is relatively marginal. Asymmetry of cumulative FOB price effects is also positive for apples, but inconclusive for peaches. For table grapes, the symmetry of the cumulative effect of shipping point prices cannot be rejected. The hypothesis of symmetric cumulative lagged own price effects is strongly rejected for apples but cannot be rejected for table grapes and peaches.

We have also examined asymmetric price transmission in the context of quantile regression. Quantile regression, which was introduced by Koenker and Bassett (1978), extends the regression model to conditional quantiles of the response variable. Quantile regression is useful when the rate of change in the conditional quantile, expressed by the regression coefficients, depends on the quantile. In addition to the fact that the quantile regression estimates are more robust against outliers in the response measurements, the quantile regression approach produces a comprehensive analysis of the relationship between variables.

We considered the quantiles at a 20% increment, and summarized the asymmetry test results in Table 6. A distinct pattern of asymmetry emerges from table 6. Negative asymmetry is, in general, found mostly at low levels of quantiles and positive asymmetry mostly at high levels of quantiles. That is, at a low level of price change the terminal price responds more to a decline in the FOB price than to an increase. On the other hand, at a relatively larger price change, the terminal price responds more to an increase in the FOB price than to a decrease. These patterns are pronounced especially for apples and table grapes. In comparison with the mean value estimation (under the usual least square estimation method), quantile estimations tend to produce negative asymmetry associated with changes in FOB price results at a relatively low quantile range. There may be a number of explanations for positive asymmetry at a high quantile level. For instance, the profit extracting behavior of terminal marketers would be a possibility, which is allowed only under certain market conditions. Another possibility has to do with the operating structure of terminal marketers. Suppose that a large increase in the FOB price occurred after a serious supply shock. A contraction in supply causes a reduction in total product quantities at the terminal market. It is easy to imagine that the terminal market may operate in less than full capacity in this case. This likely increases per unit operating cost, which results in an increase in terminal price exceeding the increase in FOB price. Regarding the negative asymmetry at a relatively low level of price change, explanations are not immediate.

Conclusions

This article has developed and tested hypotheses of asymmetric price transmission in fruit prices using the appropriate statistical tools and after tests to account for time series properties of the data. The econometric results have found evidence of asymmetric price movements between shipping point and terminal markets for fruits. We are not able to say definitively what drives the asymmetry but provide some potential rationales and ideas for further investigation.

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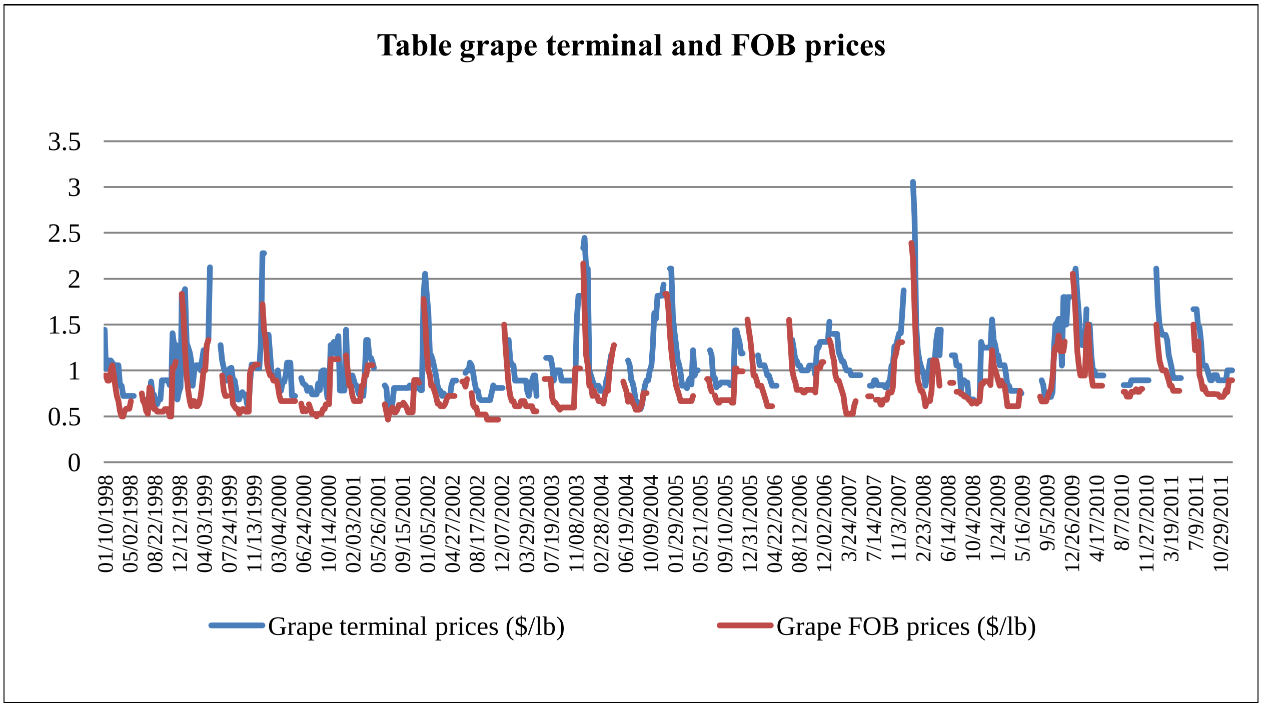
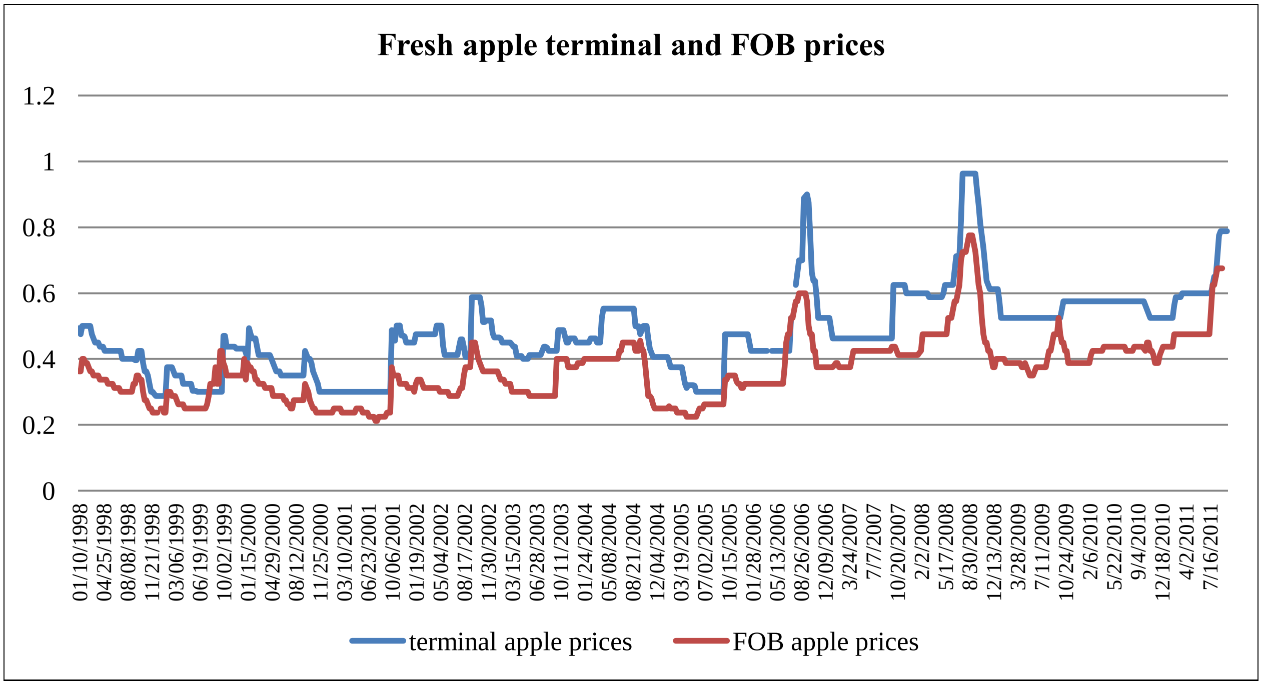
Fig. 1.a-d. weekly prices ($/lb) for table grapes, fresh apples, fresh peaches, and fresh strawberries at terminal market and shipping point (FOB)





Fresh apple terminal and FOB prices
1.2
1
0.8
0.6
0.4
0.2
0
01/10/1998
04/25/1998
08/08/1998
11/21/1998
03/06/1999
06/19/1999
10/02/1999
01/15/2000
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12/04/2004
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07/02/2005
10/15/2005
01/28/2006
05/13/2006
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12/09/2006
3/24/2007
7/7/2007
10/20/2007
2/2/2008
5/17/2008
8/30/2008
12/13/2008
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7/11/2009
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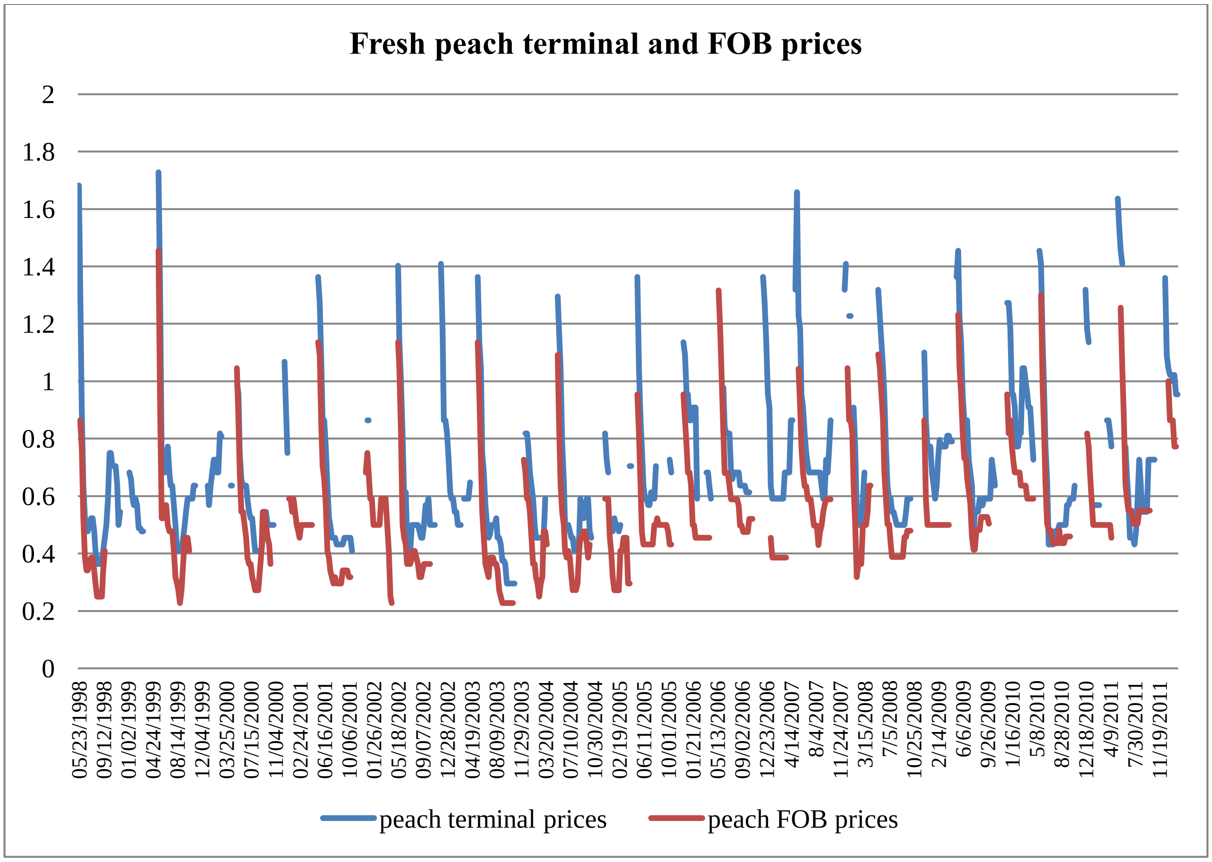
12/18/2010
4/2/2011
7/16/2011
terminal apple prices
FOB apple prices


Fresh peach terminal and FOB prices
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1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
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05/23/1998
09/12/1998
01/02/1999
04/24/1999
08/14/1999
12/04/1999
03/25/2000
07/15/2000
11/04/2000
02/24/2001
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9/26/2009
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peach terminal prices
peach FOB prices

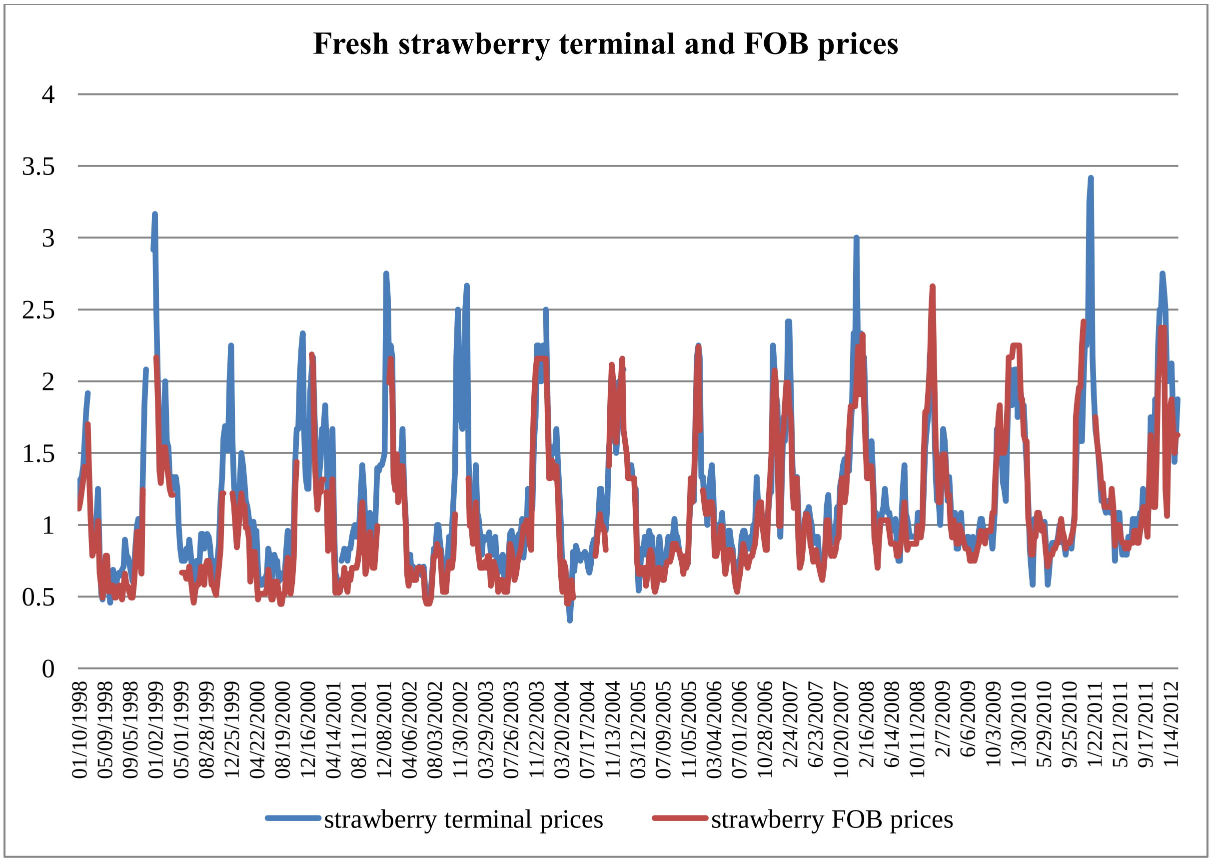


Table 1. Lag order choice

	Criteria	Lag1	Lag 2	Lag 3	Lag4	Lag 5
Apples	AIC	-10.2381	-10.2600	-10.2901	-10.3130	-10.4519
	SBIC	-10.1991	-10.1947	-10.1983	-10.1945	-10.3064
Table grapes	AIC	-3.3526	-3.6092	-3.6886	-3.8060	-3.7008
	SBIC	-3.2993	-3.5159	-3.5507	-3.6190	-3.4588
Strawberries	AIC	-1.9766	-2.1087	-2.1231	-2.1201	-2.1510
	SBIC	-1.9339	-2.0360	-2.0189	-1.9831	-1.9801
Peaches	AIC	-6.1912	-6.4914	-6.8734	-6.9510	-7.009
	SBIC	-6.1230	-6.3708	-6.6944	-6.7072	-6.6920

Choices of lag order: Apples = 1, table grapes = 4, strawberries = 3, peaches = 4

Table 2. Granger Causality test results

	Causality	chi^2 test statistic	Pr.(| chi^2 | > critical value)[1]	d.f.
Apples	H_1: Terminal price(P^T) → Shipping point Price(P^S) (H_0: $a_1^S = a_2^S = ... = a_k^S = 0$)	0.0026	0.9591	1
	H_1: Shipping point Price(P^S) → Terminal Price(P^T) (H_0: $b_1^T = b_2^T = ... = b_k^T = 0$)	30.8340	0.0000	1
Table grapes	H1: Terminal price(P^T) → Shipping point Price(P^S) (H0: $a_1^S = a_2^S = ... = a_k^S = 0$)	0.7550	0.9444	4
	H1: Shipping point Price(P^S) → Terminal Price(P^T) (H0: $b_1^T = b_2^T = ... = b_k^T = 0$)	41.3703	0.0000	4
Strawberries	H1: Terminal price(P^T) → Shipping point Price(P^S) (H0: $a_1^S = a_2^S = ... = a_k^S = 0$)	11.4412	0.0096	3
	H1: Shipping point Price(P^S) → Terminal Price(P^T) (H0: $b_1^T = b_2^T = ... = b_k^T = 0$)	166.11	0.0000	3
Apple	H1: Terminal price(P^T) → Shipping point Price(P^S) (H0: $a_1^S = a_2^S = ... = a_k^S = 0$)	1.1427	0.8874	1
	H1: Shipping point Price(P^S) → Terminal Price(P^T) (H0: $b_1^T = b_2^T = ... = b_k^T = 0$)	102.2311	0.0000	1

1. If the probability that chi^2 test statistic is greater than the critical value is less than 0.05, we reject the null hypothesis (H_0), and the alternative hypothesis (H_1) is accepted.

Table 3. Unit root test results

Variable	ADF test statistic	99% critical value
Apples		
P^T	-4.0922	-3.9710
P^S	-4.5792	-3.9711
Table grapes		
P^T	-8.1362	-3.9740
P^S	-14.4843	-3.9751
Strawberries		
P^T	-6.2987	-3.9712
P^S	-5.2867	-3.9727
Peaches		
P^T	-16.0236	-3.9780
P^S	-13.4687	-3.9799

Table 4. Estimation results

		Apples		Table grapes		Peaches	
Coefficient	Regressor	Coefficient estimate[1)]	Std. Error	Coefficient estimate[1)]	Std. Error	Coefficient estimate[1)]	Std. Error
γ		0.0002	0.0009	0.0084	0.0080	0.0053	0.0054
b_0^+	$D^+\Delta P_t^S$	0.6677***	0.0600	0.8324***	0.0702	0.2030	0.1291
b_0^-	$D^-\Delta P_t^S$	0.0796	0.0879	0.7168***	0.1841	0.2647**	0.1301
b_1^+	$D^+\Delta P_{t-1}^S$	0.2015***	0.0689	0.2646***	0.0855	0.5035***	0.1395
b_1^-	$D^-\Delta P_{t-1}^S$	0.3446***	0.0907	0.6088***	0.1488	0.7430***	0.1223
b_2^+	$D^+\Delta P_{t-2}^S$			0.2896***	0.0908	0.0651	0.1808
b_2^-	$D^-\Delta P_{t-2}^S$			-0.0032	0.1442	0.1068	0.1148
b_3^+	$D^+\Delta P_{t-3}^S$			0.3751***	0.1001	0.0792	0.1856
b_3^-	$D^-\Delta P_{t-3}^S$			0.1344	0.1231	0.3420***	0.0973
b_4^+	$D^+\Delta P_{t-4}^S$			0.0174	0.0904	0.1947	0.1880
b_4^-	$D^-\Delta P_{t-4}^S$			0.1490	0.1074	0.1925**	0.0788
a_1^+	$D^+\Delta P_{t-1}^T$	0.0229	0.0433	-0.1128*	0.0650	-0.0433	0.1058
a_1^-	$D^-\Delta P_{t-1}^T$	0.4064***	0.0758	-0.2913***	0.0769	-0.0371	0.0988
a_2^+	$D^+\Delta P_{t-2}^T$			-0.2388***	0.0724	-0.1345	0.1218
a_2^-	$D^-\Delta P_{t-2}^T$			-0.1027	0.0720	-0.1696**	0.0840
a_3^+	$D^+\Delta P_{t-3}^T$			-0.3485***	0.0826	-0.1446	0.1255
a_3^-	$D^-\Delta P_{t-3}^T$			-0.0003	0.0611	-0.1666**	0.0756
a_4^+	$D^+\Delta P_{t-4}^T$			-0.0199	0.1207	-0.1948	0.1690
a_4^-	$D^-\Delta P_{t-4}^T$			-0.0279	0.0517	-0.1946***	0.0556
D[2)]	Dumm	-0.0224***	0.0066	-0.1160***	0.0233	-0.0259*	0.0149
	R^2	0.2551		0.4291		0.3939	

F test results (table 4 continued)

Null hypothesis	Test stat. (d.f.)	Pr(|F|>c)	Test stat. (d.f.)	Pr(|F|>c)	Test stat. (d.f.)	Pr(|F|>c)
$b_0^+ = b_0^-$[3)]			0.322	0.570		

$\sum^{n} b_i^+ = \sum^{n} b_i^-$	9.700	0.001	0.293	0.5887	2.919	0.088
$\sum^{n} a_i^+ = \sum^{n} a_i^-$	18.237	0.000	1.344	0.2471	0.0263	0.871
$\sum^{n} b_i^+$	0.8692		1.7791		1.0455	
$\sum^{n} b_i^-$	0.4242		1.6058		1.6488	
$\sum^{n} a_i^+$	0.0229		-0.7201		-0.5171	
$\sum_{i=1}^{n} a_i^-$	0.4064		-0.4222		-0.5679	

1) The levels of statistical significance are denoted with *for 1%, ** for the 5% and *** for the 1%.
2) Dummy variable is set to 1 when terminal price is lower than shipping point price
3)H_0: $b_0^+ = b_0^-$ is not tested when one of the estimated coefficients is not statistically significant

Table 5. Summary of asymmetry test results

	short term	Cumulative	
	shipping point price → terminal price	shipping point price → terminal price	previous terminal price → current terminal price
Apples	Positive APT	positive APT	Negative APT
table grapes	No APT	No APT	No APT
Peaches	Negative APT	Inconclusive	No APT

Table 6. Tests of asymmetry using quantile regressions

	Level of Quantile	Short term	Cumulative	
		shipping point price → terminal price	shipping point price → terminal price	previous terminal price → current terminal price
Apples	20%	Negative APT	Negative APT	Negative APT
	40%	No APT	Negative APT	Negative APT
	60%	-	-	-
	80%	Positive APT	Positive APT	No APT
table grapes	20%	Negative APT	Negative APT	No APT
	40%	No APT	No APT	No APT
	60%	Positive APT	Positive APT	No APT
	80%	Positive APT	Positive APT	No APT
Peaches	20%	No APT	No APT	No APT
	40%	Negative APT	No APT	No APT
	60%	Positive APT	No APT	No APT
	80%	No APT	No APT	No APT

Appendix
DATA DETAILS

Fresh apples:

- Data period: from Jan 10, 1998 to Oct 1, 2011
- Variety: red delicious
- Unit: $/pound
- Other details:
  - Retail prices: region=Northwest of U.S.;
  - terminal prices: region=Seattle, grade=WaExFcy, product origin=Washington, size=88s or mid-range package=carton tray pack;
  - Shipping point prices: region=Washington state, other specifications are the same as what are reported in the terminal market.

Fresh peaches

- Data period: from 5/23/1998 to 2/1/2012
- Variety: “various yellow flesh available.”
- Unit: $/pound
- Other details:
  - Retail prices: region=Northwest U.S.
  - Terminal prices: region=Los Angeles, size=42s, package=carton 2 layer tray pack
  - Shipping point prices: region=Central and Southern San Joaquin Valley California, size=40-42s, “preconditioned”.

Table grapes

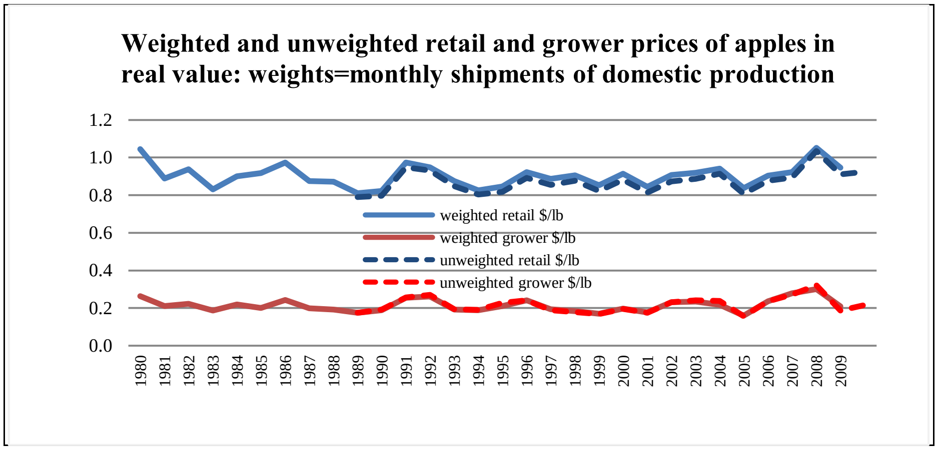
- Data period: from 1/10/1998 to 12/242011
- Variety: red/white seedless
- Other details:
  - Retail prices: region=Northwest U.S.
  - Terminal prices: region=Los Angeles, variety=Thompson seedless, size=large, product origin=California and imports, package=all containers
  - Shipping point prices: regions=Coachella Valley and Chile imports

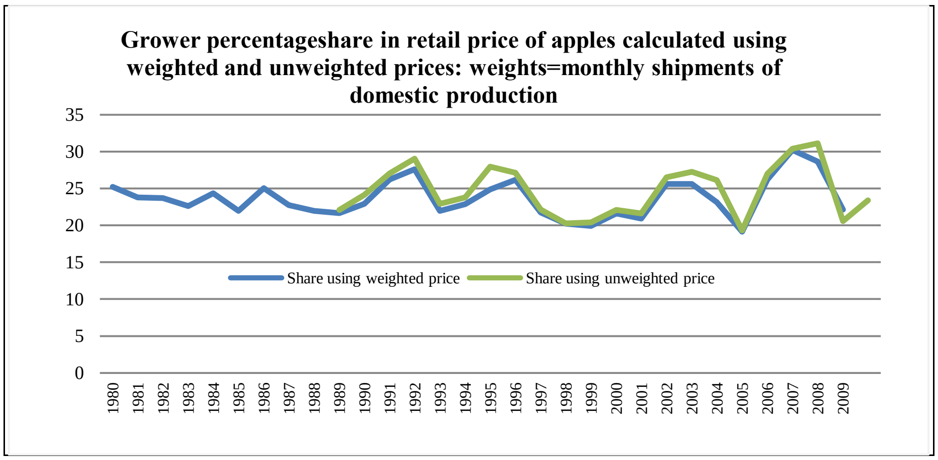
Fresh strawberries

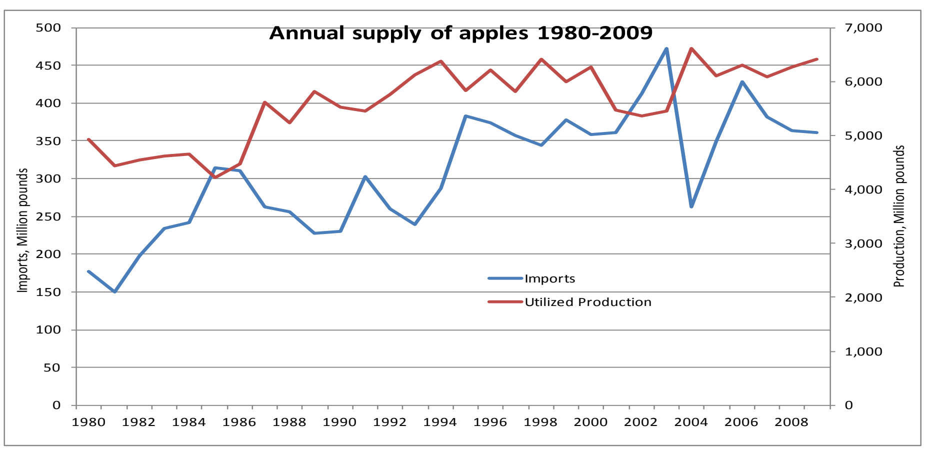
- Data period: from 1/10/1998 to 2/18/2012
- Unit: $/lb
- Other details:
  - Retail prices: region=Northwest of U.S.
  - Terminal prices: region=Los Angeles, size=medium to large, origin=Oxnard and Salinas-Watsonville, package=flats 12-pt baskets
  - Shipping point prices: region=Oxnard and Salinas-Watsonville, and other specifics are the same as reported in terminal market.

Appendix 7

<u>Apples</u>





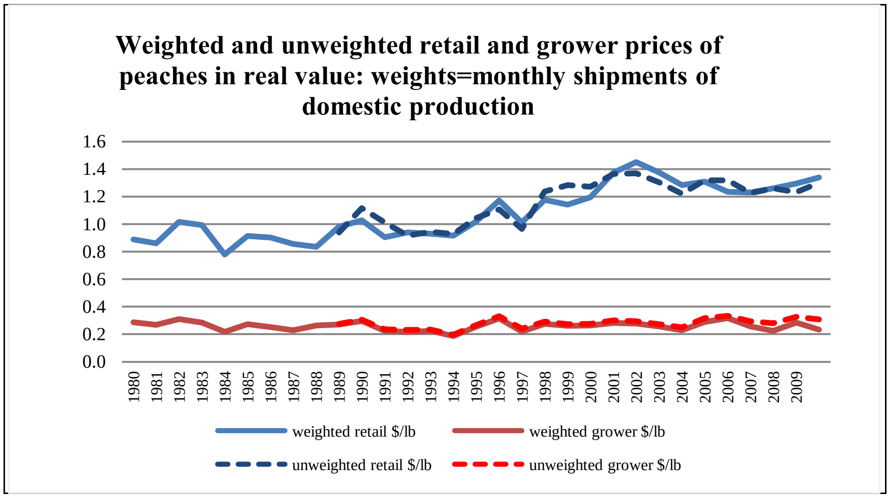


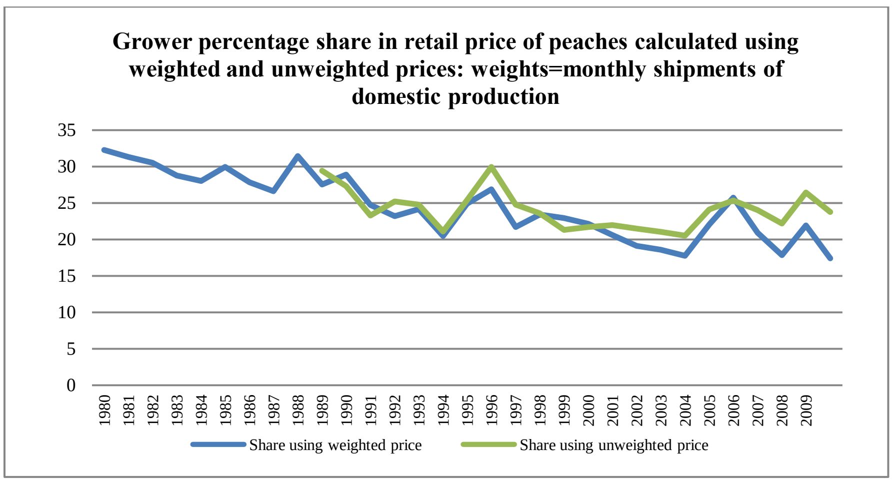
Data source: BLS for retail prices and USDA for farmers prices

Data detail:

Monthly retail apple prices are collected from BLS, and other details for retail data include: data survey area=west urban; item=apples, red delicious; unit=$ per lb. U.S. monthly shipments of domestically produced apples are collected from USDA, Economics, Statistics and Market Information System, U.S. Apple Statistics, 2010, http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1825

Fresh Peaches

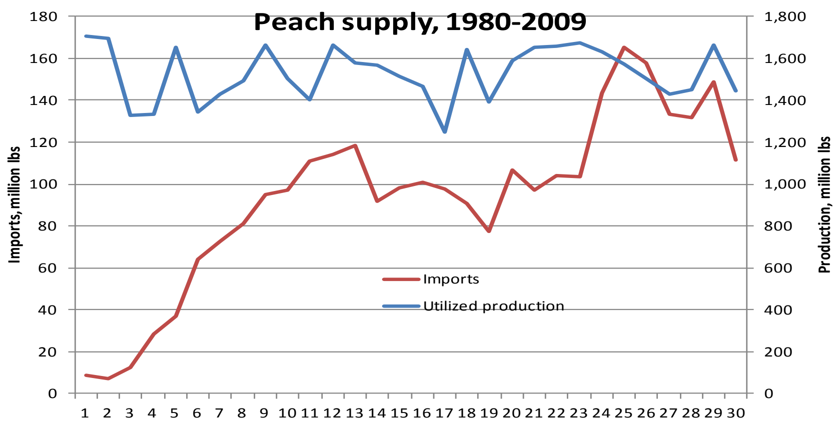




Data source: BLS for retail prices and USDA for shipment data and farm prices

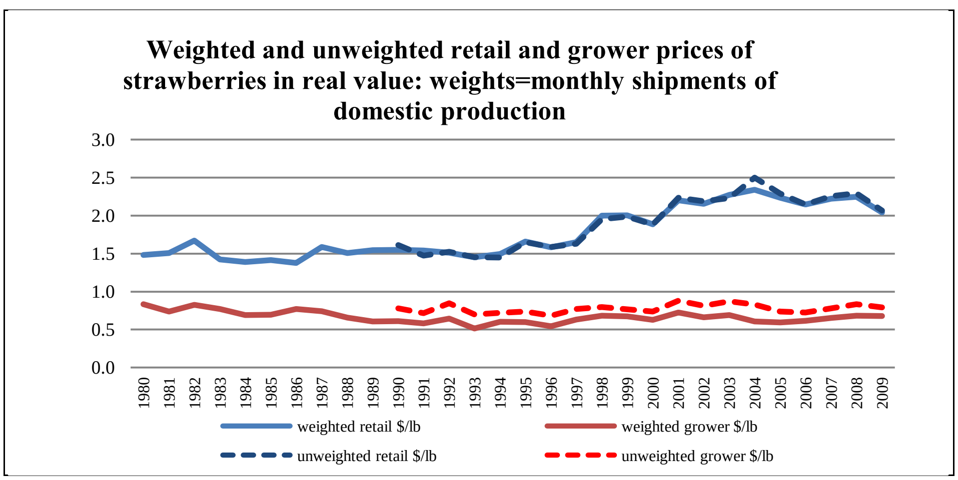
Data details:
Monthly retail prices for fresh peaches, collected from BLS, are U.S average prices per lb. Monthly grower received prices for fresh peaches are collected from Fruit and Tree Nut Yearbook Spread Sheet, 2010, USDA/Economics, statistics and market information system, http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377

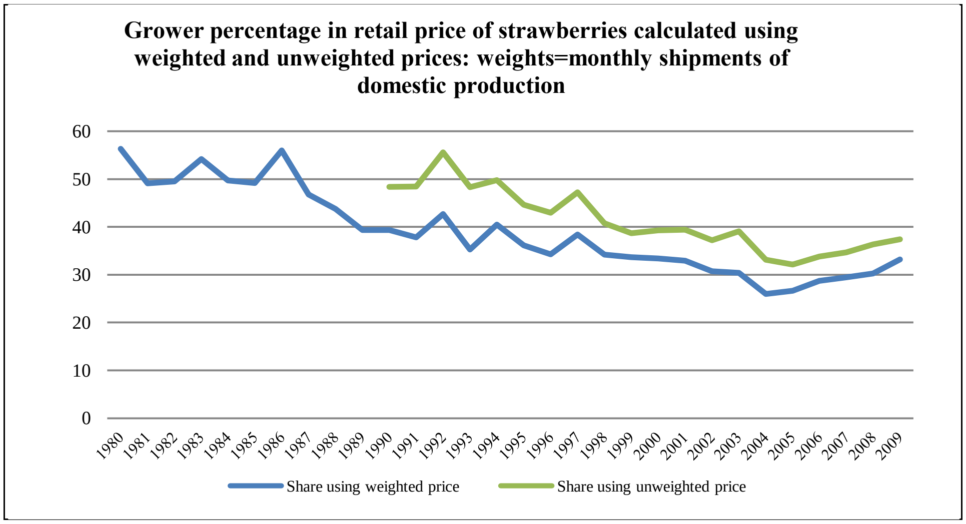
Monthly shipment data are collected from AMS/USDA. While USDA defines the fresh peach marketing season as May 1 to October 31, U.S. fresh peach production and sales volumes are concentrated during the months of June to September (for the years we considered, about 85% of total volume is traded during this period). This implies that the price data for May and October are not consistently available. Thus, the domestic season used in our study includes June through September, and their respective monthly shipment shares are 24.4%, 31.2%, 28.1%, and 16.3%.



Source: USDA, ERS. Supply and utilization

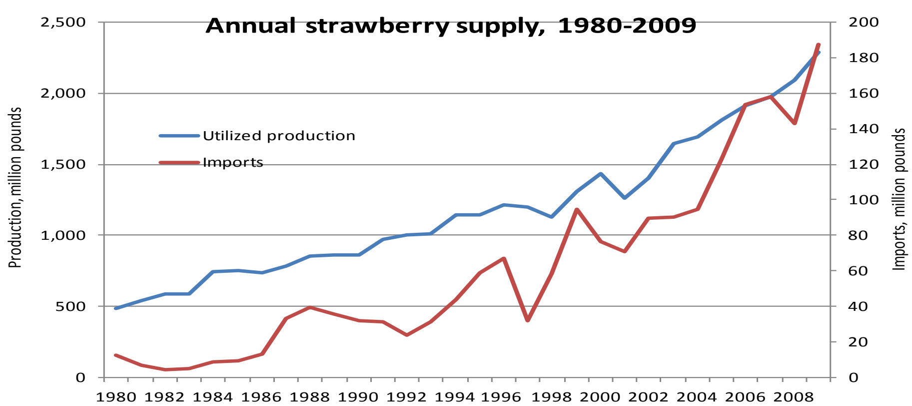
Strawberries





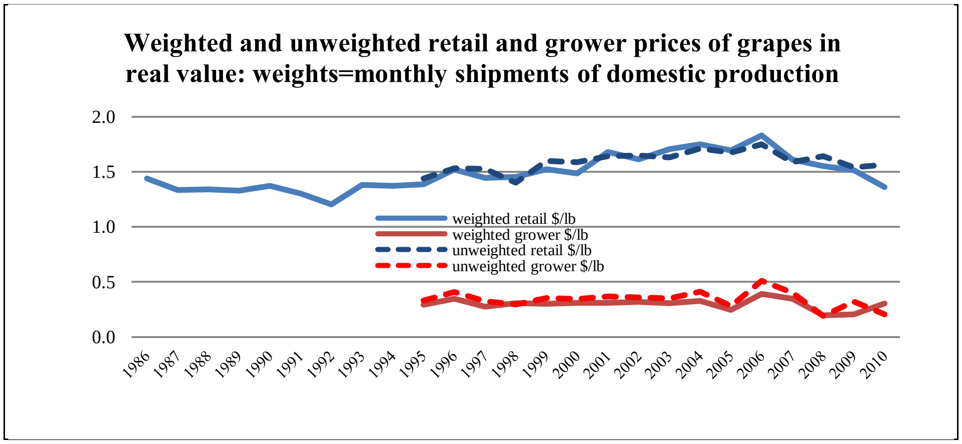
Data source: BLS for retail prices, and ERS and AMS of the USDA for farm prices and shipment data.

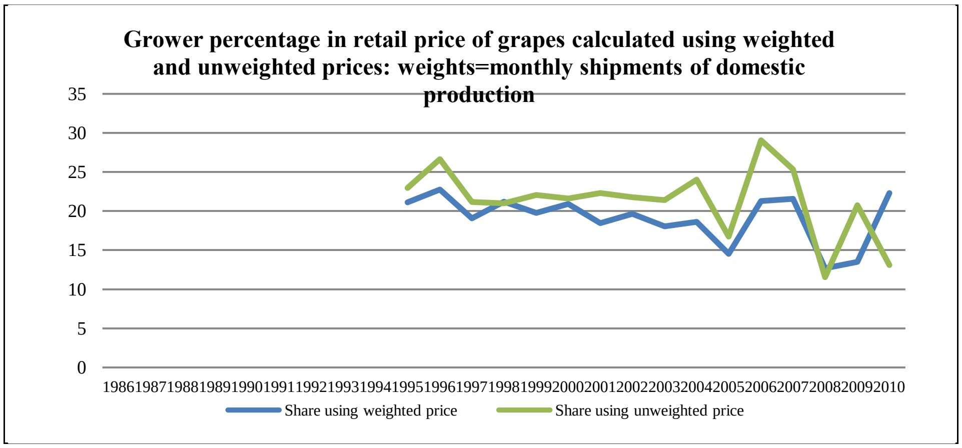
Data details:
Monthly retail prices are U.S. city average per pound and collected from BLS.
Monthly grower prices and monthly shipment data (of domestic production) are collected from USDA/ERS/Economics, Statistics, Market Information System/U.S. Strawberry Industry (95003)
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1381
While grower prices are available for all 12 months, retail prices are limited. The only months when the retail prices are consistently available are April through September. About 80% of total annual volume is traded during April through September.



Source: USDA, ERS. Supply and utilization.

Table grapes

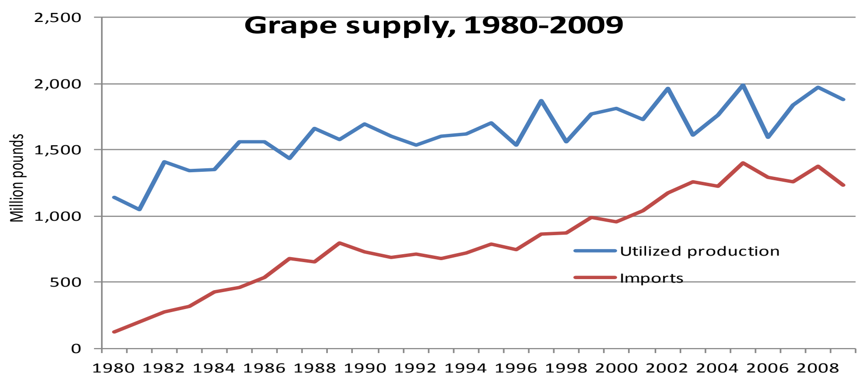




Data source:

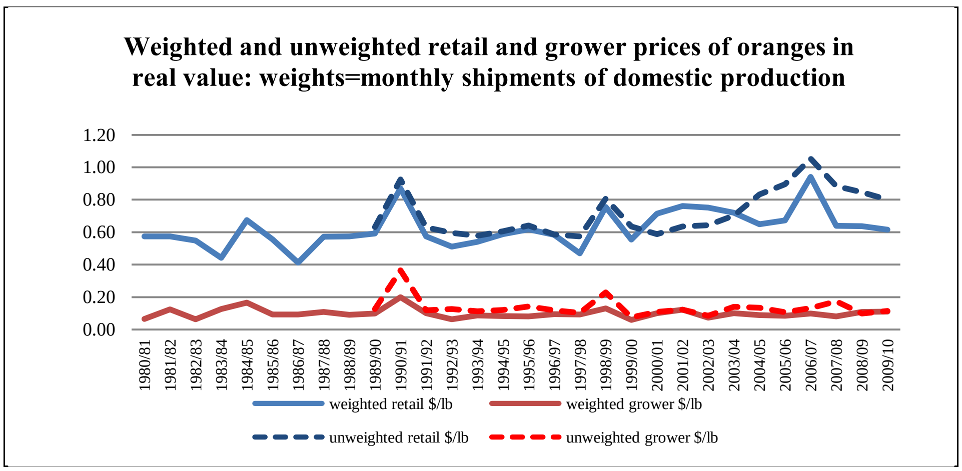
Data details:
Monthly retail price: BLS, U.S. city average, Thompson seedless
Monthly grower price: Fruit and Tree Nut Yearbook Spread Sheet, 2010, USDA/Economics, statistics and market information system,
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377

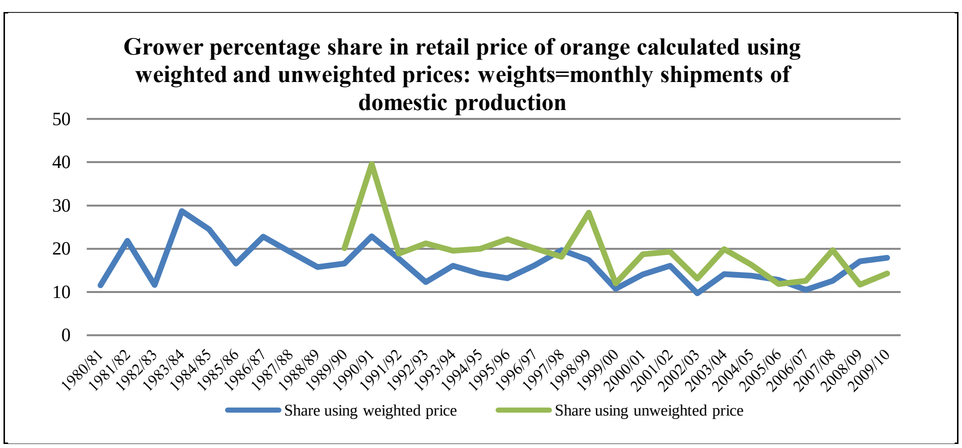
Monthly U.S. grape shipments (domestic production): AMS/USDA,
http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDc5075607
Movement of all grapes (except for organic) from California, season includes July though Novemenber and their monthly respective shares are 17%, 25%, 23%, 20% and 15%.



Source: USDA, ERS. Supply and utilization.

Oranges

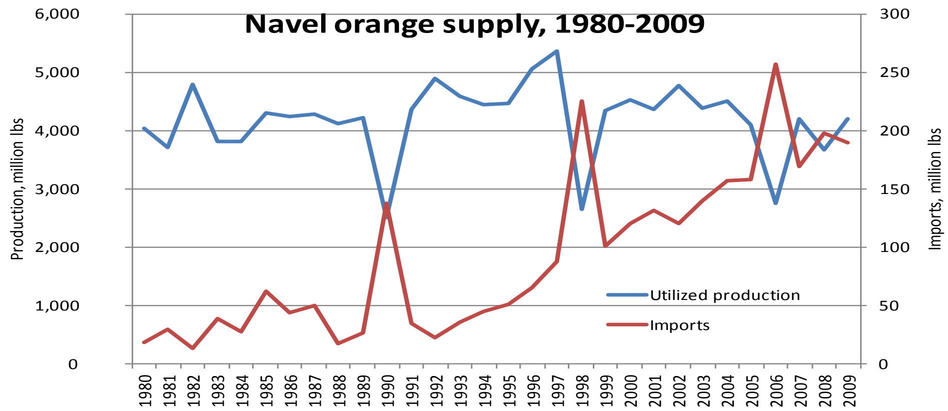




Data source:
Monthly retail price: BLS, U.S. city average,

Monthly grower price: Monthly equivalent on-tree returns received by growers, California, Fruit and Tree Nut Yearbook Spread Sheet, 2010, USDA/Economics, statistics and market information system, http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377

Monthly orange shipments (domestic production): AMS/USDA, http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDc5075607
Movement of California navel oranges by month, season includes Novembers though June next year and their monthly respective shares starting from November are 10%, 9.8%, 13.2%, 12.8%, 16.1%, 18.1%, 12.4%, and 7.6%.



Source: USDA, ERS. Supply and utilization

Pistachio Power:
A report on an industry of investment, impact and return

Pistachio Grower Economic Impact Report

California, Arizona and New Mexico

February 23, 2011

WESTERN PISTACHIO ASSOCIATION
ECONOMIC IMPACT STUDY

SUMMARY REPORT OF FINDINGS

Presented to:

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Ms. Vanessa Smith
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February 2011

TABLE OF CONTENTS

WESTERN PISTACHIO ASSOCIATION
ECONOMIC IMPACT STUDY

EXECUTIVE SUMMARY

INTRODUCTION AND PURPOSE

In July 2010, Fleishman Hillard retained Tootelian & Associates to assist it in conducting a study to assess the economic impact Western Pistachio Association (WPA) growers have overall and in their respective states of California, Arizona, and New Mexico. This impact includes the increased business activity created by growing and processing pistachio nuts, the jobs that are created as a result of this growth in activity throughout the various sectors of state economies, and the incremental business taxes that are generated.

The specific issues addressed in this study of pistachio nuts growers in California, Arizona, and New Mexico were:

- How much business activity they create and how the overall impact is diffused through the various sectors in each state's economy.
- How many jobs they create.
- How much labor income they create and how that income is diffused within the three-state region and in each state's economy.
- How much they generate in business taxes.

Two models were used in this analysis. IMPLAN was used to compute the overall economic impact, and a specially designed model was created to help define expenditure levels to use in the IMPLAN model.

FINDINGS AND CONCLUSIONS

Economic impact analyses were conducted for the total expenditures of growers in the three states and for expenditures by growers in each state. ***It is important to note that these projections are based on annual expenditures, which means that this impact is what is expected to occur each year that such spending occurs***.

The Output, Employment, Labor Income, and Indirect Business Taxes for all growers of pistachio nuts are presented in Table One and summarized below. These organizations spend nearly $415.3 million annually in California, Arizona, and New Mexico. This equates to nearly $1.2 million per day (i.e., $415.3 million divided by 365 days).

SUMMARY FOR TOTAL ECONOMIC IMPACT	TOTAL	PER DAY
Output	$682,480,972	$1,869,811
Employment	5,910	n.a.
Labor Income	$224,415,635	$614,837
Indirect Business Taxes	$24,410,415	$66,878

Based on the findings of this study, it is clear that growers of pistachio nuts have a significant impact on the economies of California, Arizona, and New Mexico. Overall, the growers create:

- Nearly $682.5 million in economic output, the best measure of economic activity, each year. This equates to nearly $1.9 million dollars each day of the year.

- Nearly 5,910 additional jobs as a result of their business activities and the multiplier effect created by the fact that their purchases create jobs in a variety of farming and non-farming economic sectors.

- More than $224.4 million in labor income as a result of their business activities. These are dollars going to wages and salaries for new employment as well as expanded incomes to those already in the labor force (e.g., overtime pay). These dollars are diffused throughout the three states' economies as the funds are spent for an array of goods and services.

- More than $24.4 million in indirect business taxes, not including income taxes. Depending on how these funds are used, they can help pay for some or all state and local programs that further benefit the people residing in California, Arizona, and New Mexico communities.

Overall, these findings demonstrate how important a role pistachio nut growers play in strengthening the economic climate of the three states. Their activities are diffused throughout each state's economy, touching nearly every aspect of life in the three states.

WESTERN PISTACHIO ASSOCIATION
ECONOMIC IMPACT STUDY

SUMMARY REPORT OF FINDINGS

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- How much they generate in business taxes.

Tootelian & Associates is a Sacramento, California-based marketing and management consulting firm. It specializes in performing economic impact studies, conducting market research, and assisting its clients with their business and marketing plans. The consultant was Dennis H. Tootelian, Ph.D. Dr. Tootelian is a Professor Emeritus of Marketing and Director of the Center for Small Business in the College of Business Administration at California State University, Sacramento. He received his Ph.D. in Marketing from Arizona State University, with minor fields in Accounting and Management.

Dr. Tootelian has published approximately one hundred articles dealing with all facets of business, and has co-authored six texts on marketing and small business management. Results of some of his applied research and writing have appeared in The Congressional Record, The Wall Street Journal, Forbes, The Kiplinger Report, USA Today, ABC National News website, and even The National Enquirer. Dr. Tootelian has worked in a consulting capacity with Fortune 500 companies (e.g., McDonald's Corporation, Merck, Johnson & Johnson, Nestles U.S.A., McKesson Corporation), not-for-profit organizations (e.g., California Pharmacists Association, California Dental Association), and federal and state governmental agencies (e.g., Centers for Disease Control, California Environmental Protection Agency, California Department of Parks and Recreation, and California Department of Food and Agriculture). He has conducted economic impact studies related to a variety of agricultural crops.

METHODOLOGY

Two models were used in this analysis. IMPLAN was used to compute the overall economic impact, and a specially designed model was created to help define expenditure levels to use in the IMPLAN model.

IMPLAN

The primary model used for this analysis was IMPLAN. It provides modeling based on data and tools to assess economic impacts at the state and other levels. IMPLAN has more than 1,500 users in the United States and internationally, including federal and state governments, universities, and private sector consultants.

The benefit of using an input-output model like IMPLAN is that it helps evaluate the effects of industries on each other based on the supposition that industries use the outputs of other industries as inputs. An input-output model makes it possible to examine economic relationships between businesses and between business and consumers. It will measure changes in any one or several economic variables on an entire economy.

Each industry that produces goods and services has an influence on, and in turn is influenced by, the production of goods and services of other industries. These interrelationships are captured through a multiplier effect as the demand and supply trickle over from industry to industry and thus impact total output, compensation, employment, etc. Of particular interest are industry output, employment, value added as measured by employee compensation, and indirect business taxes.

The full range of economic impacts includes direct, indirect, and induced benefits:

- ***Direct benefits*** consist of economic activity contained exclusively within the designated sector(s). This includes all expenditures made and all people employed.

- ***Indirect benefits*** define the creation of additional economic activity that results from linked businesses, suppliers of goods and services, and provision of operating inputs.

- ***Induced benefits*** measure the consumption expenditures of direct and indirect sector employees. Examples of induced benefits include employees' expenditures on items such as retail purchases, housing, banking, medical services, and insurance.

The total direct, indirect, and induced benefits arising due to the multiplier effect are presented in four ways:

- ***Output*** accounts for total revenues including all sources of income for a given time period for an industry in dollars. This is the best overall measure of business and economic activity because it is the measure most firms use to determine current activity levels.

- ***Employment*** demonstrates the number of jobs generated and is calculated in a full-time equivalent employment value on an annual basis.

- ***Indirect Business Taxes*** consist of property taxes, excise taxes, fees, licenses, and sales taxes paid by businesses. While all taxes during the normal opetration of bussinesses are included, taxes on profits or income are not included.

- ***Labor Income*** includes all forms of employee compensation paid by employers (e.g., total payroll costs including benefits, wages and salaries of workers, health and life insurance, retirement payments, non-cash compensation), and proprietary income (e.g., self employment income, income received by private business owners including doctors, laywers).

The ***multiplier effect*** for sales and employment reflect the increased economic activity that comes from sales being generated, and expenses being incurred, by a business. When a business generates sales, it must use some of that money to purchase other goods and other services and hire people to meet the demand for its products and services. Purchases made by the business represent sales to other firms who must then also purchase goods and services and hire people to meet their new demand. The additional hiring to meet demand means more people will have income which they will use to purchase goods and services for their households. All of this brings added sales to firms in the community. The net effect is that sales dollars are recycled in the community through this process of sales requiring additional purchases and employment, which result in sales for other firms who must use that money to make their own purchases and hire people.

Specialty Feeder Model

To provide data for the IMPLAN analysis, the analyst developed a "feeder" economic model that specifically addresses the variables and the critical issues. This model not only provides the data used in the IMPLAN analysis, but brings the economic impact down to a more understandable level to assess the impact in more detailed ways.

Because agricultural revenues and expenditures can fluctuate significantly from year-to-year, an "average year" was created based on historical and industrial operating statistics from 2000 through 2008. It is important to note, therefore, that the economic impact of pistachio nut crops could vary on an annual basis depending on climatic, pest, market, and other conditions at least partly beyond the control of growers. Computing the impact specifically for any one year was not considered appropriate because it might not be reflective of what occurs over the course of time. Using a one year basis could significantly inflate the impact of these specialty crops by simply taking a particularly "good" year or understate the impact by taking a particularly "bad" year. The process for deriving the statistics is described more fully in the Findings of the Study.

WPA Survey

Industry statistics were used to estimate average revenues, expenses, and other operating data for this study. However, to ensure that this information was appropriate, the WPA was asked to verify that the statistics being used were reasonable for growers. Based on the information received, the industry statistics were modified as deemed appropriate. Information from a prior economic impact study of fifteen other specialty crop organizations also was used in cases where information was not available from industry and WPA sources.

Data Sources

Data used to assess the economic impact came from a variety of sources. These include:

- Statistics on average pistachio production in total and by state provided by the Census of Agriculture, U.S. Department of Agriculture; California Department of Food and Agriculture's California Agricultural Production Statistics 2009-2010; and, University of California Cooperative Extension's Sample Costs to Establish and Produce Pistachios.

- Industry average financial statements for growers of agricultural products provided by the Risk Management Association (RMA) in its "Annual Statement Studies" and by BizStats.

- Agricultural industry average financial and operating statistics provided by the Census of Business, United States Bureau of the Census.

- Consumer expenditure statistics for the Western United States provided by the United States Bureau of Labor Statistics.

- Population and other state statistics provided by the United States Bureau of the Census and the California Department of Finance.

- Budget statistics for California, Arizona, and New Mexico came from each state's official website.

FINDINGS OF THE ANALYSES

The findings of this study are presented in five sections: Computation of Total Expenditures Used in the Analyses, Total Economic Impact, Economic Impacts for Each State, Possible Diffusion of Labor Income Spending, and Possible Uses for Business Taxes Created. These results are presented for the combined total of all three states and for each state. Tabled data is presented at the end of this Summary Report.

Computation of Total Expenditures Used in the Analyses

The numbers of pistachio farms in California, Arizona, and New Mexico were obtained from the Census of Agriculture. These were verified by the WPA.

Expenditure estimates for growers were based on average costs per acre as reported by the University of California, Davis for 2000 through 20088. These also were compared to financial statistics for agricultural crops reported by the Risk Management Association (RMA), an independent organization which compiles national industry average operating expenses.

Expenditures focused on total expenditures excluding depreciation and amortization. Since the economic impact of growing and processing pistachio nuts on a state's economy is a function of spending, it was not appropriate to include depreciation and amortization. However, eliminating depreciation and amortization costs, this study excludes future investments that growers will be making to replace depreciable assets such as equipment and facilities. Eventually, growers have to make capital purchases but the timing of those expenditures is unknown. The net effect is to make this analysis more conservative than it might be in terms of estimating the economic impact overall and for each state's economy.

Total expenditures also were adjusted downward to reflect the possible out-migration of some dollars for purchases of goods and services. In effect, it was assumed that not all expenditures would necessarily be made within a given state. Fifteen specialty crop organizations surveyed for a previous study indicated that about 91.1% of their expenditures were within the state. This statistic was used here because it provided an average for a wide cross-section of possible expenditure patterns.

Based on these computations, average expenditures excluding depreciation and amortization in total and in each state are shown below:

State	Total Acres	Total Cost per Acre	Cash Cost per Acre	Total Grower Expenditures	Total Grower Expend. Per Day
Total	153,774	$3,836	$2,700	$415,259,829	$1,137,698

California	151,484	$3,836	$2,700	$409,075,786	$1,120,756
Arizona	1,523	$3,836	$2,700	$4,112,794	$11,268
New Mexico	767	$3,836	$2,700	$2,071,249	$5,675

The expenditure levels (column 5 above) were used in IMPLAN to compute the economic impact of growers in total and for each of the three states.

Total Economic Impact

Economic impact analyses were conducted for the total expenditures of growers in the three states and for expenditures by growers in each state. ***It is important to note that these projections are based on annual expenditures, which means that this impact is what is expected to occur each year that such spending occurs***.

The Output, Employment, Labor Income, and Indirect Business Taxes for all growers of pistachio nuts are presented in Table One and summarized below. These organizations spend nearly $415.3 million annually in California, Arizona, and New Mexico. This equates to nearly $1.2 million per day (i.e., $415.3 million divided by 365 days).

SUMMARY FOR TOTAL ECONOMIC IMPACT	TOTAL	PER DAY
Output	$682,480,972	$1,869,811
Employment	5,910	n.a.
Labor Income	$224,415,635	$614,837
Indirect Business Taxes	$24,410,415	$66,878

The overall Output, or the amount of overall business activity created, is projected to total nearly $682.5 million, equating to nearly $1.9 million each day of the year. This includes the direct spending by growers ("Direct"), the amount of additional business activity created by that spending ("Indirect"), and the amount of additional business activity created by people's spending caused by the incremental labor income ("Induced").

Nearly 5,910 additional jobs are expected to be created as a result of the spending by these growers. More than half of these jobs (52.2%) are the direct result of grower expenditures, and 47.8% will be caused by spending resulting from increased labor income.

Labor Income resulting from the additional people employed and current employees earning more is projected to be more than $224.4 million, equating to nearly $614,840 each day of the year. About 48.8% of this income is the direct result of spending by these growers, while 51.2% is caused by labor spending. How these funds are likely to be spent based on consumer purchasing patterns is described later in this Summary Report.

Finally, more than $24.4 million in additional business taxes will be created from the increased business activity caused by these growers, equating to nearly $66,880 each day of the year. These are tax dollars generated from businesses benefiting from the heightened economic activity and the increased employment. As is described later in this Summary Report, these tax dollars can be used for programs that further serve the communities within each state.

Economic Impacts for Each State

Economic impact analyses were conducted for each of the three states. ***It is important to note that these projections are based on annual expenditures, which means that this impact is what is expected to occur each year that such spending occurs***. The economic impacts of the expenditures by growers of pistachio nuts in each state are presented in the following tables on an annual and daily basis and summarized below.

SUMMARY PER YEAR	CALIFORNIA	ARIZONA	NEW MEXICO
Output	$672,317,476	$6,759,391	$3,404,105
Employment	5,822	59	29
Labor Income	$221,073,641	$2,222,645	$1,119,349
Indirect Business Taxes	$24,046,896	$241,764	$121,755

SUMMARY PER DAY	CALIFORNIA	ARIZONA	NEW MEXICO
Output	$1,841,966	$18,519	$9,326
Employment	n.a.	n.a.	n.a.
Labor Income	$605,681	$6,089	$3,067
Indirect Business Taxes	$65,882	$662	$334

California

The Output, Employment, Labor Income, and Indirect Business Taxes for California are presented in Table Two. These growers spend nearly $409.1 million annually in California, averaging more than $1.1 million each day.

The Output, or the amount of overall business activity created, is projected to total more than $672.3 million within California, or more than $1.8 million each day of the year. This includes the direct spending by the growers ("Direct"), the amount of additional business activity created by that spending ("Indirect"), and the amount of additional business activity created by people's spending caused by the incremental labor income ("Induced"). More than half of this (60.8%) is the direct result of these grower expenditures, and 39.2% will be caused by spending resulting from increased labor income.

More than 5,820 additional jobs are expected to be created as a result of the spending by these growers. More than half of these jobs (52.2%) are the direct result of these grower expenditures, and 47.8% will be caused by spending resulting from increased labor income.

Labor Income resulting from the additional people employed and current employees earning more is projected to be nearly $221.1 million, equating to more than $605,680 each day of the year. About 48.8% of this income is the direct result of spending by these growers, while 51.2% is caused by labor spending. How these funds are likely to be spent based on consumer purchasing patterns is described later in this Summary Report.

Finally, more than $24.0 million in additional business taxes will be created from the increased business activity caused by these growers, equating to more than $65,880 each day of the year. These are tax dollars generated from businesses benefiting from the heightened economic activity and the increased employment. As is described later in this Summary Report, these tax dollars can be used for programs that further benefit the communities within California.

Arizona

The Output, Employment, Labor Income, and Indirect Business Taxes for Arizona are presented in Table Three. These growers spend nearly $4.1 million annually in Arizona, averaging nearly $11,270 each day.

The Output, or the amount of overall business activity created, is projected to total nearly $6.8 million within Arizona, or nearly $18,520 each day of the year. This includes the direct spending by the growers ("Direct"), the amount of additional business activity created by that spending ("Indirect"), and the amount of additional business activity created by people's spending caused by the incremental labor income ("Induced"). More than half of this (60.8%) is the direct result of these grower expenditures, and 39.2% will be caused by spending resulting from increased labor income.

Nearly 60 additional jobs are expected to be created as a result of the spending by these growers. More than half of these jobs (52.2%) are the direct result of these grower expenditures, and 47.8% will be caused by spending resulting from increased labor income.

Labor Income resulting from the additional people employed and current employees earning more is projected to be more than $2.2 million, equating to nearly $6,090 each day of the year. About 48.8% of this income is the direct result of spending by these growers, while 51.2% is caused by labor spending. How these funds are likely to be spent based on consumer purchasing patterns is described later in this Summary Report.

Finally, nearly $241,765 in additional business taxes will be created from the increased business activity caused by these growers, equating to more than $660 each day of the year. These are tax dollars generated from businesses benefiting from the heightened economic activity and the increased employment. As is described later in this Summary Report, these tax dollars can be used for programs that further benefit the communities within Arizona.

New Mexico

The Output, Employment, Labor Income, and Indirect Business Taxes for New Mexico are presented in Table Four. These growers spend nearly $2.1 million annually in New Mexico, averaging about $5,675 each day.

The Output, or the amount of overall business activity created, is projected to total more than $3.4 million within New Mexico, or more than $9,325 each day of the year. This includes the direct spending by the growers ("Direct"), the amount of additional business activity created by that spending ("Indirect"), and the amount of additional business activity created by people's spending caused by the incremental labor income ("Induced"). More than half of this (60.8%) is the direct result of these grower expenditures, and 39.2% will be caused by spending resulting from increased labor income.

Nearly 30 additional jobs are expected to be created as a result of the spending by these growers. More than half of these jobs (52.2%) are the direct result of these grower expenditures, and 47.8% will be caused by spending resulting from increased labor income.

Labor Income resulting from the additional people employed and current employees earning more is projected to be more than $1.1 million, equating to nearly $3,070 each day of the year. About 48.8% of this income is the direct result of spending by these growers, while 51.2% is caused by labor spending. How these funds are likely to be spent based on consumer purchasing patterns is described later in this Summary Report.

Finally, about $121,755 in additional business taxes will be created from the increased business activity caused by these growers, equating to nearly $335 each day of the year. These are tax dollars generated from businesses benefiting from the heightened economic activity and the increased employment. As is described later in this Summary Report, these tax dollars can be used for programs that further benefit the communities within New Mexico.

Possible Diffusion of Labor Income Spending

The labor income that is created will be diffused throughout the various sectors of each state's economy. As people spend this added income, those funds will be used to purchase a wide array of goods and services.

Diffusion of Total Labor Income Spending

To illustrate how those funds could be distributed to various economic sectors in the three-state region, consumer expenditures across various categories were obtained from the U.S. Bureau of the Census. Assuming that those funds will be spent in the same proportion as consumers currently spend their incomes, the dollars that are generated for each sector are shown below. The total percentages and dollars may not add up because some consumer line item purchases were omitted.

	Spending of Labor Income	Spending Per Day
Labor Income	**$224,415,635**	$614,837
Average annual expenditures	$183,285,413	$502,152
Food	$22,176,848	$60,758
Food at home	$12,444,562	$34,095
Food away from home	$9,729,030	$26,655
Housing	$64,746,237	$177,387
Shelter	$41,446,057	$113,551
Utilities, fuels, and public services	$10,513,734	$28,805
Household operations	$3,822,584	$10,473
Housekeeping supplies	$2,546,219	$6,976
Household furnishings and equipment	$6,414,387	$17,574
Apparel and services	$6,648,822	$18,216
Transportation	$32,176,128	$88,154
Vehicle purchases (net outlay)	$12,141,751	$33,265
Gasoline and motor oil	$7,778,665	$21,311
Other vehicle expenses	$9,904,856	$27,137
Public transportation	$2,347,601	$6,432
Health care	$9,312,257	$25,513
Health insurance	$4,802,650	$13,158
Medical services	$2,699,252	$7,395
Drugs	$1,383,814	$3,791
Medical supplies	$426,540	$1,169
Entertainment	$10,806,777	$29,608
Personal care products and services	$2,116,422	$5,798
Reading	$455,845	$1,249
Education	$2,741,581	$7,511
Miscellaneous	$3,487,212	$9,554
Cash contributions	$7,407,477	$20,294
Personal insurance and pensions	$18,855,693	$51,659

Diffusion of Labor Income Spending in California

Assuming that the labor income in California will be spent in the same proportion as consumers currently spend their incomes, the dollars that are generated for each sector are shown below. The total percentages and dollars may not add up because some consumer line item purchases were omitted.

	California Spending of Labor Income	California Spending Per Day
Labor Income	**$221,073,641**	$605,681
Average annual expenditures	$180,555,929	$494,674

Food	$21,846,591	$59,854
Food at home	$12,259,238	$33,587
Food away from home	$9,584,145	$26,258
	California Spending of Labor Income	**California Spending Per Day**
Housing	$63,782,037	$174,745
Shelter	$40,828,843	$111,860
Utilities, fuels, and public services	$10,357,164	$28,376
Household operations	$3,765,658	$10,317
Housekeeping supplies	$2,508,300	$6,872
Household furnishings and equipment	$6,318,864	$17,312
Apparel and services	$6,549,807	$17,945
Transportation	$31,696,962	$86,841
Vehicle purchases (net outlay)	$11,960,936	$32,770
Gasoline and motor oil	$7,662,826	$20,994
Other vehicle expenses	$9,757,353	$26,732
Public transportation	$2,312,640	$6,336
Health care	$9,173,579	$25,133
Health insurance	$4,731,129	$12,962
Medical services	$2,659,055	$7,285
Drugs	$1,363,207	$3,735
Medical supplies	$420,188	$1,151
Entertainment	$10,645,843	$29,167
Personal care products and services	$2,084,904	$5,712
Reading	$449,056	$1,230
Education	$2,700,753	$7,399
Miscellaneous	$3,435,281	$9,412

Diffusion of Labor Income Spending in Arizona

Assuming that the labor income in Arizona will be spent in the same proportion as consumers currently spend their incomes, the dollars that are generated for each sector are shown below. The total percentages and dollars may not add up because some consumer line item purchases were omitted.

	Arizona Spending of Labor Income	**Arizona Spending Per Day**
Labor Income	**$2,222,645**	$6,089
Average annual expenditures	$1,815,285	$4,973
Food	$219,643	$602
Food at home	$123,253	$338
Food away from home	$96,358	$264
Housing	$641,256	$1,757
Shelter	$410,488	$1,125
Utilities, fuels, and public services	$104,130	$285
Household operations	$37,859	$104
Housekeeping supplies	$25,218	$69
Household furnishings and equipment	$63,529	$174
Apparel and services	$65,851	$180

	Arizona Spending of Labor Income	Arizona Spending Per Day
Transportation	$318,677	$873
Vehicle purchases (net outlay)	$120,254	$329
Gasoline and motor oil	$77,041	$211
Other vehicle expenses	$98,099	$269
Public transportation	$23,251	$64
Health care	$92,230	$253
Health insurance	$47,566	$130
Medical services	$26,734	$73
Drugs	$13,705	$38
Medical supplies	$4,225	$12
Entertainment	$107,032	$293
Personal care products and services	$20,961	$57
Reading	$4,515	$12
Education	$27,153	$74
Miscellaneous	$34,538	$95

Diffusion of Labor Income Spending in New Mexico

Assuming that the labor income in New Mexico will be spent in the same proportion as consumers currently spend their incomes, the dollars that are generated for each sector are shown below. The total percentages and dollars may not add up because some consumer line item purchases were omitted.

	New Mexico Spending of Labor Income	New Mexico Spending Per Day
Labor Income	**$2,222,645**	$6,089
Average annual expenditures	$1,815,285	$4,973
Food	$219,643	$602
Food at home	$123,253	$338
Food away from home	$96,358	$264
Housing	$641,256	$1,757
Shelter	$410,488	$1,125
Utilities, fuels, and public services	$104,130	$285
Household operations	$37,859	$104
Housekeeping supplies	$25,218	$69
Household furnishings and equipment	$63,529	$174
Apparel and services	$65,851	$180
Transportation	$318,677	$873
Vehicle purchases (net outlay)	$120,254	$329
Gasoline and motor oil	$77,041	$211
Other vehicle expenses	$98,099	$269
Public transportation	$23,251	$64
Health care	$92,230	$253
Health insurance	$47,566	$130
Medical services	$26,734	$73
Drugs	$13,705	$38
Medical supplies	$4,225	$12

	New Mexico Spending of Labor Income	New Mexico Spending Per Day
Entertainment	$107,032	$293
Personal care products and services	$20,961	$57
Reading	$4,515	$12
Education	$27,153	$74
Miscellaneous	$34,538	$95

Possible Uses for Business Taxes Created

To illustrate how the business tax dollars could be used to help fund some of each state's operations, the budgets of a variety of agencies were obtained from the official websites for California, Arizona, and New Mexico. Some caution should be exercised in using these numbers since budgets are adjusted over the course of the fiscal year. Accordingly, these only are presented as illustrations of general amounts spent by each State agency.

Possible Uses for Incremental Business Taxes in California

Presented below is the percent of each California state agency's budget that could be covered by the business tax dollars generated by growers of pistachio nuts' business activities within California. It is important to recognize that the total business tax dollars generated are applied to each state agency. However, the business taxes generated by these growers could pay for 1.8% of the total of all of the agencies' budgets listed below.

California Budget Category	2008-9 State Funds	% of Each Agency's Budget
Total Indirect Business Taxes		**$24,046,896**
Arts Council	$4,286,000	561.1%
Children & Families Commission	$752,133,000	3.2%
Department of Aging	$49,705,000	48.4%
Department of Fish & Game	$285,053,000	8.4%
Department of Food & Agriculture	$249,770,000	9.6%
Department of Forestry & Fire Protection	$844,700	2846.8%
Department of Parks & Recreation	$539,535	4457.0%
Dept. of Housing & Community Development	$401,408	5990.6%
Emergency Medical Services Authority	$13,376,000	179.8%
Total of Above	$1,356,108,643	1.8%

*If percent exceeds 100.0%, it indicates the taxes could pay more than the General Revenue budget.

Possible Uses for Incremental Business Taxes in Arizona

Presented below is the percent of each Arizona state agency's budget that could be covered by the business tax dollars generated by growers of pistachio nuts' business activities within Arizona. It is important to recognize that the total business tax dollars generated are applied to each state agency. However, the business taxes generated by these growers could pay for 0.2% of the total of all of the agencies' budgets listed below.

Arizona Budget Category	2008-9 State Funds	% of Each Agency's Budget
Total Indirect Business Taxes		**$241,764**
Arizona Office of Tourism	$16,622,200	1.5%
Department of Agriculture	$12,117,500	2.0%
Department of Commerce	$15,722,200	1.5%
Department of Emergency and Military Affairs	$14,283,200	1.7%
Department of Fire, Building and Life Safety	$3,764,000	6.4%
Department of Veterans' Services	$8,220,600	2.9%
Department of Water Resources	$24,167,700	1.0%
Schools for the Deaf and the Blind	$20,681,300	1.2%
Total of Above	$115,578,700	0.2%

*If percent exceeds 100.0%, it indicates the taxes could pay more than the General Revenue budget.

Possible Uses for Incremental Business Taxes in New Mexico

Presented below is the percent of each New Mexico state agency's budget that could be covered by the business tax dollars generated by growers of pistachio nuts' business activities within New Mexico. It is important to recognize that the total business tax dollars generated are applied to each state agency. However, the business taxes generated by these growers could pay for 0.2% of the total of all of the agencies' budgets listed below.

Arizona Budget Category	2008-9 State Funds	% of Each Agency's Budget
Total Indirect Business Taxes		**$121,755**
Cultural Affairs Department	$32,728,500	0.4%
Department of Game and Fish	$333,100	36.6%
Economic Development Department	$9,382,000	1.3%
Governor's Commission on Disability	$856,600	14.2%
Homeland Security and Emergency Mgmt. Dept.	$3,308,100	3.7%
New Mexico Livestock Board	$1,726,500	7.1%
Tourism Department	$11,286,800	1.1%
Total of Above	$59,621,600	0.2%

*If percent exceeds 100.0%, it indicates the taxes could pay more than the General Revenue budget.

CONCLUSIONS

Based on the findings of this study, it is clear that growers of pistachio nuts have a significant impact on the economies of California, Arizona, and New Mexico. Overall, the growers create:

- Nearly $682.5 million in economic output, the best measure of economic activity, each year. This equates to nearly $1.9 million dollars each day of the year.

- Nearly 5,910 additional jobs as a result of their business activities and the multiplier effect created by the fact that their purchases create jobs in a variety of farming and non-farming economic sectors.

- More than $224.4 million in labor income as a result of their business activities. These are dollars going to wages and salaries for new employment as well as expanded incomes to those already in the labor force (e.g., overtime pay). These dollars are diffused throughout the three states' economies as the funds are spent for an array of goods and services.

- More than $24.4 million in indirect business taxes, not including income taxes. Depending on how these funds are used, they can help pay for some or all state and local programs that further benefit the people residing in California, Arizona, and New Mexico communities.

Overall, these findings demonstrate how important a role pistachio nut growers play in strengthening the economic climate of the three states. Their activities are diffused throughout each state's economy, touching nearly every aspect of life in the three states.

TABLE ONE: THREE-STATE TOTAL

OUTPUT	Direct	Indirect	Induced	Total
Manufacturing	$0	$29,704,541	$16,654,105	$46,358,646
Wholesaling	$0	$9,339,412	$7,869,873	$17,209,285
Retailing	$0	$900,021	$17,534,849	$18,434,870
Real Estate	$0	$8,796,646	$6,771,139	$15,567,785
Professional Services	$0	$22,247,261	$26,026,475	$48,273,737
Administrative	$0	$923,800	$1,880,209	$2,804,009
Education	$0	$487,253	$2,047,100	$2,534,353
Health	$0	$918	$15,177,310	$15,178,228
Arts, entertainment, recreation	$0	$595,220	$2,936,674	$3,531,894
Accommodations, food services	$0	$814,303	$6,804,098	$7,618,401
Farming	$415,259,829	$48,425,110	$925,111	$464,610,050
Other	$0	$16,525,986	$23,833,729	$40,359,715
Total	$415,259,829	$138,760,471	$128,460,672	$682,480,972

EMPLOYMENT	Direct	Indirect	Induced	Total
Manufacturing	0.00	34.97	8.74	43.71
Wholesaling	0.00	48.08	39.34	87.42
Retailing	0.00	4.37	205.44	209.82
Real Estate	0.00	52.45	39.34	91.79
Professional Services	0.00	91.79	144.25	236.04
Administrative	0.00	8.74	21.86	30.60
Education	0.00	4.37	30.60	34.97
Health	0.00	0.00	135.51	135.51
Arts, entertainment, recreation	0.00	0.00	30.60	30.60
Accommodations, food services	0.00	8.74	109.28	118.02
Farming	3,086.04	1,634.81	0.00	4,720.85
Other	0.00	83.05	87.42	170.48
Total	3,086.04	1,971.39	852.38	5,909.80

LABOR INCOME IMPACT	Direct	Indirect	Induced	Total
Manufacturing	$0	$3,724,487	$2,828,706	$6,553,194
Wholesaling	$0	$3,612,017	$3,032,577	$6,644,594
Retailing	$0	$373,690	$7,382,096	$7,755,786
Real Estate	$0	$1,737,491	$1,264,401	$3,001,891
Professional Services	$0	$8,610,434	$10,117,434	$18,727,869
Administrative	$0	$464,785	$932,586	$1,397,371
Education	$0	$256,849	$1,097,116	$1,353,966
Health	$0	$350	$8,613,669	$8,614,019
Arts, entertainment, recreation	$0	$221,792	$1,079,719	$1,301,512
Accommodations, food services	$0	$293,392	$2,457,158	$2,750,550
Farming	$109,569,628	$45,968,651	$186,342	$155,724,622
Other	$0	$6,549,784	$4,040,478	$10,590,262
Total	$109,569,628	$71,813,724	$43,032,283	$224,415,635

INDIRECT BUSINESS TAXES	Direct	Indirect	Induced	Total
Manufacturing	$0	$785,540	$314,242	$1,099,783
Wholesaling	$0	$1,332,110	$1,114,732	$2,446,842
Retailing	$0	$94,985	$2,396,311	$2,491,297
Real Estate	$0	$959,731	$760,712	$1,720,443
Professional Services	$0	$437,072	$654,318	$1,091,390
Administrative	$0	$12,851	$27,014	$39,865
Education	$0	$3,978	$16,960	$20,938
Health	$0	$0	$121,649	$121,649
Arts, entertainment, recreation	$0	$18,577	$170,737	$189,315
Accommodations, food services	$0	$52,585	$408,703	$461,288
Farming	$11,863,580	$785,234	$17,965	$12,666,780
Other	$0	$320,012	$1,740,813	$2,060,825
Total	$11,863,580	$4,802,677	$7,744,159	$24,410,415

TABLE TWO: CALIFORNIA TOTAL

OUTPUT	Direct	Indirect	Induced	Total
Manufacturing	$0	$29,262,181	$16,406,092	$45,668,273
Wholesaling	$0	$9,200,330	$7,752,675	$16,953,005
Retailing	$0	$886,618	$17,273,720	$18,160,338
Real Estate	$0	$8,665,646	$6,670,304	$15,335,950
Professional Services	$0	$21,915,955	$25,638,889	$47,554,845
Administrative	$0	$910,043	$1,852,209	$2,762,252
Education	$0	$479,997	$2,016,614	$2,496,611
Health	$0	$904	$14,951,289	$14,952,194
Arts, entertainment, recreation	$0	$586,356	$2,892,941	$3,479,297
Accommodations, food services	$0	$802,176	$6,702,771	$7,504,947
Farming	$409,075,786	$47,703,964	$911,335	$457,691,085
Other	$0	$16,279,881	$23,478,797	$39,758,679
Total	$409,075,786	$136,694,052	$126,547,638	$672,317,476

EMPLOYMENT	Direct	Indirect	Induced	Total
Manufacturing	0.00	34.45	8.61	43.06
Wholesaling	0.00	47.37	38.75	86.12
Retailing	0.00	4.31	202.38	206.69
Real Estate	0.00	51.67	38.75	90.43
Professional Services	0.00	90.43	142.10	232.53
Administrative	0.00	8.61	21.53	30.14
Education	0.00	4.31	30.14	34.45
Health	0.00	0.00	133.49	133.49
Arts, entertainment, recreation	0.00	0.00	30.14	30.14
Accommodations, food services	0.00	8.61	107.65	116.26
Farming	3,040.08	1,610.47	0.00	4,650.55
Other	0.00	81.82	86.12	167.94
Total	3,040.08	1,942.03	839.68	5,821.79

LABOR INCOME IMPACT	Direct	Indirect	Induced	Total
Manufacturing	$0	$3,669,022	$2,786,581	$6,455,603
Wholesaling	$0	$3,558,227	$2,987,416	$6,545,643
Retailing	$0	$368,125	$7,272,162	$7,640,287
Real Estate	$0	$1,711,616	$1,245,571	$2,957,187
Professional Services	$0	$8,482,208	$9,966,766	$18,448,973
Administrative	$0	$457,863	$918,698	$1,376,562
Education	$0	$253,024	$1,080,778	$1,333,802
Health	$0	$344	$8,485,394	$8,485,739
Arts, entertainment, recreation	$0	$218,490	$1,063,640	$1,282,130
Accommodations, food services	$0	$289,023	$2,420,566	$2,709,589
Farming	$107,937,919	$45,284,087	$183,567	$153,405,573
Other	$0	$6,452,245	$3,980,307	$10,432,552
Total	$107,937,919	$70,744,275	$42,391,447	$221,073,641

INDIRECT BUSINESS TAXES	Direct	Indirect	Induced	Total
Manufacturing	$0	$773,842	$309,563	$1,083,405
Wholesaling	$0	$1,312,272	$1,098,132	$2,410,404
Retailing	$0	$93,571	$2,360,626	$2,454,196
Real Estate	$0	$945,439	$749,384	$1,694,823
Professional Services	$0	$430,563	$644,574	$1,075,137
Administrative	$0	$12,660	$26,611	$39,271
Education	$0	$3,919	$16,708	$20,626
Health	$0	$0	$119,838	$119,838
Arts, entertainment, recreation	$0	$18,301	$168,195	$186,495
Accommodations, food services	$0	$51,802	$402,617	$454,419
Farming	$11,686,908	$773,541	$17,698	$12,478,146
Other	$0	$315,247	$1,714,889	$2,030,135
Total	$11,686,908	$4,731,155	$7,628,833	$24,046,896

TABLE THREE: ARIZONA TOTAL

OUTPUT	Direct	Indirect	Induced	Total
Manufacturing	$0	$294,198	$164,945	$459,143
Wholesaling	$0	$92,499	$77,944	$170,443
Retailing	$0	$8,914	$173,668	$182,582
Real Estate	$0	$87,123	$67,062	$154,186
Professional Services	$0	$220,340	$257,770	$478,110
Administrative	$0	$9,149	$18,622	$27,771
Education	$0	$4,826	$20,275	$25,101
Health	$0	$9	$150,318	$150,327
Arts, entertainment, recreation	$0	$5,895	$29,085	$34,980
Accommodations, food services	$0	$8,065	$67,389	$75,454
Farming	$4,112,794	$479,609	$9,162	$4,601,565
Other	$0	$163,676	$236,053	$399,728
Total	$4,112,794	$1,374,304	$1,272,293	$6,759,391

EMPLOYMENT	Direct	Indirect	Induced	Total
Manufacturing	0.00	0.35	0.09	0.43
Wholesaling	0.00	0.48	0.39	0.87
Retailing	0.00	0.04	2.03	2.08
Real Estate	0.00	0.52	0.39	0.91
Professional Services	0.00	0.91	1.43	2.34
Administrative	0.00	0.09	0.22	0.30
Education	0.00	0.04	0.30	0.35
Health	0.00	0.00	1.34	1.34
Arts, entertainment, recreation	0.00	0.00	0.30	0.30
Accommodations, food services	0.00	0.09	1.08	1.17
Farming	30.56	16.19	0.00	46.76
Other	0.00	0.82	0.87	1.69
Total	30.56	19.52	8.44	58.53

LABOR INCOME IMPACT	Direct	Indirect	Induced	Total
Manufacturing	$0	$36,888	$28,016	$64,904
Wholesaling	$0	$35,774	$30,035	$65,809
Retailing	$0	$3,701	$73,113	$76,814
Real Estate	$0	$17,208	$12,523	$29,731
Professional Services	$0	$85,279	$100,205	$185,484
Administrative	$0	$4,603	$9,236	$13,840
Education	$0	$2,544	$10,866	$13,410
Health	$0	$3	$85,311	$85,314
Arts, entertainment, recreation	$0	$2,197	$10,694	$12,890
Accommodations, food services	$0	$2,906	$24,336	$27,242
Farming	$1,085,193	$455,280	$1,846	$1,542,319
Other	$0	$64,870	$40,017	$104,887
Total	$1,085,193	$711,254	$426,198	$2,222,645

INDIRECT BUSINESS TAXES	Direct	Indirect	Induced	Total
Manufacturing	$0	$7,780	$3,112	$10,892
Wholesaling	$0	$13,193	$11,040	$24,234
Retailing	$0	$941	$23,733	$24,674
Real Estate	$0	$9,505	$7,534	$17,040
Professional Services	$0	$4,329	$6,480	$10,809
Administrative	$0	$127	$268	$395
Education	$0	$39	$168	$207
Health	$0	$0	$1,205	$1,205
Arts, entertainment, recreation	$0	$184	$1,691	$1,875
Accommodations, food services	$0	$521	$4,048	$4,569
Farming	$117,499	$7,777	$178	$125,454
Other	$0	$3,169	$17,241	$20,411
Total	$117,499	$47,566	$76,699	$241,764

TABLE THREE: NEW MEXICO TOTAL

OUTPUT	Direct	Indirect	Induced	Total
Manufacturing	$0	$148,161	$83,068	$231,229
Wholesaling	$0	$46,583	$39,254	$85,837
Retailing	$0	$4,489	$87,461	$91,950
Real Estate	$0	$43,876	$33,773	$77,650
Professional Services	$0	$110,966	$129,816	$240,782
Administrative	$0	$4,608	$9,378	$13,986
Education	$0	$2,430	$10,211	$12,641
Health	$0	$5	$75,702	$75,707
Arts, entertainment, recreation	$0	$2,969	$14,648	$17,617
Accommodations, food services	$0	$4,062	$33,938	$37,999
Farming	$2,071,249	$241,537	$4,614	$2,317,400
Other	$0	$82,429	$118,879	$201,308
Total	$2,071,249	$692,115	$640,741	$3,404,105

EMPLOYMENT	Direct	Indirect	Induced	Total
Manufacturing	0.00	0.17	0.04	0.22
Wholesaling	0.00	0.24	0.20	0.44
Retailing	0.00	0.02	1.02	1.05
Real Estate	0.00	0.26	0.20	0.46
Professional Services	0.00	0.46	0.72	1.18
Administrative	0.00	0.04	0.11	0.15
Education	0.00	0.02	0.15	0.17
Health	0.00	0.00	0.68	0.68
Arts, entertainment, recreation	0.00	0.00	0.15	0.15
Accommodations, food services	0.00	0.04	0.55	0.59
Farming	15.39	8.15	0.00	23.55
Other	0.00	0.41	0.44	0.85
Total	15.39	9.83	4.25	29.48

LABOR INCOME IMPACT	Direct	Indirect	Induced	Total
Manufacturing	$0	$18,577	$14,109	$32,686
Wholesaling	$0	$18,016	$15,126	$33,142
Retailing	$0	$1,864	$36,821	$38,685
Real Estate	$0	$8,666	$6,307	$14,973
Professional Services	$0	$42,947	$50,464	$93,412
Administrative	$0	$2,318	$4,652	$6,970
Education	$0	$1,281	$5,472	$6,753
Health	$0	$2	$42,964	$42,965
Arts, entertainment, recreation	$0	$1,106	$5,385	$6,492
Accommodations, food services	$0	$1,463	$12,256	$13,719
Farming	$546,516	$229,284	$929	$776,729
Other	$0	$32,669	$20,153	$52,823
Total	$546,516	$358,195	$214,638	$1,119,349

INDIRECT BUSINESS TAXES	Direct	Indirect	Induced	Total
Manufacturing	$0	$3,918	$1,567	$5,486
Wholesaling	$0	$6,644	$5,560	$12,204
Retailing	$0	$474	$11,952	$12,426
Real Estate	$0	$4,787	$3,794	$8,581
Professional Services	$0	$2,180	$3,264	$5,444
Administrative	$0	$64	$135	$199
Education	$0	$20	$85	$104
Health	$0	$0	$607	$607
Arts, entertainment, recreation	$0	$93	$852	$944
Accommodations, food services	$0	$262	$2,039	$2,301
Farming	$59,174	$3,917	$90	$63,180
Other	$0	$1,596	$8,683	$10,279
Total	$59,174	$23,955	$38,627	$121,755

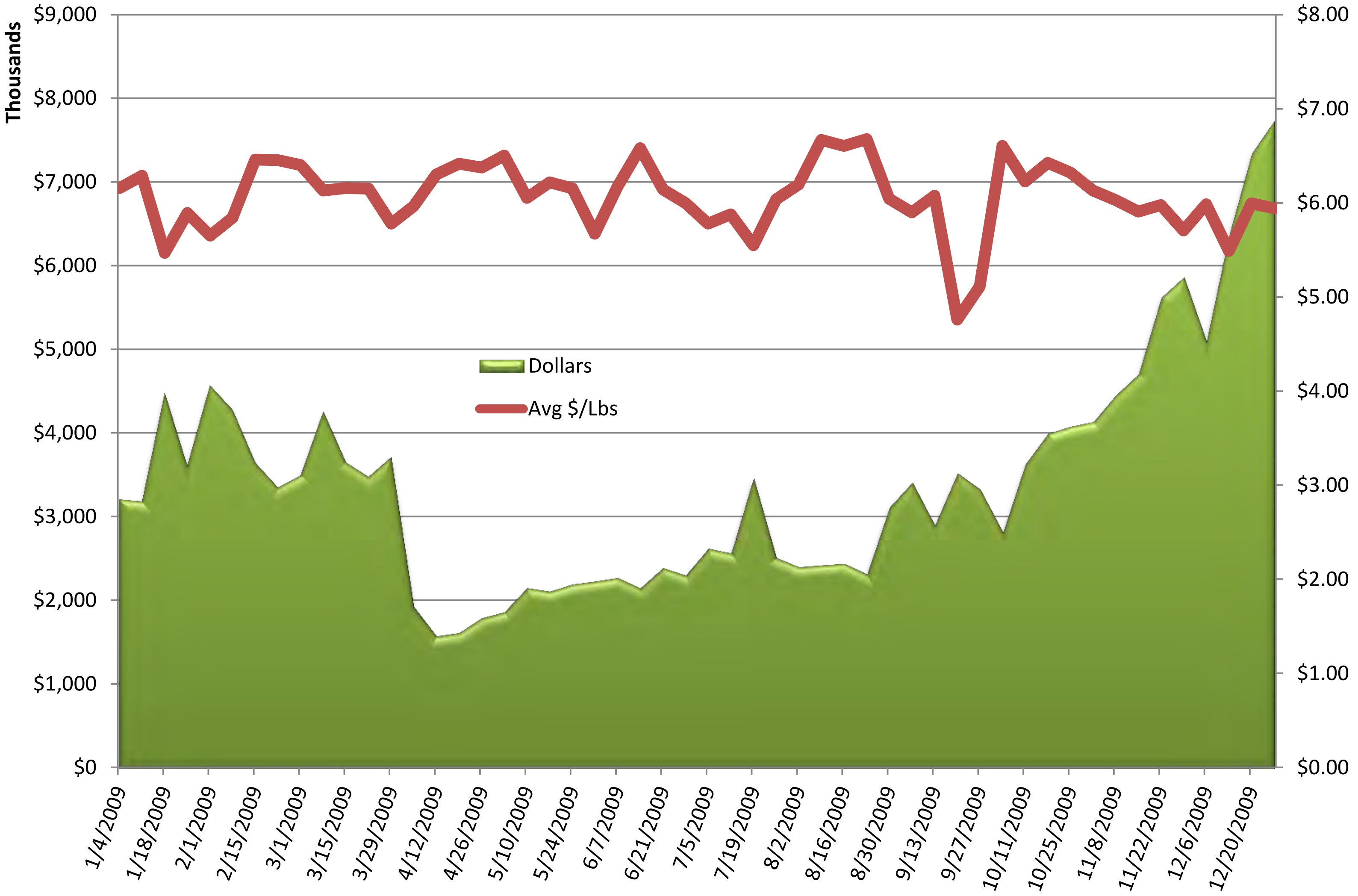
2009 Pistachio Season—A look back at the salmonella issue and its impact on sales

IRI InfoScan – 52wks Ending 12/27/09

AMERICAN PISTACHIO GROWERS

765

2009 Dollars & Avg $/Lbs by week

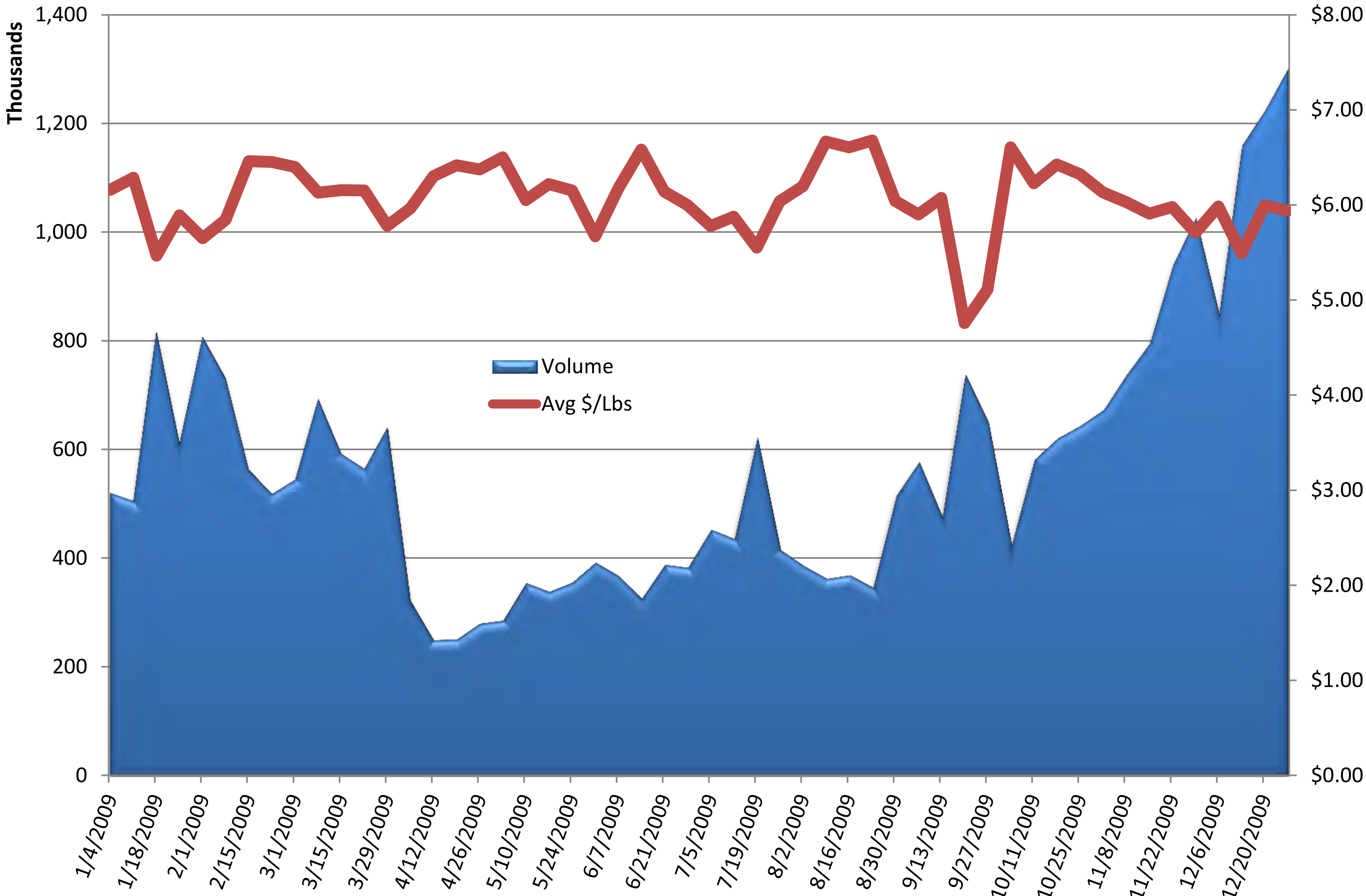


IRI InfoScan – 52wks Ending 12/27/09

AMERICAN PISTACHIO GROWERS

766

2009 Volume & Avg $/Lbs by week



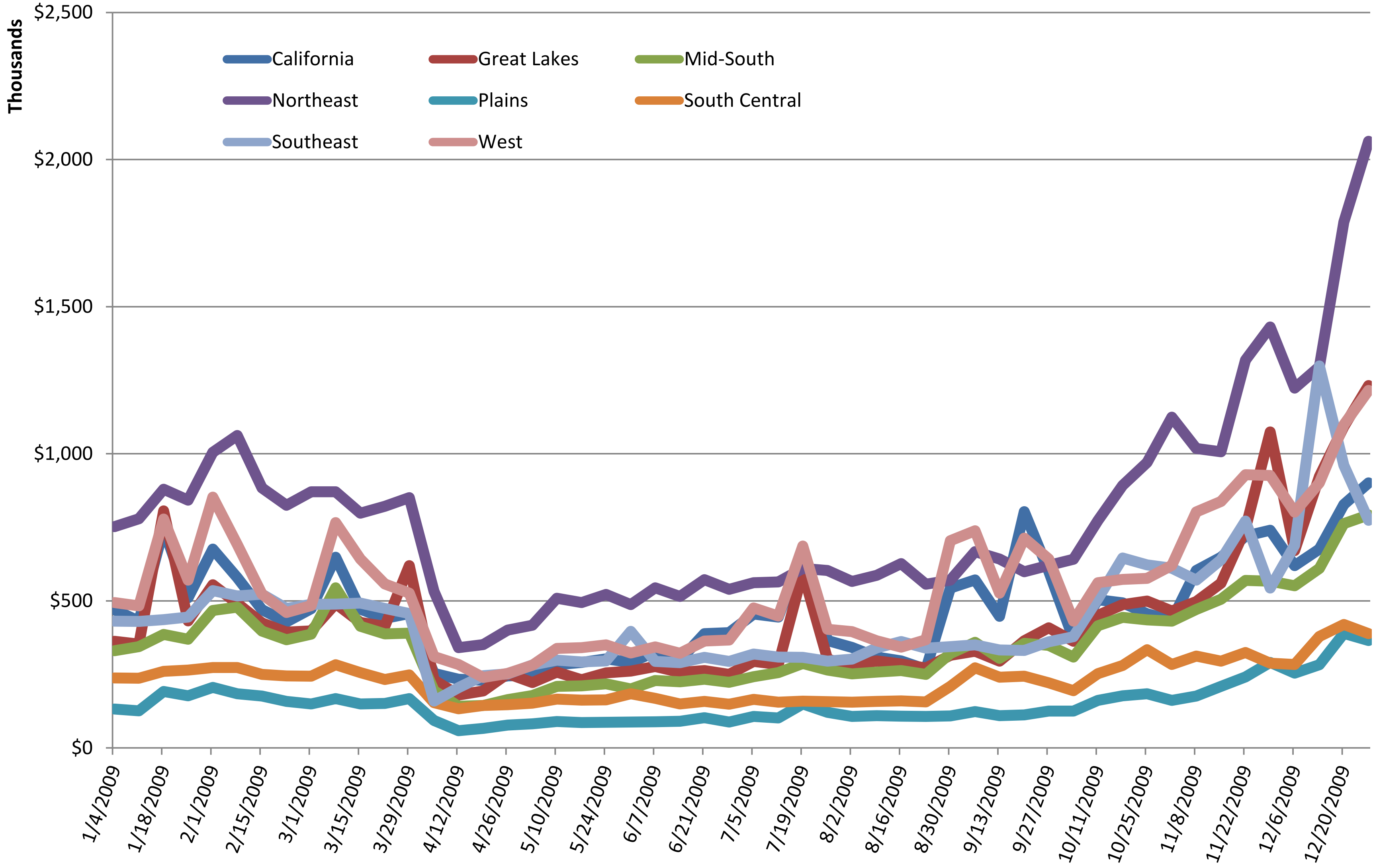
Pistachio sales were hit hard at the end of March, a 50% drop of volume in just one weeks time. Sales did not pick back up on a consistent basis until September.

AMERICAN PISTACHIO GROWERS

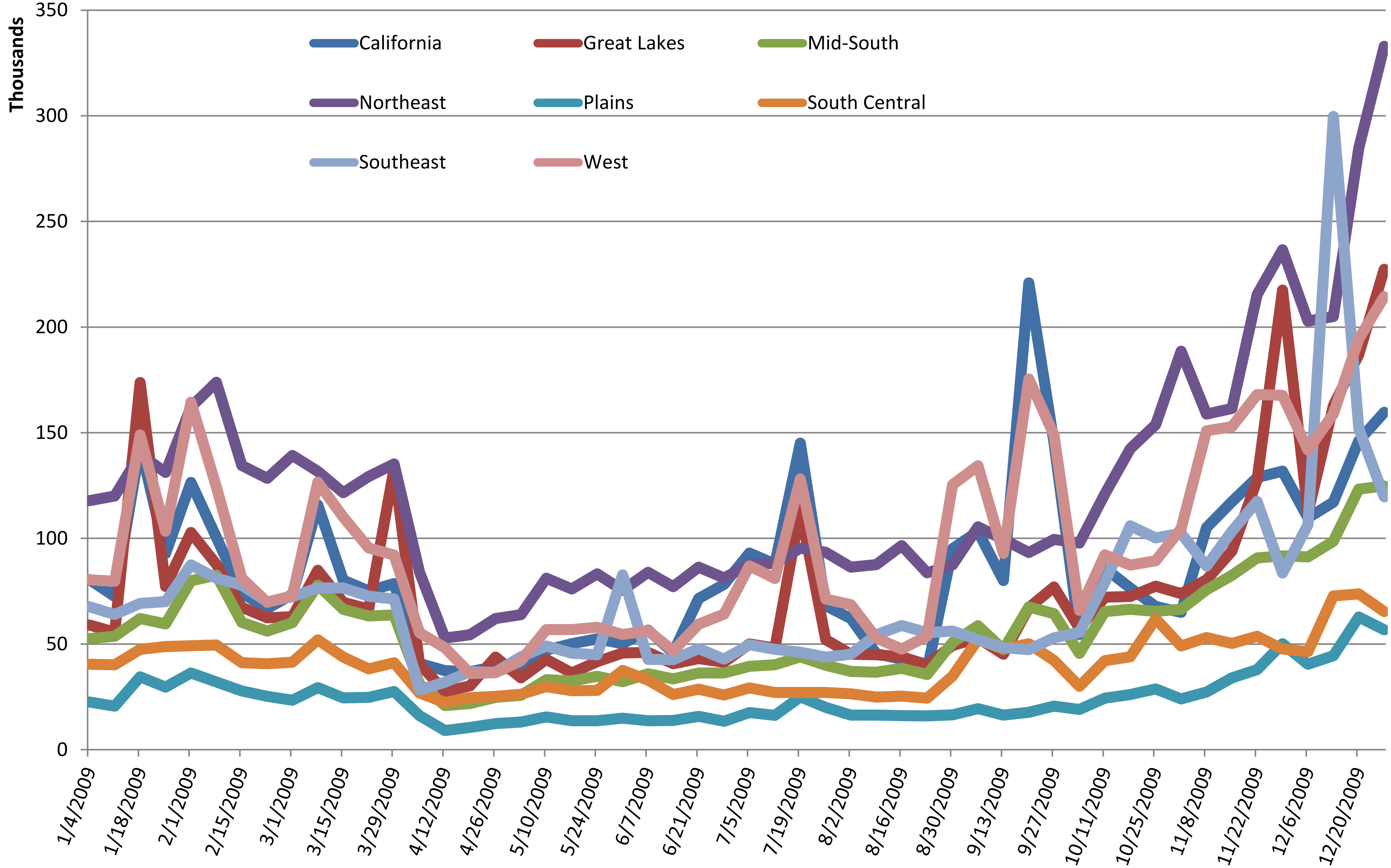
767

IRI InfoScan – 52wks Ending 12/27/09

2009 Dollars by Region per week



2009 Volume by Region per week



IRI InfoScan – 52wks Ending 12/27/09

AMERICAN PISTACHIO GROWERS

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Community Alliance with Family Farmers
Final Report to the Great Valley Center
Specialty Crop Growers Partner with City of San Francisco for Healthy People and Bottom Lines

August 2011

Summary
"Specialty Crop Growers Partner with City of San Francisco for Healthy People and Bottom Lines" has been an incredible learning experience for all the stakeholders involved. The result of a recommendation from policy leaders to increase connections between Bay Area farmers and consumers within San Francisco, the project's goal was to support small growers and simultaneously increase the amount of local produce available in the city. With a vibrant agricultural community and interest from a city with a strong culinary reputation, the goals of the project were well conceived and opportune.

Community Alliance with Family Farmers (CAFF) along with sub-grantees Marin Organic, Brentwood Agricultural Land Trust, Farms Reach (FR), approached the project with enthusiasm. Over two years of activities, CAFF and the partners made commendable achievements completing the project tasks that at first appeared straightforward, but were actually incredibly complex and challenging. In the end, a number of the objectives were achieved through the considerable ingenuity of the partners, collaborating entities, distributors, farmers and chefs.

Challenges
Part of the complexity confronted in this project had to do with the logistics of moving fresh produce from small farms into the wholesale distribution supply chain. Small farms often specialize in unique products, growing techniques, and direct sales in order to receive a price premium for their specialty crops. Without the cost saving and efficiency gains that large-scale mechanized operations benefit from while producing a standardized product, small farmers need to earn a price premium on a diverse array of products in order to make their farm financially viable. While wholesale produce distribution requires consistency, high volume, and significant capitalization to maintain the chain from field to kitchen, small farms focus on direct or short supply lines, harvesting at peak ripeness for taste, and producing a variety of products.

Accomplishments
During the first six months of the project, CAFF spent considerable time meeting with project partners, organizing the first trade mission event, reaching out to potential buyers in the city, and negotiating pricing with farmers, aggregators, and distributors. CAFF also worked on the logistics of packaging, transporting, storage, final delivery of product and development of the ordering and communication systems with FR.

On May 24th 2010, the CAFF team hosted the first trade mission event for over 80 food industry professionals, non-profit directors, academic partners, and farmers at Mills College in Oakland. Entitled *Scaling Up Local: Expanding Markets for Values-Based Food Distribution*, the half-day forum began with a lunch catered by Bon-Appétit Management with local ingredients donated through the Growers Collaborative Bay Area, SF Specialty, and a group of Hmong growers from the Fresno Area. Following the lunch, CAFF research partners Gail Feenstra and Shermain Hardesty from UC Davis led an engaging discussion with four Bay Area produce distributors including Chris Charlesworth, Director of Sales for SF Specialty, Scott Davis, Vice President of Sales at Fresh Point, Paula Linton Sales at Green Leaf, and Annie Ratto, Manager of the Growers Collaborative Bay Area.

While the discussion ranged from Bay Area seasonality, food safety, marketing and communications, the conclusion was that large customers of these major distributors are demanding locally sourced and verified products, and the industry must follow. The panel discussion was followed by and a meeting for the entire project team where the project was discussed along with goals.

By June 2010, several large buyers based in San Francisco expressed interest in the project after extensive outreach efforts by FR and CAFF. These buyers included San Francisco Juvenile Hall, Paula LeDuc Catering, Taste Catering, the Gap's in house food service department, the W Hotel, Living Room Events Catering, Ritz Carlton Hotel, Palace Hotel, St. Regis Hotel. With the Growers Collaborative (GC), CAFF and FR designated a list of 30 products that were seasonably available and in consistent demand by the buyers mentioned above. Each of these customers was serviced by one of three distributors: Fresh Point, SF Specialty, and Vegiworks.

By July 2010, sales had begun with the majority of the buyers. The product was sourced and aggregated by the Growers Collaborative and delivered by one of the three distributors. Growers Collaborative, with significant support from FR and CAFF, developed a specific availability list for these SF customers based on this project, offering lower prices, regular deliveries, marketing materials, and requiring substantial hours problem solving.

CAFF created over 20 farmer profiles over the project to use as promotional and advertising materials for the farmers. The profiles were created through interviews with farmers and included a picture of the farm. CAFF, Growers Collaborative and the distributors used the profiles when they marketed products to food service and end customers.

In January of 2011, CAFF and Growers Collaborative engaged one of the largest distributors in the nation. Sysco Foodservice supplies restaurants, schools, and other foodservice clients across San Francisco. In an agreement that was signed soon after, Sysco is now offering locally grown specialty crops to their clients in

San Francisco, sourced by the Growers Collaborative. Through this partnership, Growers Collaborative was also able to participate in the Sysco Food Show in early February. At the event CAFF and Growers Collaborative engaged Sysco account managers and hundreds of foodservice operators about offering locally grown products to their customers.

In March 2011, CAFF found another opportunity to connect local growers with consumers in San Francisco. CAFF was contacted by Whole Food's Bay Area Produce Coordinator, Karen Wolf, who was interested in creating a program for specialty Asian crops. While conducting outreach to provide the supply, Fresno area UC Cooperative Extension agents Richard Molinar and Michael Yang introduced CAFF to a group of five Hmong growers who specialized in these crops. Over phone calls and three in-person meetings (twice visiting with the growers at the farmers market), CAFF worked with them on the logistics of the sales. CAFF spent significant time consulting with growers on price, volume, and how the specialty crops would be packaged and delivered to the city. Growers Collaborative was to pick up the product on the farm, and transport it directly to a pilot store in San Francisco.

Unfortunately, due to this year's uncommonly cold and wet spring, the volumes projected by the farmers fell drastically as well as the quality of their products. After reviewing the product, it was clear that there was not sufficient volume of high quality product that would satisfy the volume needed by Whole Foods. There is continued interest from Whole Foods in establishing the program, and CAFF intends to try to connect the parties at a later date.

Conclusion
In collaboration with many partners along the supply chain, CAFF increased the supply of source identified, locally grown specialty crops entering the city of San Francisco. The project helped to expand markets for specialty crop growers, and increase grower knowledge as well as their access to wholesale customers.

Become a Marin Organic Business Member!

"The 'Marin Organic' sign tells us that the restaurant is a serious food destination…participating in the west county's responsible-agriculture culture while committing itself to do right by the high-quality ingredients thereby produced."

-Paul Reidinger, *San Francisco Business Guardian*

Member Benefits:

Customer Goodwill

Engage and connect your customers with the farmers you support through a personalized online Seasonal Sourcing List, tickets to a Farm Tour or special promotions via the Marin Organic Eat Local loyalty program.

Local Leadership

Share your values by making sustainable farming viable. Invest in your sourcing partners and support a local, thriving foodshed. Lead the way!

Quality Organic Products

Get access to the freshest, local food grown and produced without harmful chemicals or GMO seeds from Marin Organic Producers.

About Marin Organic

Marin Organic is a nonprofit organization working to cultivate a thriving, organic food and agricultural system that improves human health, promotes environmental stewardship and supports a local economy.

A Successful Local Food Economy Starts with Your Business

Marin Organic Business Members **understand the value of cultivating a vibrant local economy** nourished by sustainable, organic farming practices. Over the last 10 years, the financial contributions and sourcing commitments of Business Members have been critical in converting 20,000 acres to certified organic and GMO-free acreage, supporting a school lunch program that provides access to locally produced, nutritious food for 14,000 children every week, and ensuring the livelihoods of dozens of hard-working Bay Area farmers and artisan food producers.

Marin Organic Business Members live by the philosophy that enterprise is a source of positive and lasting change. Come join us and see how important your involvement can be!

Whichever membership level you choose, your support benefits customers, farmers and your business needs.

MEMBERSHIP BENEFITS*	Seed Level $150	Locavore Level $350	Harvest Level $500	Farm-to-Fork Level $1,000	Feast Level $1,500
Listing on Website	✓	✓	✓	✓	✓
Marin Organic Decal	✓	✓	✓	✓	✓
"Just the Dirt" Exclusive Newsletter Subscription	✓	✓	✓	✓	✓
Marin Organic Metal Sign		✓	✓	✓	✓
Business Profile Highlighted on Website		✓	✓	✓	✓
Inclusion on Marin Organic Eat Local Google Map		✓	✓	✓	✓
Business Profile & Logo Rotated on Homepage			✓	✓	✓
Featured Business on Eat Local Loyalty Program for Marin Organic Friends			✓	✓	✓
Social Media Promotion Via Marin Organic Networks				✓	✓
Farm Tour Passes - 4 per year for any event(s)					✓
Feature Article on Marin Organic Blog & Newsletter - Syndicated to 5,000+ Subscribers					✓
Personalized Online Seasonal List & Promotional Materials					✓

***See following page for details on individual membership levels and benefit descriptions.**

Marin Organic Business Member Benefits
Sourcing Commitment and Tier Details

Sourcing Commitment

Business Member applicants commit to regularly* sourcing from at least two Marin Organic Producers while their membership is active. Applications for membership are accepted throughout the year and renewed on a rolling basis every 12 months. **On your menu or selection of product offerings at all times*

A snapshot of Marin Organic Producers includes:

Detailed Benefits

Basic Listing and/or Profile on Website – Business name listed on the Eat Local Guide webpage. For Locavore Level members and up, business receives a profile page on MarinOrganic.org with company information and images. Harvest Level and up also secure rotating logo on Marin Organic Homepage

Marin Organic Signage – Business Member sticker for in-store window display. Locavore Level members and up also receive a large metal sign. *New design for sticker coming in 2012*

"Just the Dirt" Access – Subscription to exclusive seasonal email for ordering available and fresh produce and artisanal items from Marin Organic Producers, connecting your business directly to your sourcing partners

Eat Local Google Map – Business highlighted on Marin Organic Google Map. *Coming in 2012*

Social Media Promotion - Business-supplied news, events and other announcements promoted via Marin Organic Twitter and Facebook networks up to two times per month. Promotion must involve support or mention of a Marin Organic Producer

"Eat Local" Loyalty Card Program – Business included in promotions program for Friends-level donors of Marin Organic. By offering pre-determined "special deals" such as a free dessert or 20% off dinner coupon once a year (for a deal duration of 14 days, etc.), business receives exposure to new and existing customers through Loyalty Card email newsletter and online feature on Marin Organic website. *Coming in 2012*

Farm Tour Passes – Receive four passes to any Farm Tour event(s) of your choosing. No more than two tickets redeemed per tour. Give to staff or host a ticket contest for customers

Featured Article – Blog post written exclusively about the business and syndicated to Marin Organic's 5,000+ subscriber network

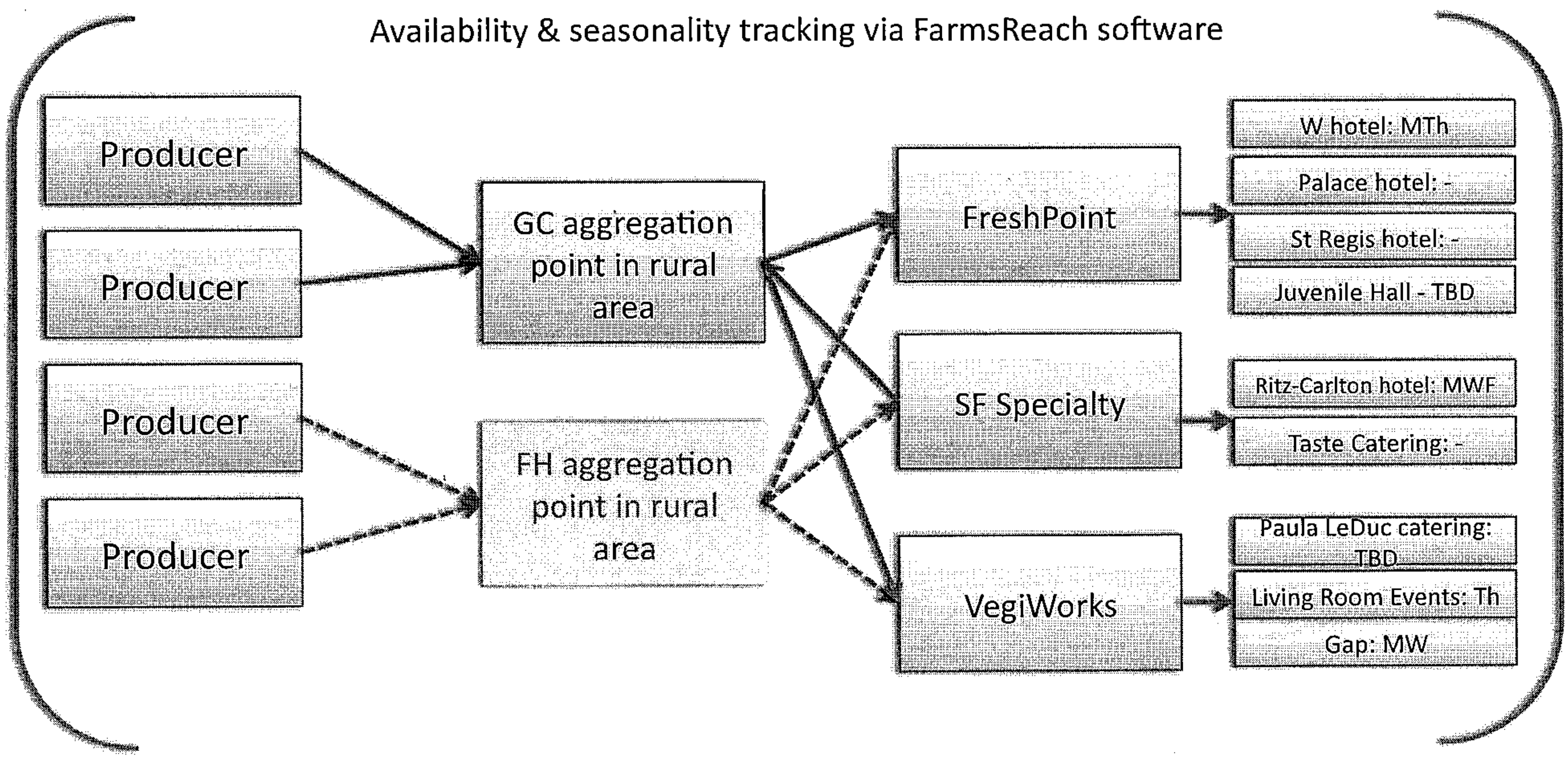
Seasonal List and Promotional Templates – Seasonal Sourcing profile customized and updated for your business every four months. All the farmers you support will be featured dynamically on your page, allowing customers to understand your business' unique 'sourcing story.' In-store promotional material template to direct customers to your online profile page is also provided. *Coming in 2012*

***A La Carte* Staff Farm Tour –** Customized celebration or team-building day for your staff (up to 25 people) available for any member level for $500. Connect employees to the business' roots and show them the importance of local, sustainable sourcing

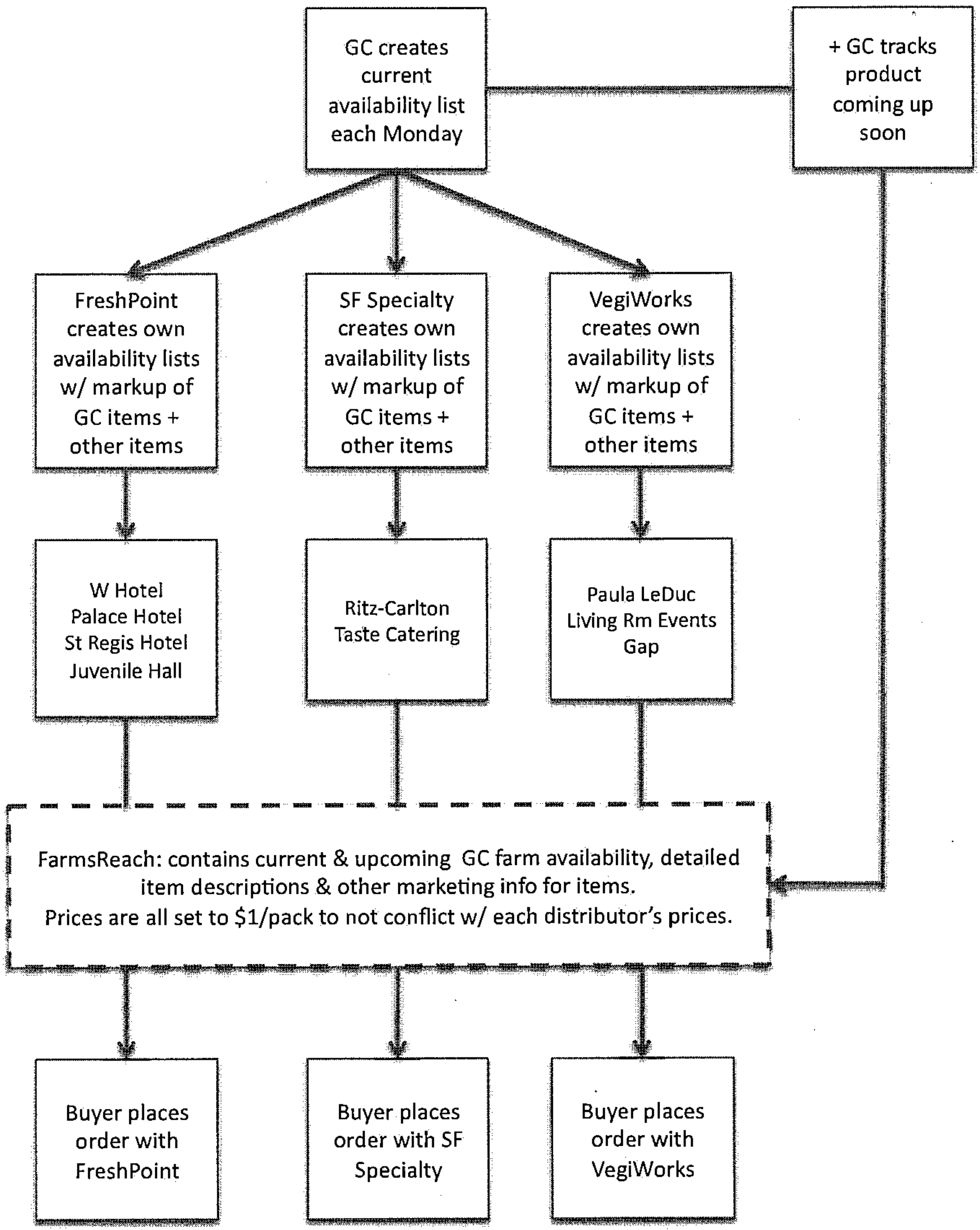
Ready to Join or Have Questions?

Contact Sasha Fedulow, Business Member Manager, at 415.663.9667 ext. 103 or sasha@marinorganic.org for more information.

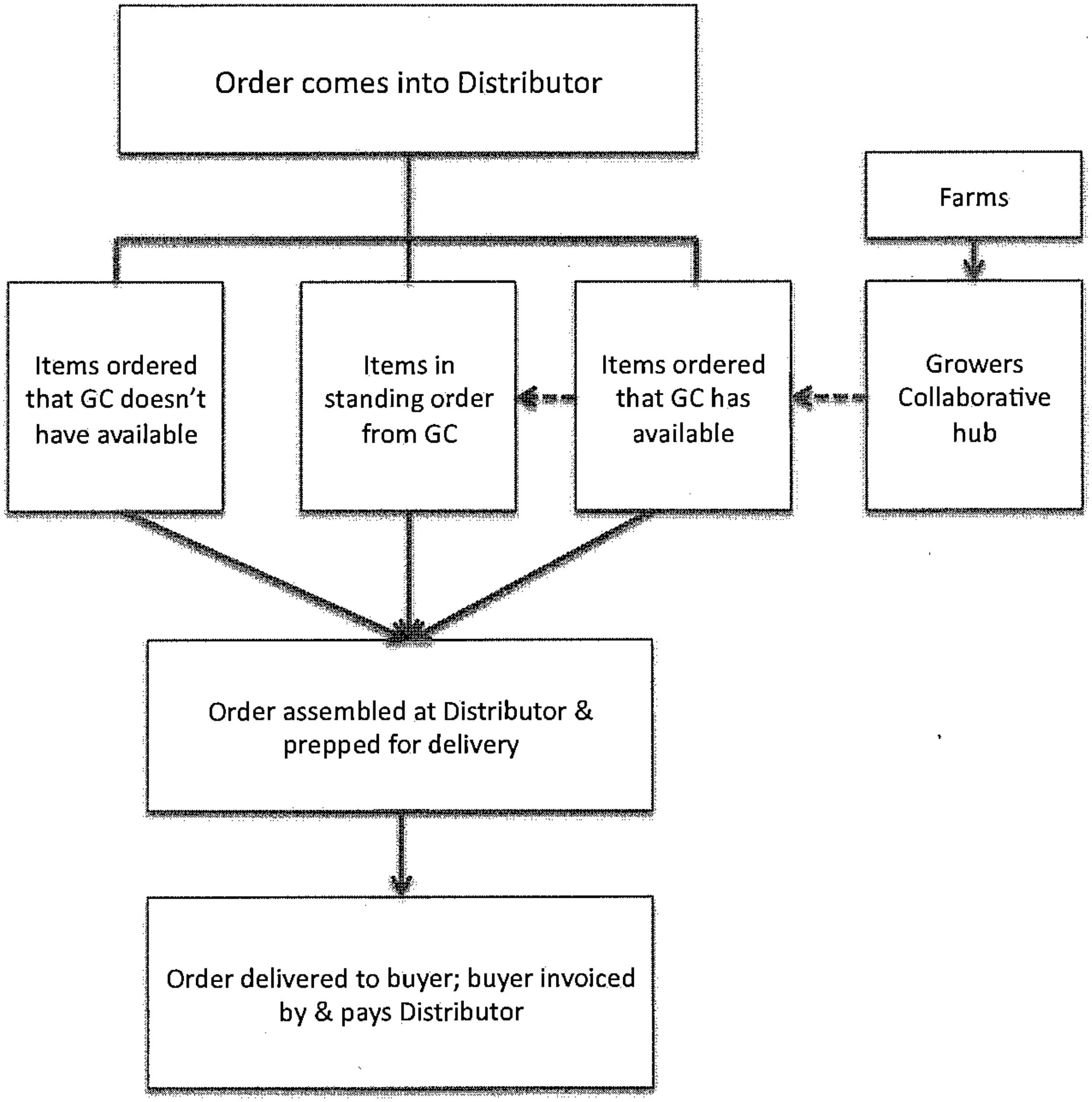
Project model



Availability tracking & ordering



Order processing & reports



Distributor provides FR/GC monthly reports of project buyers' purchasing

2010 & 2011 Summary of Work
on the CDFA Bay Area Specialty Crop Block Grant

Executive Summary

Marin Organic is an association of organic specialty crop producers in Marin County, California. Our mission is to cultivate a thriving and sustainable food and agricultural system that improves human health, promotes environmental stewardship, and supports a local economy. As a result of this grant, Marin Organic successfully realized two main accomplishments that benefit our local specialty crop producers and the regional economy: 1) Marin Organic established and deepened new and existing relationships with distributors and buyers; 2) Marin Organic clarified the needs of its specialty crop producers. This grant has made Marin Organic a better qualified advocate and marketer of North Bay specialty crops now and going forward.

Background

With a focus on the economic viability of small scale organic agriculture, Marin Organic has spent the past 10 years since its inception creating educational programs for local and regional consumers to learn about the importance and value of local agriculture. In addition, Marin Organic has created a marketing infrastructure to directly assist member farmers in their marketing and sales efforts.

In our approach, we emphasize relationship building as a keystone to creating ongoing success. Initiating conversations and creating lasting relationships is a time intensive and sometimes difficult task, yet the success of Marin Organic and its specialty crop producers throughout the years has confirmed it is a worthwhile effort.

Challenges

Marin Organic's specialty crop farmers produce diverse, high quality food crops on organic plots ranging from 1 acre to 40 acres of certified organic land. An ongoing challenge for Marin Organic's small scale growers has been outreach to San Francisco buyers due to lack of time, technology and expertise. To help address this challenge, Marin Organic has restructured its Supporting Business Program, a program that connects local buyers to our producer members, due to launch at the beginning of 2012. This is one lasting impact of the grant, and is explained in detail below, in the *Sustainability* section.

Another critical challenge for our producer members in meeting the needs of specialty crop buyers and distributors in San Francisco is distribution. In 2011, the North Coast Regional Food System Network was formed to begin to address this challenge. Marin Organic and other partners, including fellow grantee, CAFF, represent the counties of Marin, Sonoma, Napa, Mendocino, and Lake and are committed to aligning needs and common priorities of the five North Bay counties. A main focus of the network is aggregation, including ways for various partners to act as hubs in order to serve North Bay industrial buyers, such as schools.

Accomplishments and Impact

The collaborative grant (CDFA Contract SCB09028) has been instrumental to Marin Organic's marketing capacity for our specialty crop growers' products to businesses and institutions in San Francisco. During the first year of the grant (2010), Marin Organic worked in collaboration with our fellow grantees, each from our unique perspectives, to create sales leads and marketing opportunities for our producer members. During the second year of the grant (2011), Marin Organic worked more independently of the grantee partners, but to the same end: sales leads and marketing opportunities in San Francisco for our specialty crop producer members.

Marin County lies just north of the Golden Gate Bridge - about an hour drive away from San Francisco. Because of our producer member's proximity and high quality small scale production, we have focused our efforts to market our producer's products specifically to restaurants and natural food stores in San Francisco to ensure a maximum profit to our producer members and a maximum return of investment to CDFA. Along the way, we explored the gamut of options available for our producer members through various local distributors and in partnership with other non-profit organizations. Below is an explanation of our engagement, accomplishments and impact with each stakeholder group.

Marin Organic Specialty Crop Growers:
Marin Organic began in early 2010 by surveying all of our specialty crop grower members to determine, among other things, interest and capacity to produce for the San Francisco markets. Over the subsequent months, we worked closely with Star Route Farm, RedHill Farms, AllStar Organics, Paradise Valley Produce, Sartori Farms, La Tercera, Wild Blue Farm, Worsley Farm, McEvoy Ranch, Cow Track Ranch, Fairfax Fresh, Indian Valley Campus Farm, Marin Roots Farm, and Conlan Ranch. We hosted a trade mission for regional buyers from Whole Foods Market featuring some of the above farms. We also hosted farmer dinners and held various meetings with current or prospective growers for the San Francisco marketplace.

Natural Food Stores:
During the first year of this collaborative grant (2010), Marin Organic worked closely with Whole Foods Market to increase the amount of local specialty crops offered in the three San Francisco locations. This work has resulted in an overall renewed commitment by Whole Foods Market to offer local products in their store locations in San Francisco, and in other Bay Area locations. Working with Whole Foods Market included a multilateral approach of meetings with regional buyers and regional management, staff education, and a regional management/buyer team field visit/trade mission at Marin Organic specialty crop member farms in West Marin (please see " Supporting Documentation" from our four 2010 invoices for details).

In addition, in 2011, Marin Organic had conversations with Rainbow Grocery Cooperative about sourcing more specialty crops from the North Bay. Ultimately, Rainbow was not able to make a commitment but remains open to the continued conversation.

Restaurants:
With the awareness about local organic food systems growing every month across the nation, many restaurants in San Francisco have already or are in the process of switching to local products. Beyond offering excellent flavor, the freshness of local foods and the associated local

"story" of the farmer and of how things are grown add additional excitement to the menu. For a local specialty crop producer, restaurants offer a niche-marketing opportunity where a premium price can be fetched and a lasting business relationship can be built between farmer and chef.

Local organic hotel restaurants are some of the most preferred outlets due to their order volume and purchase power. In 2010, Marin Organic worked with high end hotel restaurants such as W Hotel and Clift Hotel in San Francisco to assist them in their commitment to sustainability and to help manifest a menu that features local specialty crops throughout the year and seasons (please see "Supporting Documentation" for details). In addition, Marin Organic built relationships with other leading San Francisco restaurants committed to local and organic foods such as Coco500, the Boiler House Restaurant, Foreign Cinema, Tartine Bakery, Water Bar and several others.

Specialty Crop Distributors:
To expand the market contacts and possible sales leads of our specialty crop producers, Marin Organic met with San Francisco Specialty Crop Distributors such as Thumbs Up - A Growers Collaborative, Earls Organic and Veritable Vegetable. All are distributors of regional high end specialty crops and this grant allowed us to deepen our relationship with these companies and to help educate the buyers on specialty product availability throughout the year.

Organizational Partners:
As a last targeted group, we identified and initiated conversations with leaders and organizations such as Slow Food and Slow Money, which both have strong relationships with and a multitude of contacts in the restaurant and food scene in San Francisco in order to maximize our reach and possible sales leads. We found that building meaningful and successful relationships takes time and purchasing decisions are not made overnight. However, the CDFA grant allowed us to continue our work in this important area of building up "new business."

Findings

As the partnership between all the grantees unfolded, it became clear that each group was working independently to bring specialty crops from their respective regions into the San Francisco markets. As such, after each grantee's initial survey results were shared with the grantee partner responsible for aggregation, Marin Organic began its own 18-month process of meeting each of the remaining grant deliverables. The process was incremental. We followed sales leads on behalf of our specialty crop producers, many of which did not materialize into commitments to purchase North Bay-grown specialty crops during this grant's timeline. However, several leads did begin purchasing regularly from Marin Organic growers, such as Whole Foods Market. Other buyers expressed strong interest and may have subsequently begun buying directly from individual growers, as well.

Sustainability

Marin Organic will build upon the foundation laid by this grant opportunity to continue marketing and promoting North Bay specialty crops to San Francisco buyers through its revamped Supporting Business Program, a major component in the lasting impact of this work. The new program includes various tiers of "membership" with corresponding benefits at each level such as: a biweekly newsletter listing available products and prices from Marin Organic producer members; a buyer's profile on the Marin Organic website; farm tours for the buyer's employees; marketing via social media; and more. In addition, in 2012 Marin Organic will host a networking “meet and greet” event in San Francisco with the intent of introducing Marin Organic farmers to new potential clients in the city.

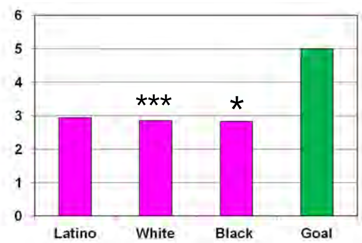
Acknowledgement

Marin Organic is grateful to the CDFA and the Great Valley Center for the opportunity to do this important work promoting the purchase of North Bay-grown specialty crops throughout San Francisco area over the past two years.

Promoting Fruit and Vegetable Consumption through WIC

Lucia Kaiser, PhD RD
Nutrition Specialist
UC Davis Dept of Nutrition
April 2, 2012

Fruit and Vegetable Intakes of (California women , 2005)



*** $p < 0.001$; * $p < 0.05$ between Latinos and other

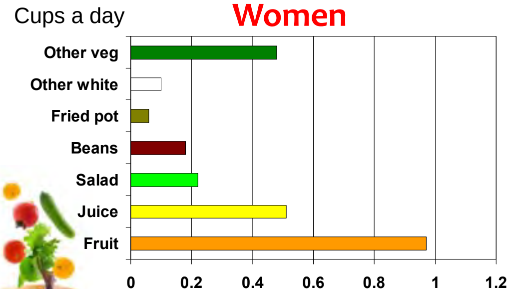
Colon-Ramos et. al. JADA 2009; 109:1878

New Study on Diet Patterns in Pregnant Women

- Observational study of German mothers (n=3207)
- Greater adherence to a Mediterrean diet (fruit, vegetables, vegetable oil, fish, pasta, rice):
  – Lower risk of growth retardation (IUGR)
  – Greater folate and B12

Timmermans et. al. British Journal of Nutrition 2012

Types of Fruit and Vegetables consumed among Mex-Am. Women



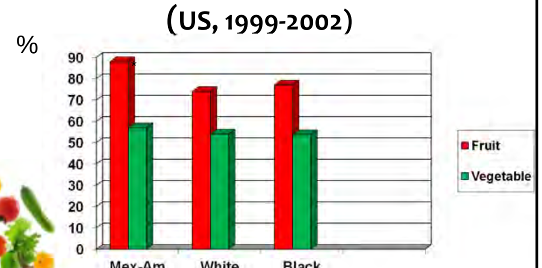
Colon-Ramos et. al. JADA 2009; 109:1878

Dietary Pattern and Weight Gain in African American Women

- Black Women's Health Study: 59,000 women (21-69 yrs) followed for 14 yrs.
- Lower weight gain among those with higher:
  – Cruciferous vegetables
  – Noncruciferous vegetables
  – Tomatoes
  – Fruit
  – Legumes
  – Fish (not fried)
  – Whole grains

Boggs DA et al Am J Clin Nutr 2011; 94: 86-94

% of Children who met MyPyramid Recommendations (US, 1999-2002)



For fruit: * $P < 0.05$ MX vs White/AfrAm

Lorson et. al. JADA 2009; 109:474

Acculturation effects

- Comparison of national MX and US data:
  - Mexican (MX), n=1978
  - Mex-born & living in US (MAMX), n=802
  - US-born & of MX heritage (MAUS), n=486
  - Non-Hispanic White, n=2297
- Higher F & V intakes among Mexican-Born living in US, esp. in women

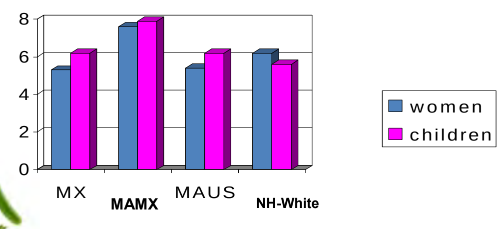
Batis et al J Nutr 2011 0: 1898-1906

Review of Fruit & Vegetable Behavioral Interventions

- A review of 34 behavioral interventions since 2005 (RCT > 30 subjects in a study or pre-post > 80 subjects)
- Adults: 9 (of 11 studies): inc. +1.13 svg)
  - Among low SES: 5 (of 9 studies): inc +0.97 svg
- Children: 3 (of 7 studies): inc. +0.39 svg)

Thomson & Ravia, JADA; 2011: 1523-1535

Mean % energy from Fruit & Vegetables



P < 0.01 in women
MAMX vs all others

Batis et al J Nutr 2011 0: 1898-1906

What works to promote fruit and vegetable intake in kids?

Low food security affects food purchased

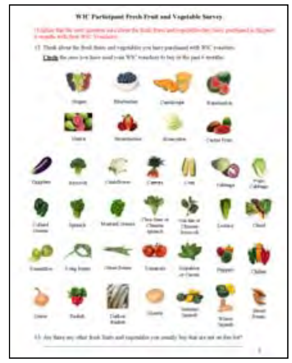
- Lower household supplies of F& V
- Higher intake of high-fat snacks, sweets, saturated fat among the children

Kaiser et al JNEB 2003
Rosas et al. JADA 2009; 109:2001

Recent Interventions

- Improved parenting skills (monitoring, reinforcing) increased F& V intake but no effect on BMI (Crespo 2012)
- Pairing veggies with familiar (liked) food increased veggie intake in obese kids (Johnston, 2011)
  - But repeated exposure in "Vegetable Resistant" kids does not work
- In preschoolers, while repeated exposure thru school cafeteria does not increase intake , peer influence does (O'Connell, 2012)

Sample question related to WIC purchases



Purpose of the survey

- Where do WIC participants use their fruit & vegetable vouchers?
- What do they buy? What would they like to buy?
- What influences their choice of stores and produce?

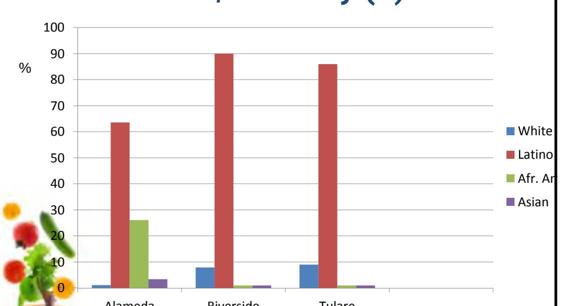
Sample Characteristics

- Total # compete surveys = 289 (Tulare = 100, Riverside = 101, Alameda = 88)
- Education = 52-64% at least high school/GED or more
- Average age=27-29 years
- All English or Spanish-speaking

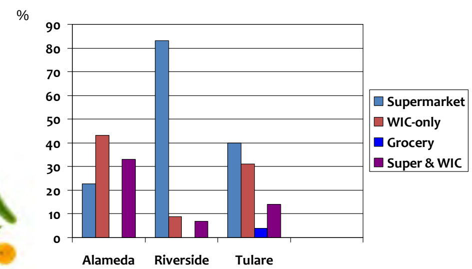
Methods

- Developed and piloted survey among 20 WIC participants
- Trained staff on interviewing techniques in Adobe Connect meeting
- Staff interviewed WIC participants, selected by convenience, in waiting rooms of WIC clinics
- All interviews were completed between April-June 2010 in Alameda, Riverside, and Tulare WIC clinics
- Protocol approved under exempt status by UC Davis Institutional Review Board

Race/Ethnicity (%)



Where do you shop for fruit and vegetables with your WIC vouchers?



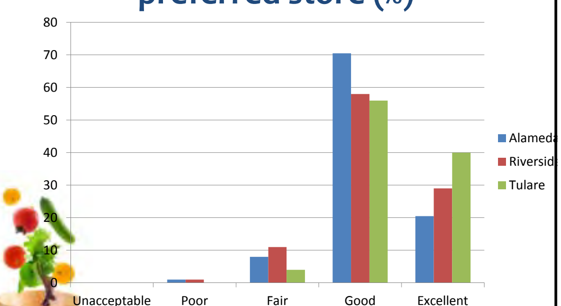
Preferred Store for Fruit/Veg

- Alameda: Prime Time Nutrition/WIC only (62.5%)
- Riverside: Cardenas (31.5%); Food4less (22.8%)
- Tulare
  - Dinuba, Earlimart, Porterville, Woodlake: WIC only
  - Farmersvillle: R & N

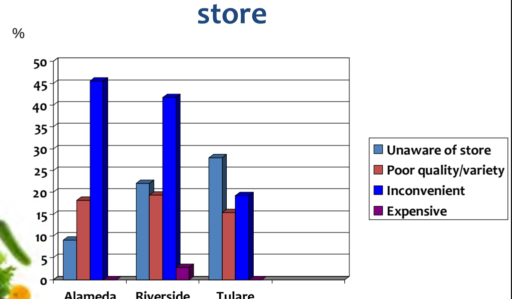
Ever shop at WIC-only Store

- Alameda: 88.6%
- Riverside: 37.6%
- Tulare: 75%

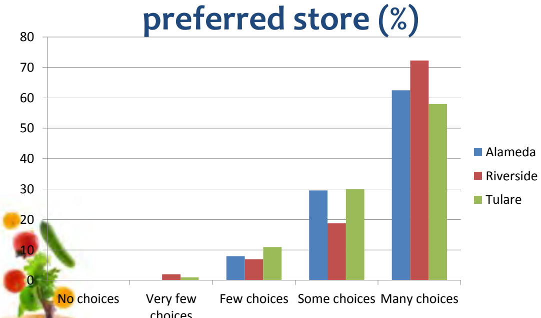
Perceived quality of F/V at preferred store (%)



Reasons for not using the WIC-only store



Perceived variety of F/V at preferred store (%)



Very Important Reason for Choosing F/V (in rank order)

- They are fresh and good quality: 96-99%
- They have lots of vitamins/minerals: 95-99%
- My family likes the taste: 84-98%
- I like the taste: 87-92%
- They are available where I shop: 76-95%
- They are on sale: 52-73%
- I need them for a recipe: 50-63%

What did WIC participants learn ?

- Preparation : "I didn't know that spinach could go into a sandwich. I've never eaten spinach before."
- Storage: "How long nopales last – they need to be used in 1 week."
- Nutrition: "Vitamin C – didn't know that broccoli had it."
- Selection: "How to choose a good one (tomato)."

Alameda: Most commonly purchased items in last 6 months

- > 50% Currently buy:
  - Grapes
  - Strawberries
  - Broccoli
  - Tomatoes
  - Onions
  - Carrots
- Other
  - Banana
  - Apple
  - Orange
  - Avocado
  - Pear
  - Mango

What suggestions do WIC participants make?

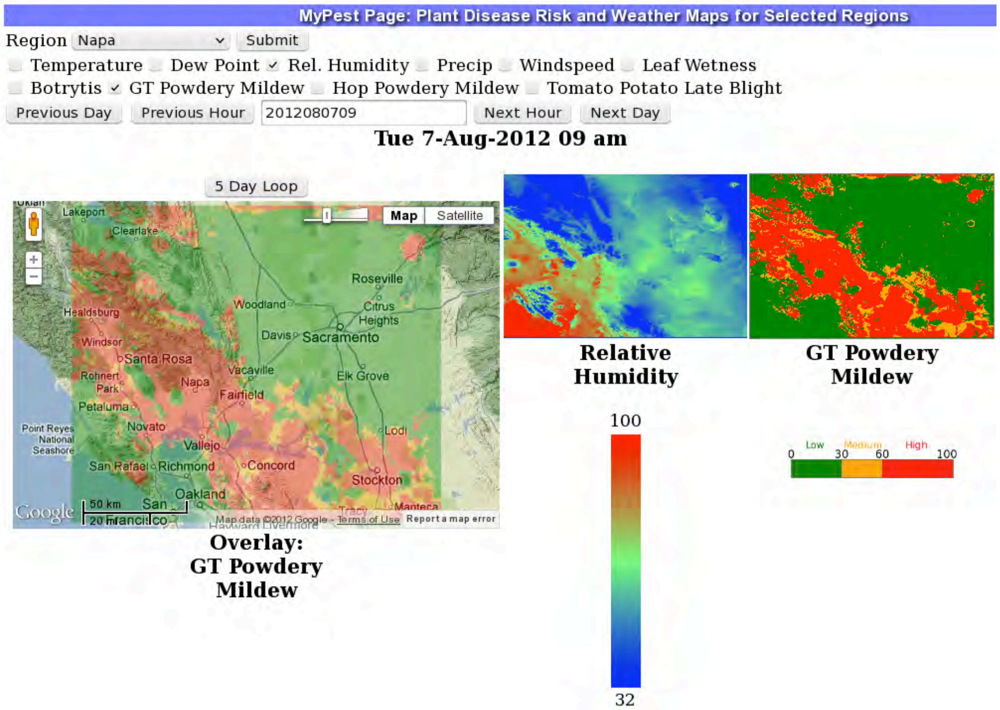
- "Blend and add (strawberries) to pancake mix or cupcake batter."
- "Blend and add carrots to juice."
- "Add cooked nopales to scrambled eggs with cheese."
- "Cut broccoli and dip it in low-fat cottage cheese instead of ranch."

Additional items where purchase would increase to >50% with greater availability

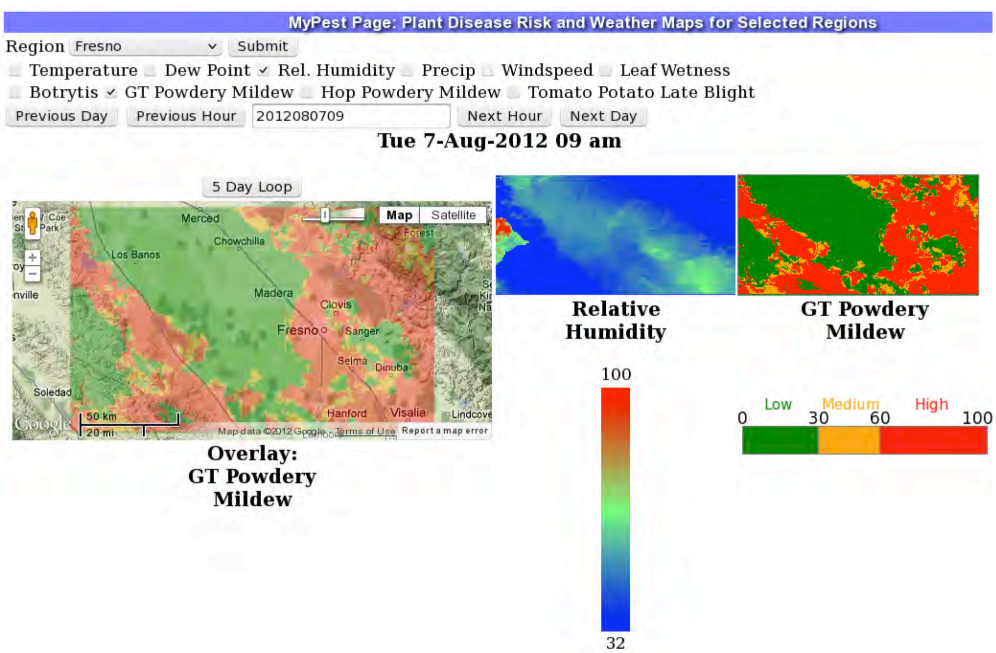
- Alameda
  - Cantaloupe
  - Watermelon
  - Cauliflower
  - Sweet corn
  - Cabbage
  - Spinach
  - Lettuce
  - Green beans
  - Bell peppers
  - Sweet potatoes

Attachment 1: Current status of gridded disease maps for Napa (A) and Fresno (B) grape growing regions. Examples show relative humidity and GT Powdery mildew grids and GT PM Google map. Clicking the "5 Day Loop" button animates the display, providing the ability to see changing disease risk conditions over time and space.

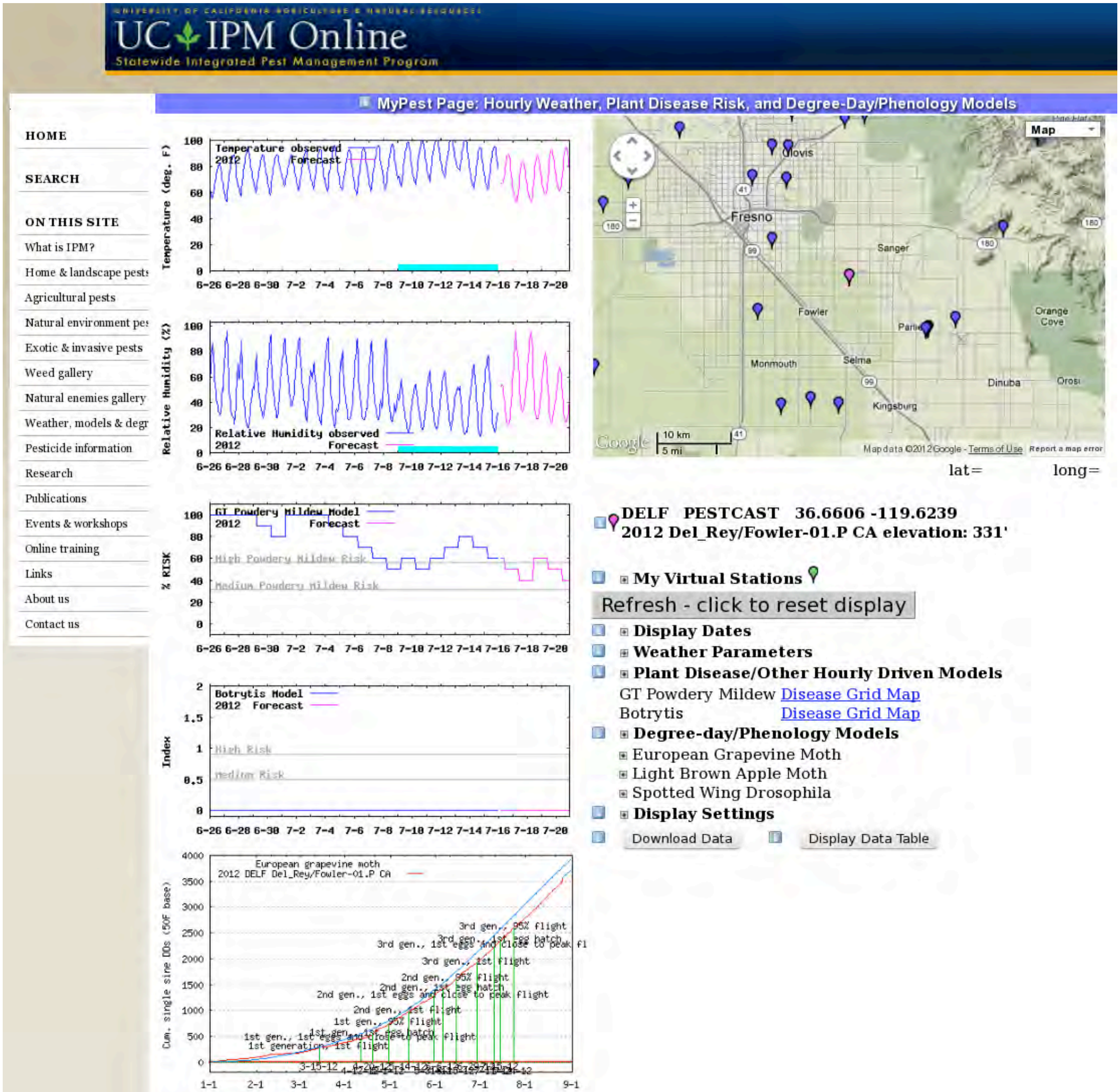
A.



B.



Attachment 2: UC IPM/IPPC "MyPest Page" showing integrated weather data, weather forecasts, disease and insect pest models, and google map, with links to gridded weather and disease outputs.



Attachment 3. Number of fungicide sprays and end-of the season evaluation of disease incidence and severity (2010)

Location	Treatment	No. of sprays	Date of application, fungicides used & rates	clusters Incid. (%)	clusters Sever. (%)
Sacramento	Untr. control	0	None	100	100
	calendar	7	4/22/10 Quintec (6 oz/A); 5/12/10 Rally (4 oz/A) 5/26/10 Stylet-oil (1%); 6/9/10 Rally (4 oz/A) 6/23/10 Flint (2 oz/A); 7/14/10 Quintec (6 oz/A) 8/3/10 Stylet-oil (1%);	92.5	19.39
	GT original	6	5/8/10 Stylet-oil (1%); 5/20/10 Stylet-oil (1%) 6/3/10 Quintec, (6 oz/A); 6/21/10 Rally (4 oz/A) 7/1/10 Flint (2 oz/A); 7/20/10 Stylet-oil, 1%	95	16.52
	34°C x 4h	7	5/8/10 Stylet-oil (1%); 5/20/10 Stylet-oil (1%) 6/3/10 Quintec (6 oz/A); 6/21/10 Rally (4 oz/A) 7/5/10 Flint (2 oz/A); 7/26/10 Stylet-oil (1%) 8/3/10 Quintec (6 oz/A)	97.5	14.76
	36°C x 4h	7	5/8/10 Stylet-oil (1%); 5/20/10 Stylet-oil (1%) 6/3/10 Quintec (6 oz/A); 6/21/10 Rally (4 oz/A) 7/5/10 Flint (2 oz/A); 7/23/10 Stylet-oil (1%) 8/3/10 Quintec (6 oz/A)	95	16.14
	38°C x 2h	7	5/8/10 Stylet-oil (1%); 5/20/10 Stylet-oil (1%) 6/3/10 Quintec (6 oz/A); 6/21/10 Rally (4 oz/A) 7/5/10 Flint (2 oz/A); 7/23/10 Stylet-oil (1%) 8/3/10 Quintec (6 oz/A)	97.5	21.88
	Mahaffee rev.	7	5/8/10 Stylet-oil (1%); 5/20/10 Stylet-oil (1%) 6/3/10 Quintec (6 oz/A); 6/21/10 Rally (4 oz/A) 7/5/10 Flint (2 oz/A); 7/26/10 Stylet-oil (1%) 8/3/10 Quintec (6 oz/A)	85	21.75
Solano	Untr. control	0	None	87.5	16.17
	calendar	5	5/18/10 Quintec (6 oz/A); 6/8/10 Rally (4 oz/A) 6/18/10 Flint (2 oz/A); 7/9/10 Quintec (6 oz/A) 7/30/10 Rally (4 oz/A)	2.5	0.01
	GT original	5	5/18/10 Quintec (6 oz/A); 6/8/10 Rally (4 oz/A) 6/18/10 Flint (2 oz/A); 7/5/10 Quintec (6 oz/A) 7/26/10 Rally (4 oz/A)	0	0
	34°C x 4h	5	5/18/10 Quintec (6 oz/A); 6/8/10 Rally (4 oz/A) 6/18/10 Flint (2 oz/A); 7/9/10 Quintec (6 oz/A) 7/30/10 Rally (4 oz/A)	0	0
	36°C x 4h	5	5/18/10 Quintec (6 oz/A); 6/8/10 Rally (4 oz/A) 6/18/10 Flint (2 oz/A); 7/9/10 Quintec (6 oz/A) 7/30/10 Rally (4 oz/A)	0	0
	38°C x 2h	5	5/18/10 Quintec (6 oz/A); 6/8/10 Rally (4 oz/A) 6/18/10 Flint (2 oz/A); 7/9/10 Quintec (6 oz/A) 7/30/10 Rally (4 oz/A)	0	0
	Mahaffee rev.	5	5/18/10 Quintec (6 oz/A); 6/8/10 Rally (4 oz/A) 6/18/10 Flint (2 oz/A); 7/9/10 Quintec (6 oz/A) 7/30/10 Rally (4 oz/A)	3.3	0.03

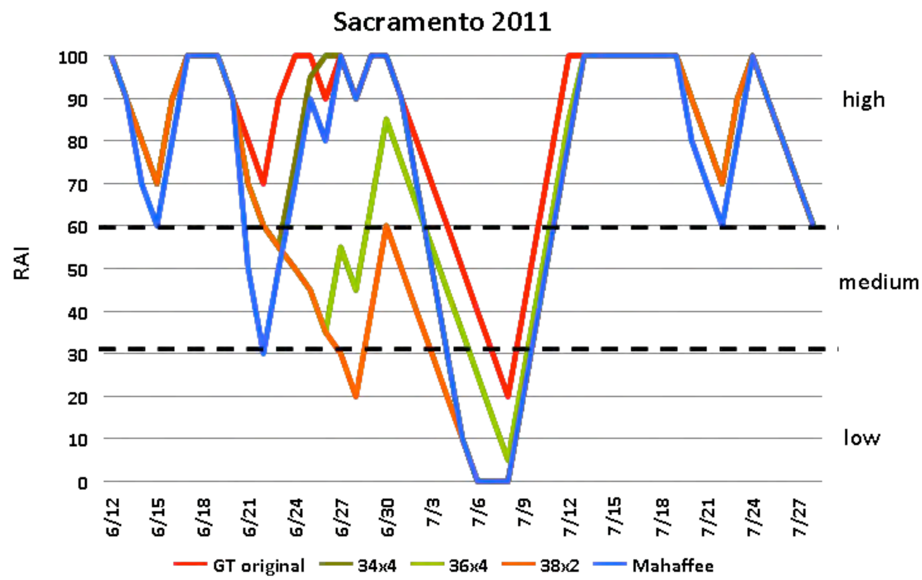
Attachment 4. Number of fungicide sprays and end-of the season evaluation of disease incidence and severity (2011)

Location	Treatment	No. of sprays	Date of application, fungicides used & rates	leaves		clusters	
				Incid. (%)	Sever. (%)	Incid. (%)	Sever. (%)
Sacramento	Untr. control	0	None	100	52.3	100	98.1
	calendar	7	4/21/11 Quintec (6.6 oz/A); 5/5/11 Rally (4 oz/A); 5/20/11 Flint (2 oz/A); 6/3/11 Quintec (6.6 oz/A); 6/17/11 Luna Experience (6 oz/A); 7/1/11 Flint (2 oz/A); 7/15/11 Quintec (6.6 oz/A)	12.04	0.56	2.78	0.07
	GT original	5	5/3/11 Quintec (6.6 oz/A); 5/18/11 Luna Experience (6 oz/A); 6/8/11 Flint (2 oz/A); 6/22/11 Quintec (6.6 oz/A); 7/17/11 Luna Experience (6 oz/A)	10.19	0.37	17.59	0.35
	34°C x 4h	5	5/3/11 Quintec (6.6 oz/A); 5/18/11 Luna Experience (6 oz/A); 6/8/11 Flint (2 oz/A); 6/22/11 Quintec (6.6 oz/A); 7/17/11 Luna Experience (6 oz/A)	9.26	0.22	18.52	1.14
	36°C x 4h	6	5/3/11 Quintec (6.6 oz/A); 5/18/11 Luna Experience (6 oz/A); 6/8/11 Flint (2 oz/A); 6/22/11 Quintec (6.6 oz/A); 7/6/11 Luna Experience (6 oz/A); 7/25/11 Flint (2 oz/A);	4.63	0.19	6.48	0.12
	38°C x 2h	6	5/3/11 Quintec (6.6 oz/A); 5/18/11 Luna Experience (6 oz/A); 6/8/11 Flint (2 oz/A); 6/22/11 Quintec (6.6 oz/A); 7/6/11 Luna Experience (6 oz/A); 7/25/11 Flint (2 oz/A);	9.26	0.28	1.85	0.03
	Mahaffee rev.	5	5/3/11 Quintec (6.6 oz/A); 5/18/11 Luna Experience (6 oz/A); 6/8/11 Flint (2 oz/A); 6/22/11 Quintec (6.6 oz/A); 7/17/11 Luna Experience (6 oz/A)	4.63	0.11	9.26	0.15
Solano	Untr. control	0	None	90.74	30.59	90.74	34.34
	calendar	7	4/26/11 Quintec (6.6 oz/A); 5/10/11 Rally (4 oz/A); 5/24/11 Flint (2 oz/A); 6/9/11 Quintec (6.6 oz/A); 6/23/11 Luna Experience(6 oz/A); 7/8/11 Flint (2 oz/A); 7/22/11 Quintec (6 oz/A)	10.19	0.19	0	0
	GT original	5	5/3/11 Quintec (6.6 oz/A); 5/19/11 Luna Experience (6 oz/A); 6/9/11 Flint (2 oz/A); 6/23/11 Quintec (6.6 oz/A); 7/13/11 Luna Experience (6 oz/A)	21.03	0.31	0	0
	34°C x 4h	5	5/3/11 Quintec (6.6 oz/A); 5/19/11 Luna Experience (6 oz/A); 6/9/11 Flint (2 oz/A); 6/30/11 Quintec (6.6 oz/A); 7/13/11 Luna Experience (6 oz/A)	12.96	0.23	0	0
	36°C x 4h	5	5/3/11 Quintec (6.6 oz/A); 5/19/11 Luna Experience (6 oz/A); 6/9/11 Flint (2 oz/A); 6/23/11 Quintec (6.6 oz/A); 7/13/11 Luna Experience (6 oz/A)	13.89	0.27	0	0
	38°C x 2h	5	5/3/11 Quintec (6.6 oz/A); 5/19/11 Luna Experience (6 oz/A); 6/9/11 Flint (2 oz/A); 6/23/11 Quintec (6.6 oz/A); 7/13/11 Luna Experience (6 oz/A)	19.44	0.3	0	0
	Mahaffee rev.	5	5/3/11 Quintec (6.6 oz/A); 5/19/11 Luna Experience (6 oz/A); 6/9/11 Flint (2 oz/A); 6/30/11 Quintec (6.6 oz/A); 7/13/11 Luna Experience (6 oz/A)	17.59	0.44	0	0

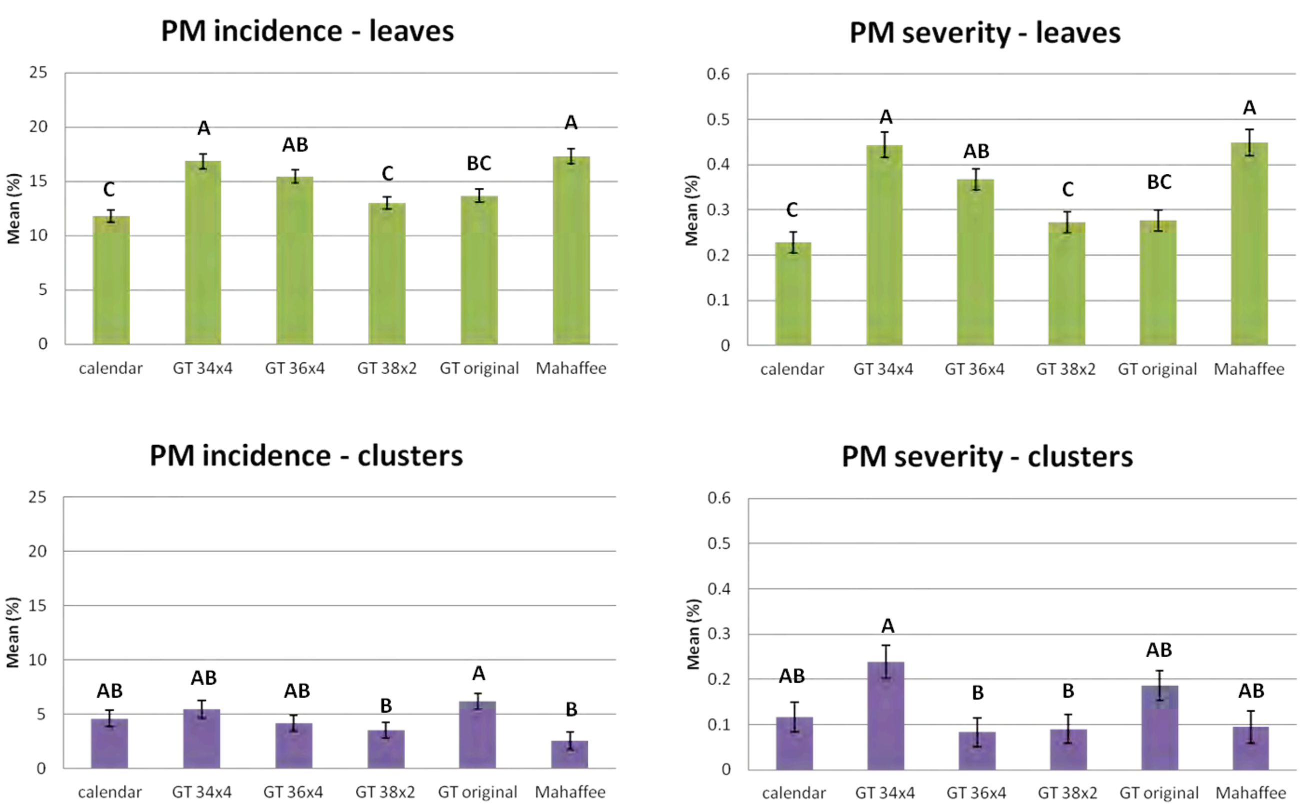
Attachment 5. Number of fungicide sprays and end-of the season evaluation of disease incidence and severity (2012)

Location	Treatment	No. of sprays	Date of application, fungicides used & rates	leaves		clusters	
				Incid. (%)	Sever. (%)	Incid. (%)	Sever. (%)
Fresno	Untr. control	0	None	67.6	7.5	85.18	19.33
	calendar	6	4/24/12 Quintec (6.6 oz/A); 5/8/12 Adament (4 oz/A); 5/22/12 Flint (2 oz/A); 6/5/12 Quintec (6.6 oz/A); 6/19/12 Adament (4 oz/A); 7/3/12 Flint (2 oz/A)	24.07	0.77	12.92	0.14
	GT original	5	4/24/12 Quintec (6.6 oz/A); 5/8/12 Adament (4 oz/A); 5/22/12 Flint (2 oz/A); 6/5/12 Quintec (6.6 oz/A); 6/26/12 Adament (4 oz/A);	14.81	0.29	20.37	0.05
	36°C x 4h	5	4/24/12 Quintec (6.6 oz/A); 5/8/12 Adament (4 oz/A); 5/22/12 Flint (2 oz/A); 6/12/12 Quintec (6.6 oz/A); 6/26/12 Adament (4 oz/A);	29.62	0.89	13.88	0.17
	38°C x 2h	5	4/24/12 Quintec (6.6 oz/A); 5/8/12 Adament (4 oz/A); 5/22/12 Flint (2 oz/A); 6/12/12 Quintec (6.6 oz/A); 7/3/12 Adament (4 oz/A)	33.33	1.05	12.96	0.15

Attachment 6: Example of the trend of the Risk Assessment Index (RAI) due to the original Gubler-Thomas model and its revisions in the Sacramento trial (2011)



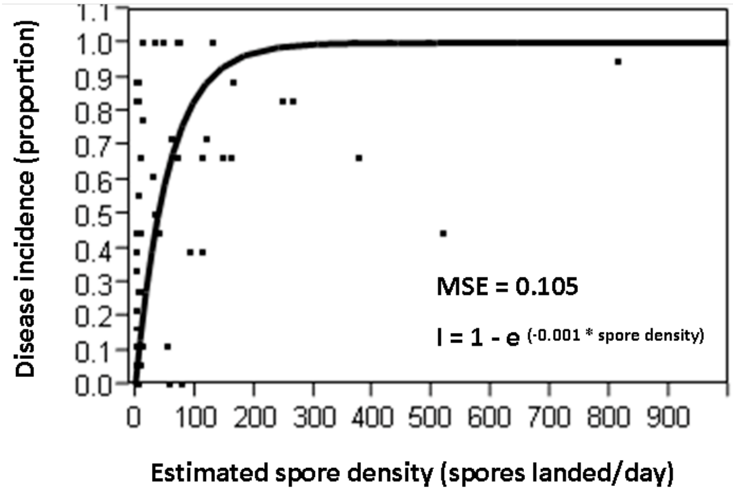
Attachment 7: Effect of fungicide applications timed by the original Gubler-Thomas model and its revisions on powdery mildew incidence and severity over 3 season's data (2010-2012)



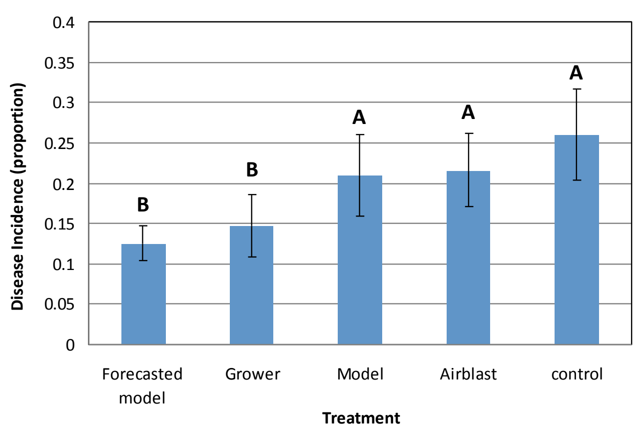
Attachment 8. Spore trapping trials for grapevine powdery mildew in California vineyards (2010-2012)

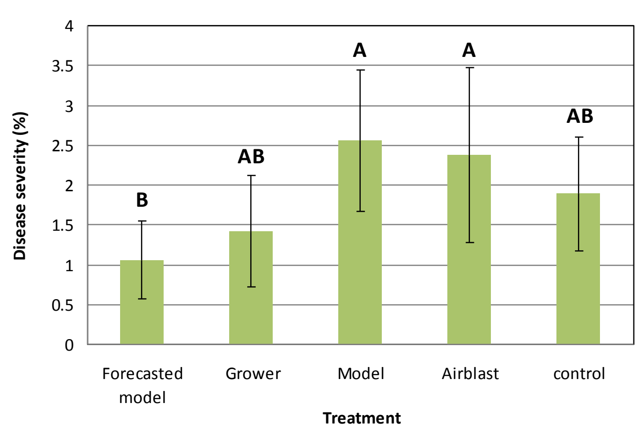
year	Vineyard location	Variety	Trap set-up	Bud break	Date trap first positive	Date disease first observed
2010	Solano Co.	Thompson seedless	3-17-2010	3-22-2010	6-10-2010	6-25-2010
	Sacramento Co. trap 1	Chardonnay	3-17-2010	3-19-2010	5-21-2010	5-20-2010
	Sacramento Co. trap 2	Chardonnay	3-18-2010	3-19-2010	5-06-2010	5-05-2010
	Monterey Co. trap 1	Chardonnay	3-26-2010	3-15-2010	4-7-2010	4-14-2010
	Monterey Co. trap 2	Chardonnay	3-26-2010	3-15-2010	N/A	N/A
	Sonoma Co. trap 1	Chardonnay	3-30-2010	3-20-2010	N/A	N/A
	Sonoma Co. trap 2	Chardonnay	3-30-2010	3-20-2010	N/A	N/A
	Napa Co.	various	4-01-2010	4-01-2010	N/A	N/A
	Fresno Co. trial 1	Thompson seedless	3-31-2010	3-15-2010	5-10-2010	4-28-2010
	Fresno Co. trial 2	Thompson seedless	3-31-2010	3-15-2010	6-23-2010	7-19-2010
	Kern Co. trap 1	Crimson	5-05-2010	3-15-2010	N/A	7-19-2010
	Kern Co. trap 2	Crimson	5-05-2010	3-15-2010	N/A	7-19-2010
2011	Sacramento Co.	Chardonnay	3-01-2011	4-01-2011	3-15-2011	4-26-2011
	Solano Co.	Thompson seedless	3-01-2011	3-25-2011	3-11-2011	4-19-2011
	Monterey Co.	Chardonnay	2-28-2011	3-16-2011	3-10-2011	4-18-2011
	Sonoma Co.	Chardonnay	3-22-2011	3-28-2011	N/A	N/A
	Fresno Co. trial 1	Thompson seedless	2-28-2011	3-16-2011	4-25-2011	5-09-2011
	Fresno Co. trial 2	Thompson seedless	2-28-2011	3-16-2011	3-10-2011	4-18-2011
2012	Sacramento Co.	Chardonnay	3-06-2012	3-27-2012	3-13-2012	5-01-2012
	Solano Co.	Thompson seedless	3-06-2012	3-15-2012	3-13-2012	4-24-2012
	Monterey Co.	Chardonnay	3-09-2012	3-26-2012	3-30-2012	5-04-2012
	Fresno Co. trial 1	Thompson seedless	3-07-2012	3-27-2012	3-13-2012	4-17-2012
	Fresno Co. trial 2	Thompson seedless	3-07-2012	3-15-2012	3-20-2012	4-24-2012

Attachment 9: Relationship between spore density and disease incidence following a modified Poisson distribution

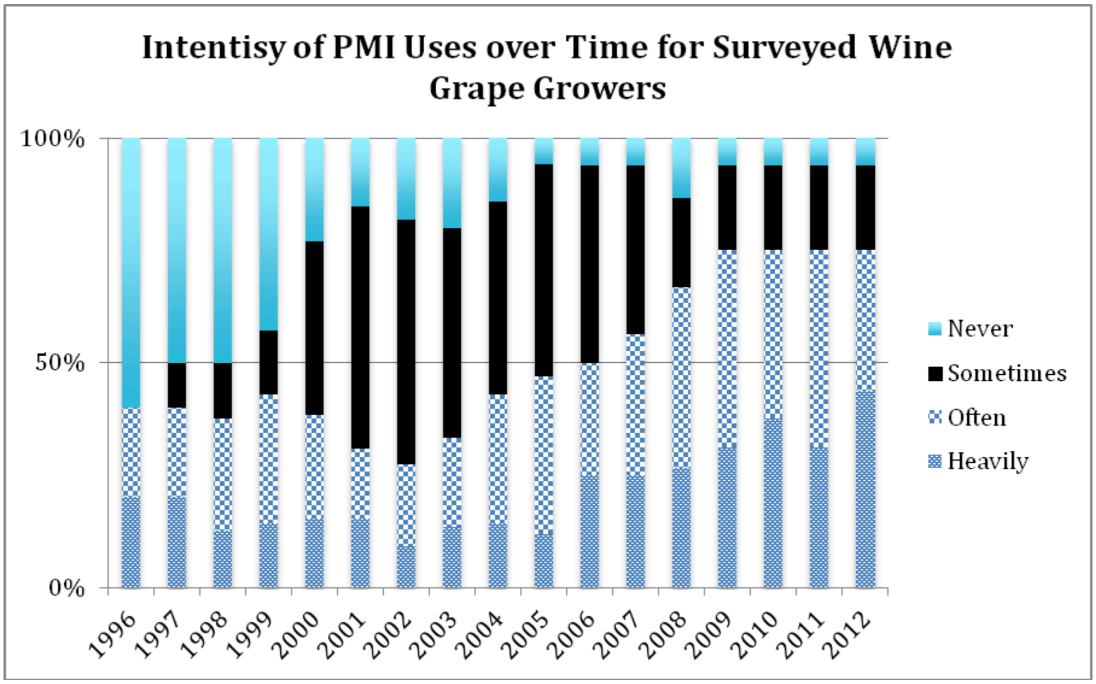


Attachment 10: Effect of treatments on Botrytis bunch rot's incidence and severity (mean ± standard errors of the mean) over two season's data (2010-2011). Means comparison performed via Student's t test on LS means

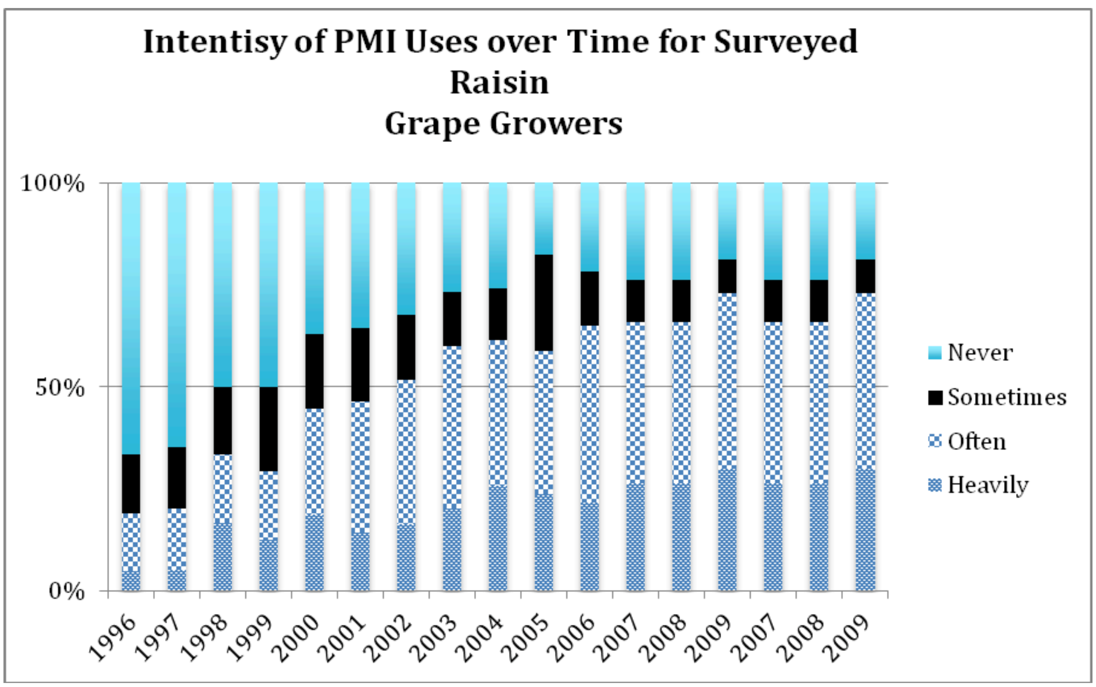




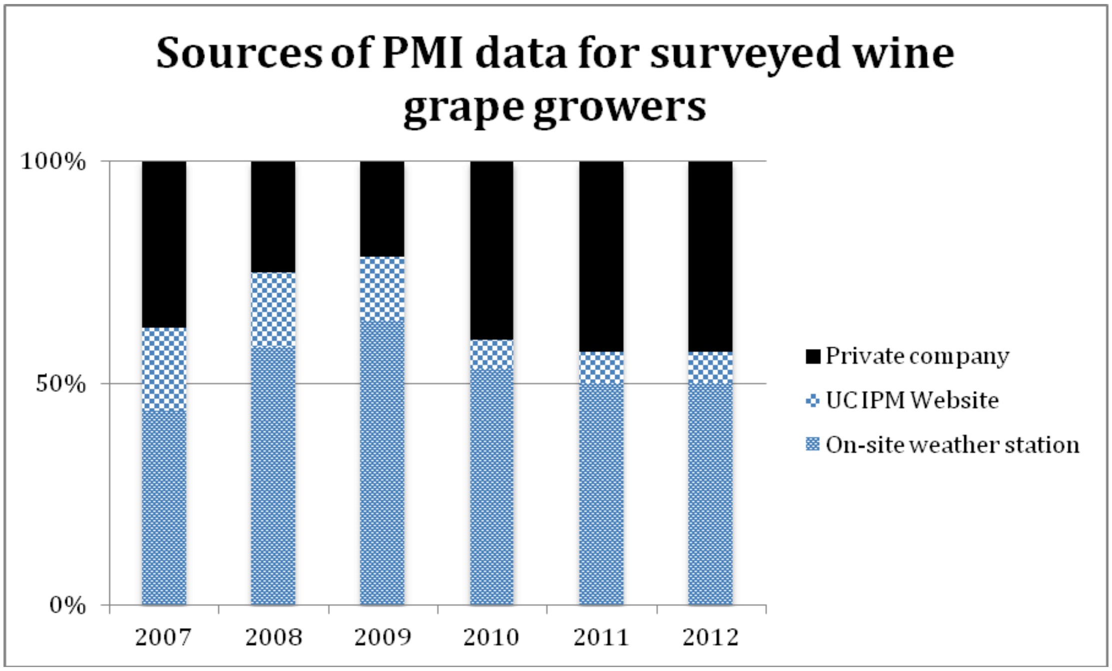
Attachment 11: Intensity of wine grape growers' use of PMI over time (1996-2012)



Attachment 12: Intensity of raisin grape growers' use of PMI over time (1996-2009)



Attachment 13: Sources of PMI data for surveyed wine grape growers (2007-2012)



The Gubler-Thomas Grapevine Powdery Mildew Risk Index – Revising the High Temperature Threshold and Adding Early Season Inoculum Detection

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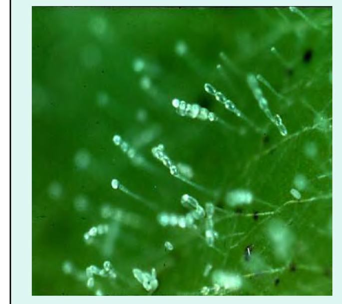  

Introduction:

Powdery mildew, caused by *Erysiphe necator,* is an important disease of grapes. A temperature-driven disease risk model (Gubler-Thomas = GT) was developed to time fungicide applications and in some years it has reduced applications by 2-3 sprays. Expanding knowledge of the high temperature growth range of the fungus could potentially reduce fungicide use further. Two years of detached leaf co-culture studies conducted with single high temp treatments at a range of durations showed that *E. necator* continues to grow and reproduce in the lab at higher temperatures than previously reported. We are now testing how consecutive, multiple heat treatments affect the same fungal growth parameters. In 2009 & 2010, we tested possible revisions of the GT model; we raised the high temperature threshold and lengthened its duration and adjusted how the index accounts for delays in fungal growth. We started preliminary work integrating information on early season vineyard inoculum density using spore traps and quantitative Polymerase Chain Reaction (qPCR) into using the GT index. .

Materials and Methods:

Multiple, consecutive heat treatments. Detached leaf (8-10 leaves) co-cultures (Backup 2009) were inoculated with *E. necator* on day 1 at 3-4 locations on each leaf, allowed to grow at room temperature for 48 hrs, then placed in incubators to test the impacts of 3 high temperatures (34, 36 and 38° C) at 2 and/or 4 hr durations over 1, 2 and 3 consecutive days (days 3, 4 and 5). Starting on day 2 spore germination and mycelium growth were noted, on day 4 colonies were inspected for growth and spore production. Fungal growth parameters measured over a month included colony growth and survival, days to colony sporulation, and spore production on day 15 using a hemacytometer. Five trials of one month duration were conducted in 2009. Results of the last two are combined and presented. Fungal response factors were analyzed using a 3 factor (temp, number of trts, date) ANOVA with a Mixed Model and date as a random factor.

High temperature revisions to the GT Index. Potential changes in the GT index based on controlled laboratory work by Backup (2009) were tested on 2-3 vine replicates (with 4-8 replicate blocks) in a randomized complete block design at two vineyards, Sacramento and Solano Counties, CA in 2009 and 2010 (Table 1). Vines were sprayed with Flint (2 oz/ac), Quintec (6 oz/ac), and Rally (4 oz/ac) in rotation in 150-200 gal/ac, or with JMS Stylet oil (1-2%) as an eradicant if needed. Disease incidence and severity was assessed weekly. iMetos weather stations were used to collect the temperature data for the GT index according to its original rules (GT Original) and with 3 high temperature threshold modifications (GT34for4; GT36for4: and GT38for2). All 4 versions of the GT index values were generated in MS Excel. Treatment effects on changes in disease over time were analyzed with Proc Mixed ANOVA for repeated measures.

Inoculum detection. Two sample rods (1.5 x 40 mm) per spore trap (sample 50.1 L/min) were collected weekly from 8 CA vineyards, 12 traps total. Samples were shipped to the lab by overnight carrier. Fungal DNA was extracted from both rods together using the MoBio Power Soil DNA extraction kit. Quantitative Polymerase Chain Reaction (qPCR) was used to amplify and quantify a targeted DNA molecule specific to the pathogen (Falacy et al. 2007). Sequence-specific DNA probes (UNC144, UNC511) were labeled with fluorescent reporter dyes to allow detection only after hybridization of the probe with its complementary DNA target if it was present. A Taqman master mix and the specially designed oligo primers and fluorescent probes (FAM) were used with an ABI 7500 Fast qPCR machine which runs through pre-set heat cycles and detects any fluorescence given off by the samples. Appropriate positive and negative controls, including a test for DNA extraction, reagent purity and aerosol drift, and an Internal Positive Control (IPC), were used for each run. The cycle threshold (Ct) is the number of cycles it takes for the fluorescent signal to exceed the level of background fluorescence. Ct values are inversely proportion to the amount of target DNA present - samples with lower Ct values have more DNA than samples with higher Ct values. We ran a 10x dilution series of 100,000 to 100 spores to create a standard curve to compare the Ct values of the unknown samples.

Table 1. Potential high temperature revisions to the GT index

Treatment	Temp (F)	Temp (C)	Hours at threshold	Points to Subtract Initially	# Days to Delay Index Increase	Points to Subtract Each Delay Day
Control						
GT Original	95	35	¼ hour	10	0	0
GT 34for4	93.2	34	4	20	2	5
GT 36for4	96.8	36	4	20	4	5
GT 38for2	100.4	38	2	20	6	5

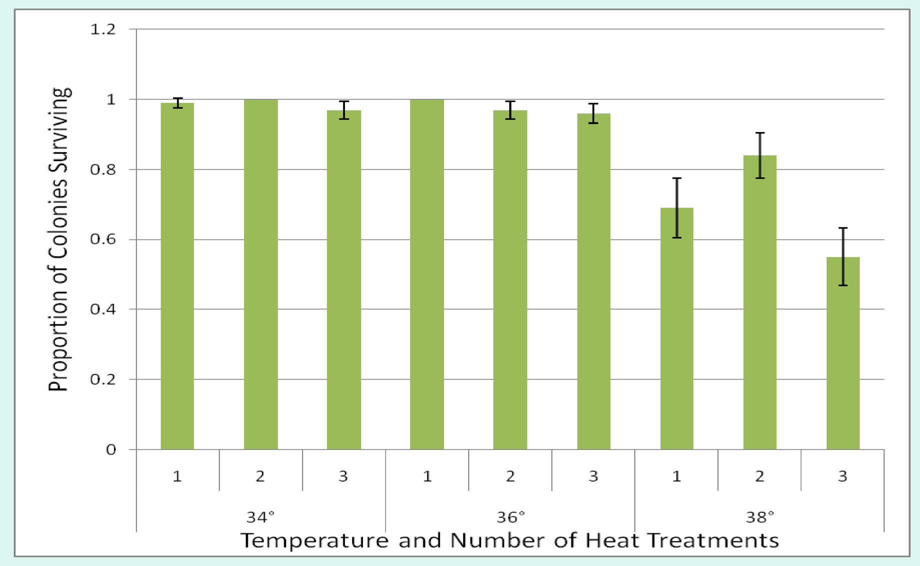

Figure 1. Effect of temperature and number of consecutive heat treatments on mean (+/- SE) colony survival. Leaves (n=20) inoculated in Sept. and Nov. 2009 and starting on day 3 treated With 1, 2 or 3 heat treatments on subsequent days for 4 hours at the indicated temperatures. The proportion of colonies surviving at room temperature (22° C) controls was 1 (n=18).

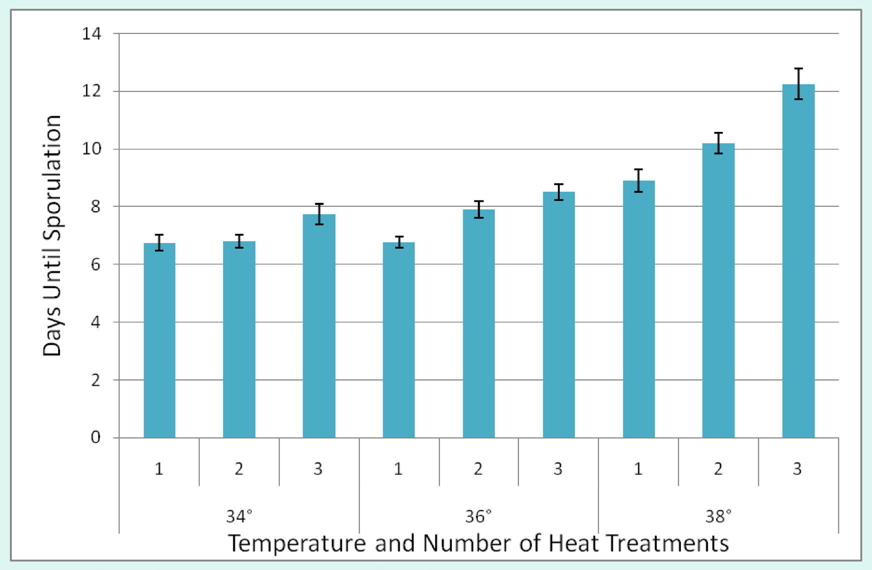

Figure 2. Effect of temperature and number of consecutive heat treatments on the mean number of days (+/- SE) before colony sporulation observed. Leaves (n=20) inoculated in Sept. and Nov. 2009 and starting on day 3, treated with 1, 2 or 3 heat treatments on subsequent days for 4 hours at the indicated temperatures. The mean number of days until sporulation of colonies was observed for room temperature controls (22° C) was 8 +/- 0.7 days (n=18).

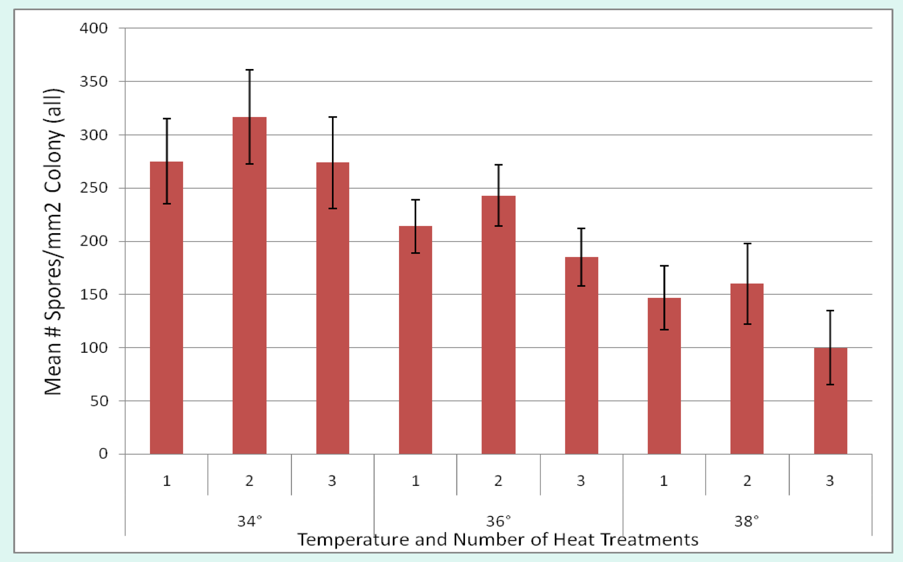

Figure 3. Effect of temperature and number of consecutive heat treatments on the mean number of spores produced per colony area (mm2) (+/- SE) as measured on all leaves (n=20) where initial colony growth observed. On day 3, leaves were heat treated; subsequent treatments were on day 4 and 5, for a total of 1, 2 or 3 heat treatments for 4 hours at the indicated temperatures. The mean number of spores produced at room temperature controls (22° C) was 260 +/- 68 per mm2 of colony area sampled (n=18).

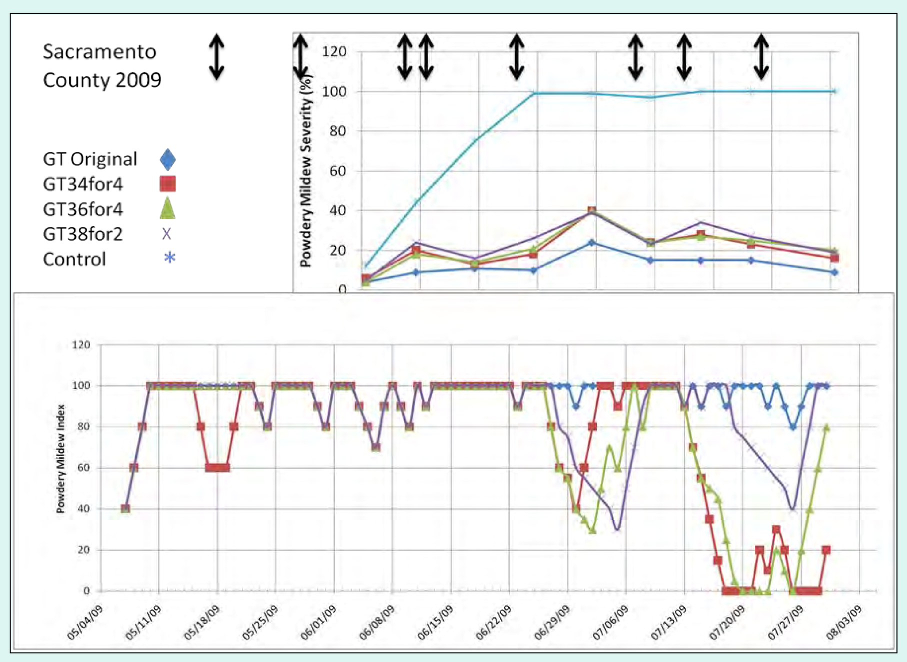

Figure 4. Sacramento County CA grape cluster powdery mildew severity and GT index in 2009. Arrows indicate dates of fungicide applications.

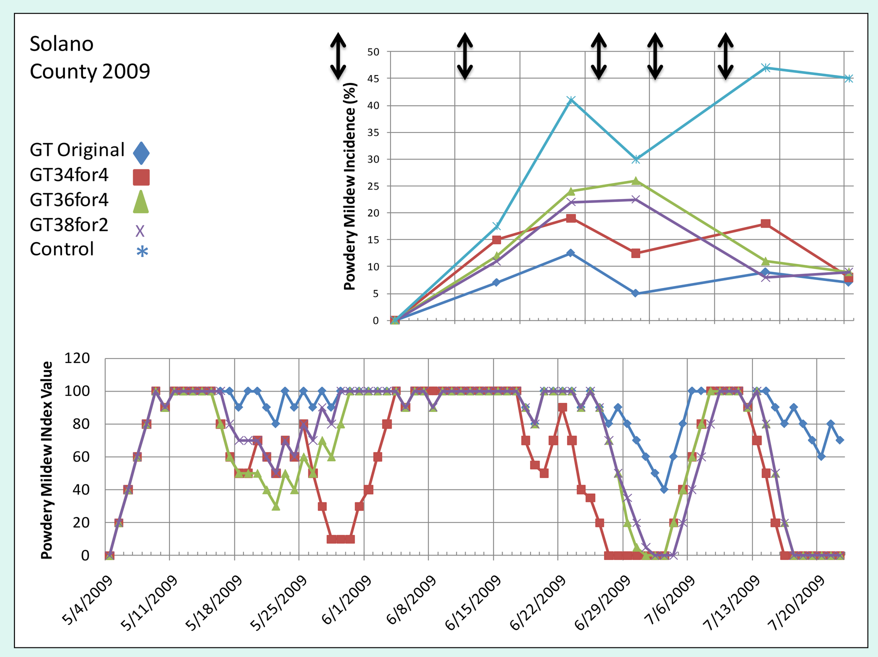

Figure 5. Solano County CA grape cluster powdery mildew incidence and the GT index 2009. Arrows indicate dates of fungicide applications.

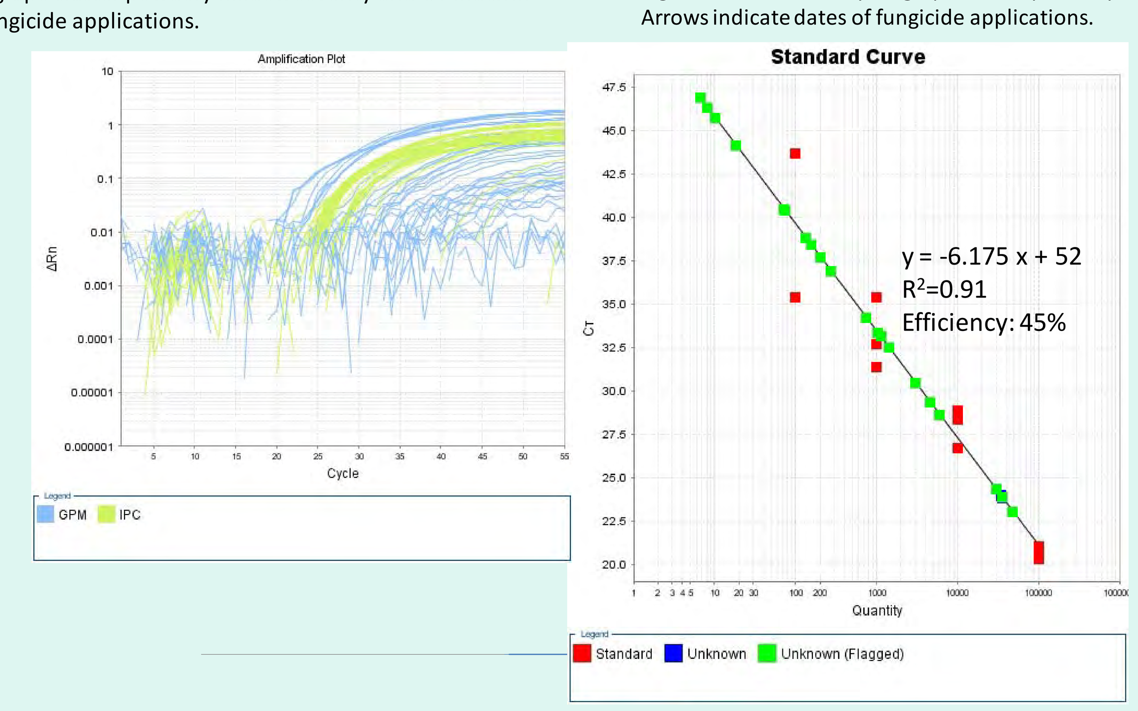

Figure 6. Example of qPCR amplification plot and standard curve from air samples collected weekly with rotorod spore traps from 8 CA vineyards.

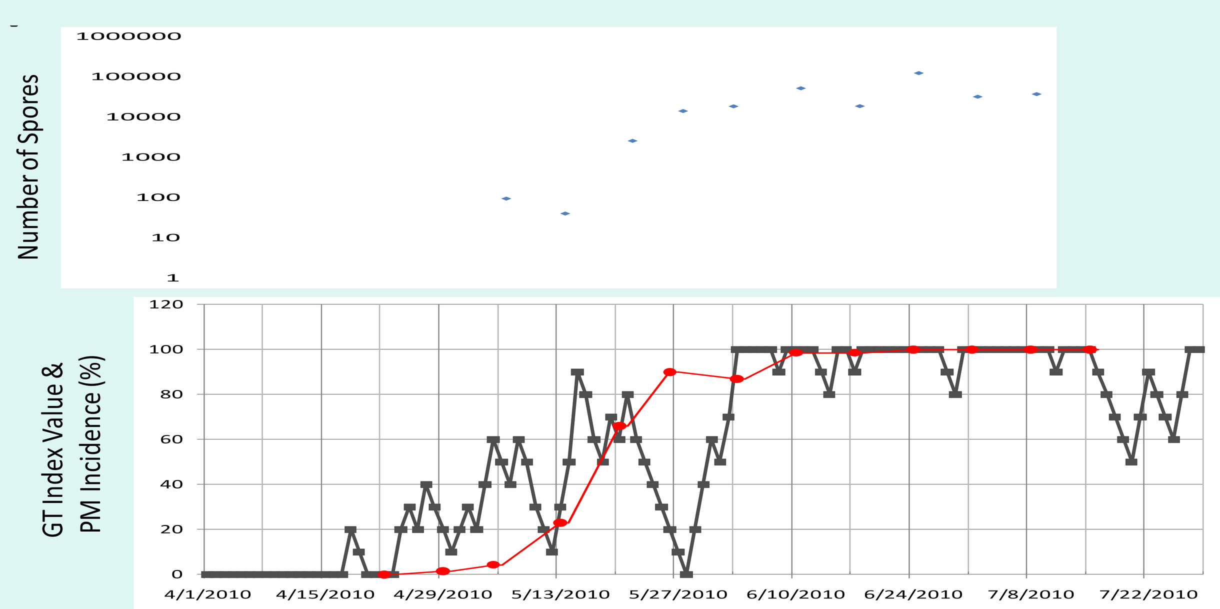

Figure 7. Sacramento County vineyard GT index from a Metos weather station in the vineyard, PM leaf incidence on untreated leaves (n=18), and estimate of the number of grapevine powdery mildew spores detected using qPCR from a weekly spore trap. A master standard curve was generated to predict spore numbers based on Ct values (n=21): Ct value = -2.176 ln (spore #) + 49.115; R2 = 0.98.

Results:

Multiple, consecutive heat treatments. Higher temperatures were increasingly lethal to the pathogen, reduced colony survival, and delayed and reduced spore production (Fig 1 - 3). Temperature alone had a more pronounced effect (p=0.0001) than did the number of consecutive heat treatments (p=0.01) on colony survival (Fig 1), both had a similar, significant effect on days until sporulation (Fig 2; p=0.001), and only temperature significantly reduced spore production (Fig 3; p=0.01). Repeated consecutive exposures of 4 hrs at 36 and 38°C up to 3 days in a row resulted in less colony death and higher spore production, than one continuous exposure of 12 hrs at the same temperature (Backup 2009). At 38° C, 8 and 12 hour continuous exposures resulted in colony death and no spore production (Backup 2009). Similarly for 36° C, 3 separated treatments of 4 hours had an impact on fungal activity, but much less than the 12 hours straight, which reduced spore production by >90% and delayed colony appearance by 4 days (Backup 2009).

High temperature revisions to the GT index. For Sacramento County (Fig 4), date, treatment and replicate block and date*treatment interactions were all significant (p=0.0001). Mean separation by Fishers LSD was significant for each model treatment compared to the untreated control (p=0.0001). Disease severity in the GT38for2 treatment was significantly greater than the GT original (p=0.065). For Solano County (Fig 5), date, treatment and replicate block and date*treatment interactions were all significant (p=0.01). Mean separation by Fishers LSD was significant for each model treatment compared to the untreated control (p=0.01), but no significant differences were observed among the model treatments. Results from the 2010 season are still being collected and analyzed.

Inoculum detection. Since mid-March 2010 we have been able to collect weekly, continuously run, vineyard air samples, extract DNA, amplify and detect specific DNA present in the grapevine powdery mildew pathogen (Fig 6). We have detected as little as 50 -100 spores, and as many as 100,000 spores collected weekly (50.1 L/m air sampled) in 8 vineyards around CA; 5 wine grape, 2 raisin and 1 table grape vineyard. At some locations qPCR results indicated pathogen presence a week or more before it was detected by visual assessment of leaves. At other locations, such Sacramento County, we have begun to relate the GT mildew index, spore trap results, and disease incidence and severity over time (Fig 7).

Conclusions:

Overall higher temperatures appear more important than the number of consecutive heat events on fungal growth parameters tested. It appears that lower temperatures in between higher ones, such as occurs on a diurnal basis, favor pathogen survival. In 2009 & 2010, we tested possible revisions of the GT model; we raised the high temperature threshold and lengthened its duration from 35°C for 15 m, to 36°C and 38°C for 4 and 2 hrs, respectively. We adjusted how the index accounts for delays in fungal growth due to suboptimal, higher temperatures. We started preliminary work integrating information on early season detection of vineyard air inoculum levels from spore traps and qPCR, with the GT index, and powdery mildew incidence and severity.

References:

Backup, P. 2009. Effects of high temperature on grape powdery mildew (*Erysiphe necator*). M.S. Thesis, Dept. of Plant Pathology, University of California, Davis.

Costadone L. 2009. Development and evaluation of detection-based air sampling programs for grapevine powdery mildew, M.S. Thesis, Dept of Plant Pathology, Washington State University.

Falacy J.S., G.G. Grove, W.F. Mahaffee, H. Galloway, D.A. Glawe, R.C. Larsen, and G.J. Vandemark 2007. Detection of *E. necator* in air samples using polymerase chain reaction and species specific primers. Phytopath.97:1290-1297.

Acknowledgements:

Funding for this work was generously provided by the California Department of Food and Agriculture's 2009 Specialty Crops Block Grant (# SCB 09047), the USDA AFRI Plant Biosecurity grants program (award # 2010-85605-2054**),** and the American Vineyard Foundation. Special thanks to Ian Bay, Jim Eynard, Andrew Sutherland, Priyanka Parikh, Larry Bettiga, Rhonda Smith, Mike Moriyama, Kristi Harrer, and Joseph Schechtor for assistance with fungicide applications, disease ratings, and spore trap collections, and to John Baronek, Norm Engleman, Grant Miramoto, Gallo Sonoma, Lone Oak vineyards, and Marko Zaninovtich for allowing us to work in their vineyards. A very special thanks to Walt Mahaffee and Tara Neill for sharing so freely their knowledge of powdery mildew, spore traps and the qPCR process, strategy, and materials.

SUSTAINABLE GRAPE PEST MANAGEMENT FOR CALIFORNIA USING WEATHER DATA AND DISEASE RISK MODELS

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DEMONSTRATE THE USE OF WEATHER DATA FROM PUBLIC AND VIRTUAL WEATHER STATION NETWORKS TO IMPROVE DISEASE CONTROL AND REDUCE FUNGICIDE USE

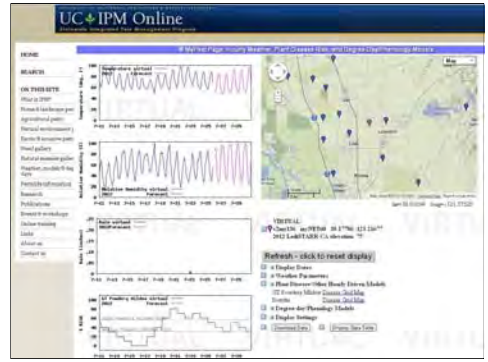
A Specialty Crop Block Grant was awarded to UC Davis from California Department of Food and Agriculture to develop sustainable grape pest management programs for raisin, table and wine grapes using science-based decision tools. A 3-year project was conducted in collaboration with the Western Weather Work Group based at Oregon State University Integrated Plant Protection Center (OSU-IPPC), to develop and demonstrate the use of weather data from public and virtual weather station networks to improve disease control and reduce fungicide use.

OSU-IPPC together with OSU PRISM (Parameter-Regression on Independent Slopes Model) group, worked to provide weather-driven IPM disease models and risk maps that are intended to improve the state of the art in IPM decision support in California. OSU-IPPC worked with UC Davis to add weather data from research directed observing weather networks to its 15,000 station system. UC Davis worked to expand the accessibility, accuracy, and ease of use of grape disease risk models using these public weather station networks. Weather data ingest systems were programmed at OSU to allow weather data to be incorporated into UC IPM weather and disease modeling infrastructures. UC Davis has integrated these products into its web interface for end-user access and decision support to help optimize management of these diseases (Fig. 1).

Grape growers, farm advisors and consultant groups were involved to configure and field test virtual weather stations (Fig. 2).

Fig 1. University of California IPM web interface for end-user access to disease risk models and public and virtual weather network

Fig 2. Example of virtual weather network webpage



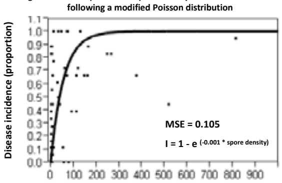
EARLY SEASON DETECTION OF *Erysiphe necator* USING SPORE TRAPS COUPLED WITH REAL-TIME PCR

Materials & Methods: Five spore trapping trials were set-up for 2 consecutive seasons (2011-2012) in different locations in California (Fig. 3) to monitor early season vineyard inoculum. In each trial we tested the efficacy of rotorod spore traps (Fig. 4) coupled with Real Time PCR (qPCR) to detect airborne disease inoculum. From the beginning of March of every year, we visited the vineyards weekly for 10 consecutive weeks to collect and replace the spore trap sampling units and to visually inspect the plot and rate for disease. The day following the collection, the DNA was extracted in the lab and Real Time PCR runs were performed using specific primers and probes. Data were used to correlate estimates of aerial spore density according to spore trap catches with observations of visible mildew colonies.

Fig 3. Spore trapping trials used in 2011-2012

Fig 4. Rotorod spore traps used in this study. Traps were manufactured by Dr. Walt Mahaffee at USDA-ARS HCRL in Corvallis, Oregon.

Fig 5. Relationship between spore density and disease incidence following a modified Poisson distribution



Results: The rotorod spore traps coupled with qPCR were efficient at all locations in detecting early season vineyard inoculum. According to rotorod traps, increasing spore density quickly resulted in a saturation of disease incidence on leaves (Fig. 5). The ultimate goal is to use information about spore load to further refine fungicide spray application timing; there is no need to spray for a disease if the pathogen is not yet present in the vineyard.

REVISIONS TO THE HIGH TEMPERATURE THRESHOLD OF THE GUBLER-THOMAS MODEL FOR GRAPEVINE POWDERY MILDEW

In 1994 a temperature-driven model for grapevine powdery mildew was developed by Gubler and Thomas to time fungicide applications based on the pathogens' biology. Two years of controlled environmental studies conducted in Dr. Gubler's laboratory at UC Davis in 2007-2009 have shown that *E. necator* continues to germinate, infect, grow and sporulate at higher temperatures than previously thought. Thus, a revision to the high temperature threshold of the Gubler-Thomas (GT) model has been proposed.

Materials & Methods: Trials were conducted in different locations in California for 3 consecutive seasons (2010-2012) to test revisions to the high temperature threshold of the GT model. Compared to the original threshold of the model (35°C x 15min), revisions were as follows: 34°C x 4h, 36°C x 4h, 38°C x 2h (table 1). At all locations, vineyards had weather stations and included researcher controlled fungicide applications based on a calendar schedule (every 14 days), the original model, and its revisions. Trials were set-up following a randomized complete block design (6 blocks) with 3 plants per unit. Every week, from May to August (leaves) and June to August (clusters), we assessed disease incidence and severity on 18 samples per unit. Data analysis was performed using a mixed model approach. Means comparison was performed via Tukey HSD test using Least Squared means.

Results: Similar number of fungicide sprays were applied to the treatments during the course of this project. However, the timing was slightly different due to temperature-driven variations of the model revisions (example in Fig. 6). Statistical analysis of combined data for the 3 years of the project demonstrate that among the revisions of the original model, GT 38x2 exhibited statistically significantly lower incidence and severity on leaves than did the other revisions (Fig. 7). The level of control exhibited by both the original model and GT 38x2 was statistically equivalent to that of calendar based treatments, but with as many as 4 fewer applications. As far as clusters are concerned, GT 38x2 and GT36x4 exhibited lower incidence and severity than did all other treatments.

Table 1. High temperature thresholds of the original GT model and its revisions

	HT threshold	Time at threshold	Points to subtract	Days to delay index increase	points/delay day
GT original	35°C	15 min	-10	0	0
GT 34x4	34°C	4 hours	-20	2	-5
GT 36x4	36°C	4 hours	-20	4	-5
GT 38x2	38°C	2 hours	-20	6	-5

Fig 6. Example of the trend of the RAI due to the original GT model and its revisions

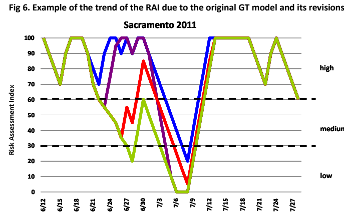
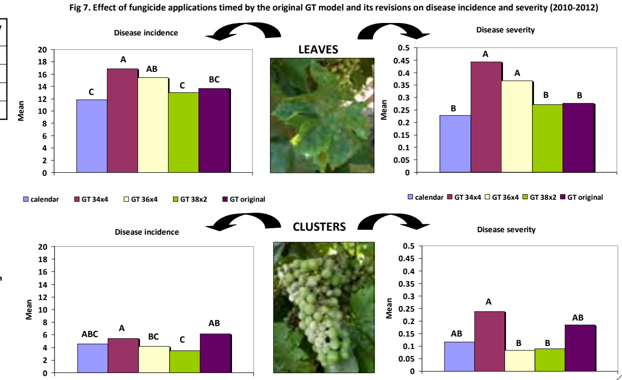


Fig 7. Effect of fungicide applications timed by the original GT model and its revisions on disease incidence and severity (2010-2012)



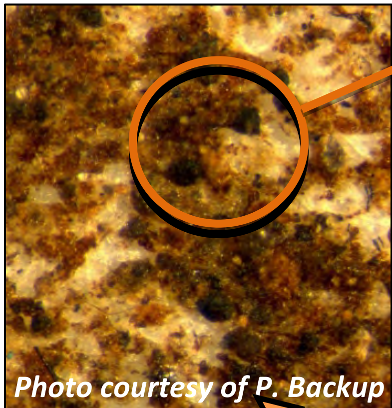
This work was funded by CDFA Specialty Crop Block Grant # SCB09047

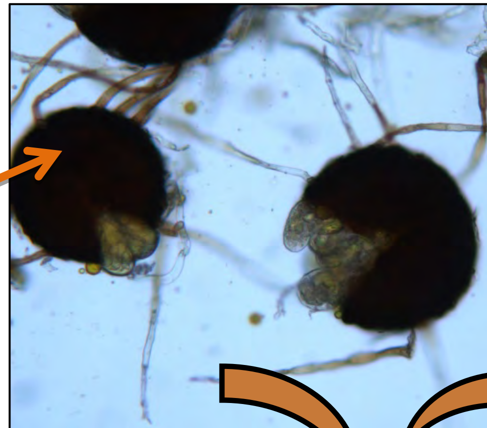
Comparing the efficiency of visual scouting, spore trapping systems and a bioindicator for early detection of *Erysiphe necator* in California vineyards

F. Peduto, A. M. Sutherland, E. K. Hand, J. C. Broome, P. D. Parikh, L. J. Bettiga, R. J. Smith, W. F. Mahaffee, W. D. Gubler

2011 APS-IPPC, August 6-10, Honolulu HI, USA

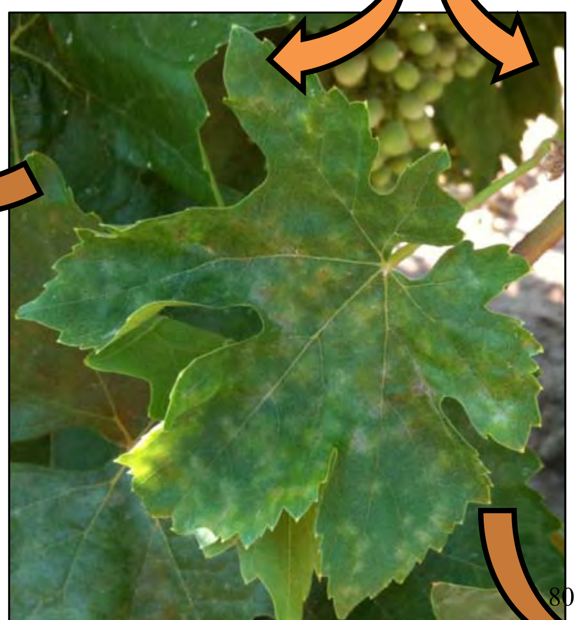
Powdery Mildew of Grapevines

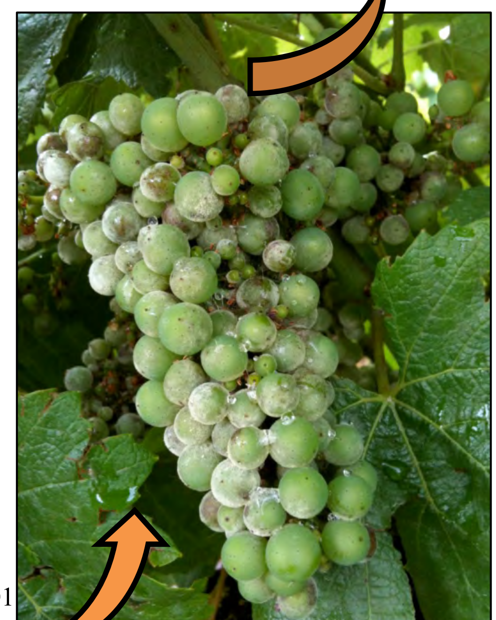




Rain, dew

wind





- decreased photosynthetic activity
- increased respiration
- chlorosis
- leaf curl

- fruit abortion
- berry crack
- Low sugar content
- Reduced quality

Powdery Mildew of Grapevines

- **Severity of infection is dependent on:**
  - ✓ **cultivar**
  - ✓ **how early disease onset occurs**
  - ✓ **weather conditions during season**

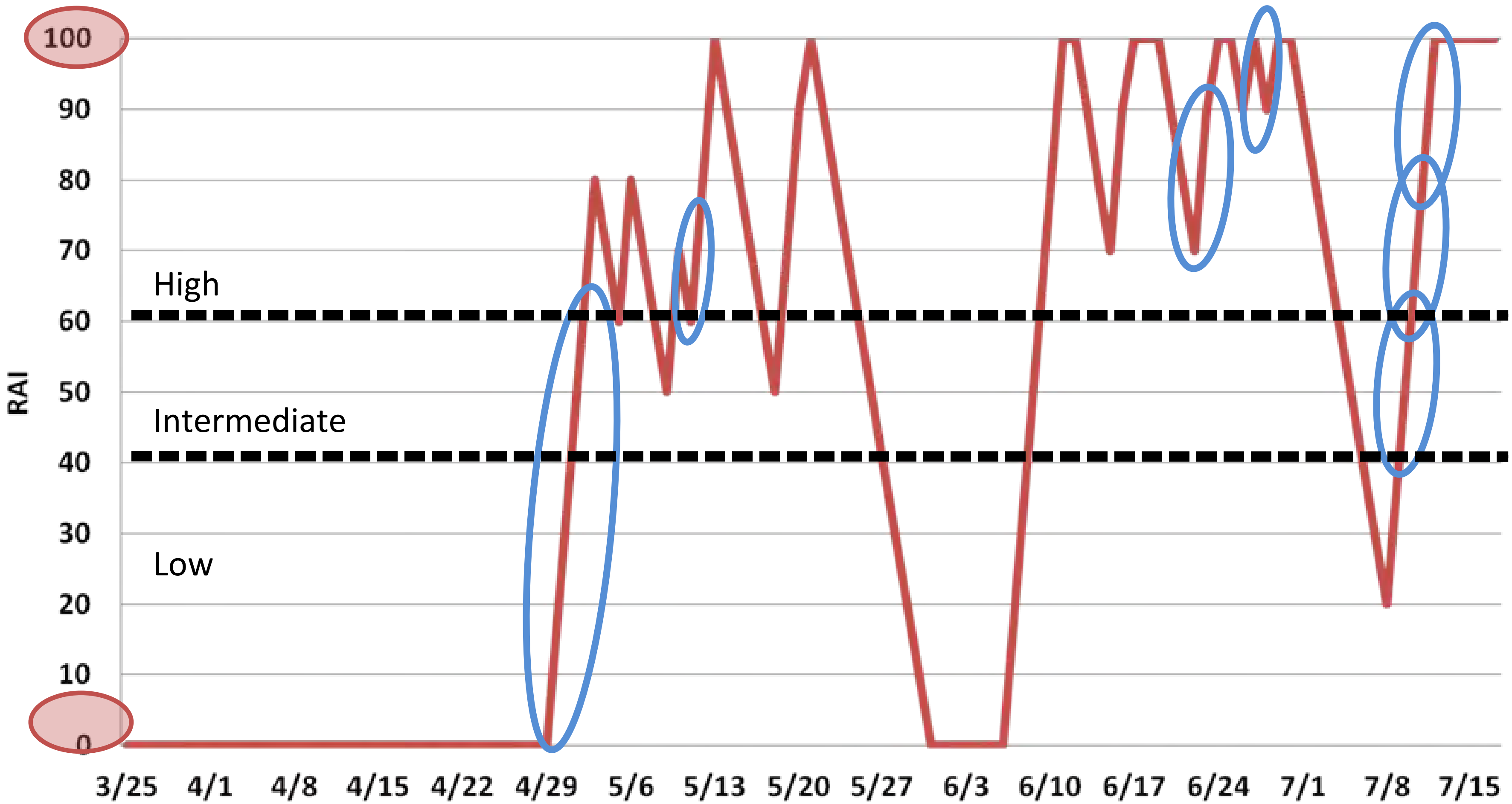
21-30°C 5 days
30-33°C 15 days
>33°C greatly reduced

- **Timed fungicide applications are in most cases necessary to manage the disease**
  - ✓ **high costs**
  - ✓ **resistance of *E. necator* to QoI and DMI documented**

⬇

Monitor presence of the pathogen in the vineyard ⟷ Integrated Pest Management ⟷ **Use of forecasting epidemiological models**

Gubler-Thomas PM Model



Considerations

- **Ascospore release forecast is sometimes inaccurate**

- **Visual scouting is sometimes used after spring rainfalls to detect ascospore infections in the vineyard and start RAI**

- **Spore traps**

- **Bio-indication?**

Psyllobora vigintimaculata

- Native mycophagous beetle
- Obligate consumer of powdery mildew
- Studies suggest that adults respond to olfactory stimuli during flight

Sutherland and Parrella (2009) *Annals of the Entomological Society of America* 102, 484-491

Objective

- **To test and compare the efficiency of different methods to detect the presence of the pathogen in the vineyard early in the season**

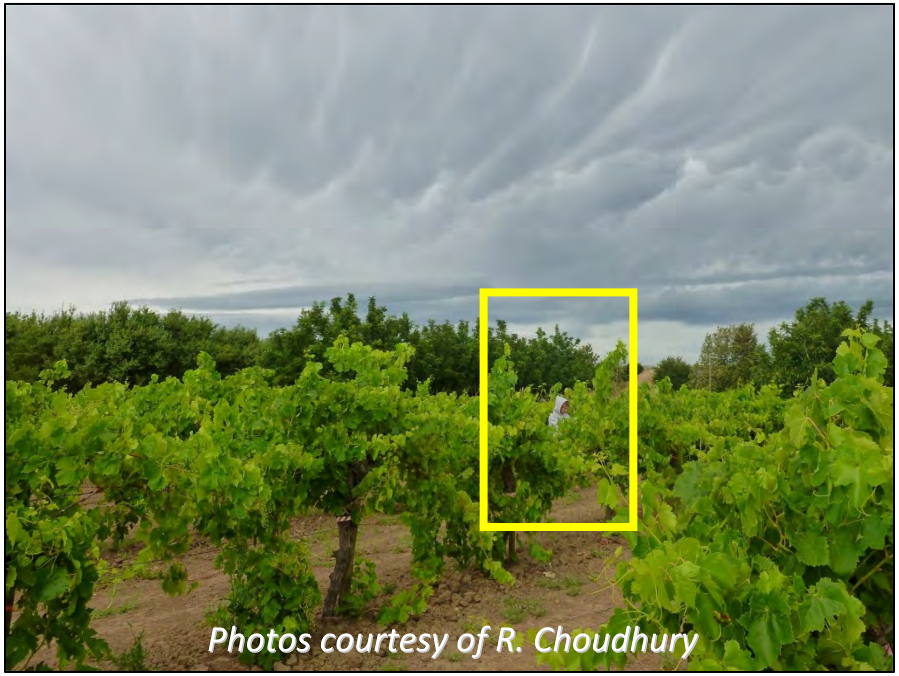
Materials and methods:

same plot

Materials and methods: Visual scouting

18 leaves/week

Leaf inspection (lab + field)



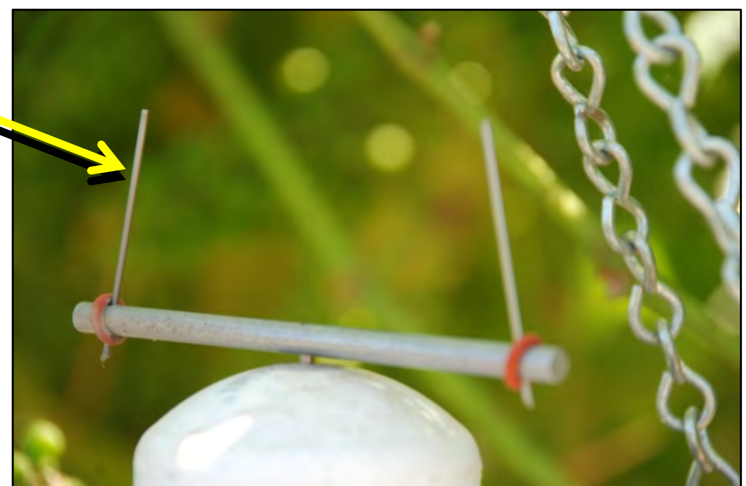
- Disease incidence
- Disease severity (% of leaf area covered by PM)

Materials and methods: Rotorod Spore Traps

- ✓ Operate continuously
- ✓ battery operated – solar powered
- ✓ 2 stainless steel rods (1.5x40 mm) grease coated
- ✓ Volume sampled: 50.1 L/min

<u>Rods collection:</u>

- Weekly from 3/1 to 6/30



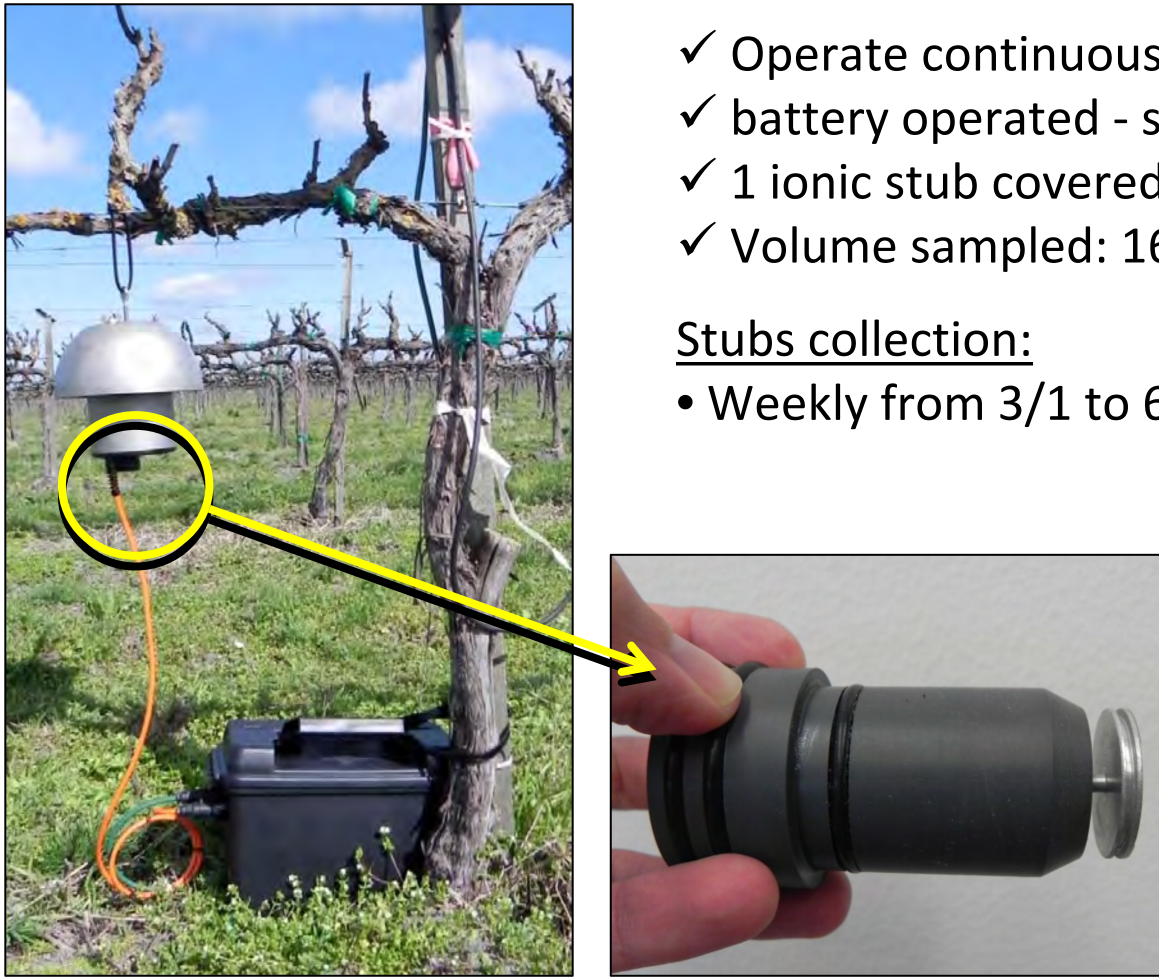
Manufactured by Dr. W. F. Mahaffee USDA-ARS HCRL Corvallis, OR (Poster #652)

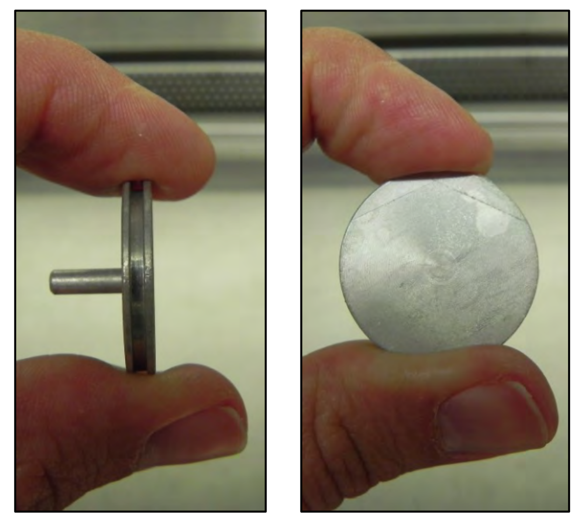
Materials and methods:
Ionic Spore Traps

- ✓ Operate continuously
- ✓ battery operated - solar powered
- ✓ 1 ionic stub covered with double sided tape
- ✓ Volume sampled: 162 L/min

<u>Stubs collection:</u>

- Weekly from 3/1 to 6/30



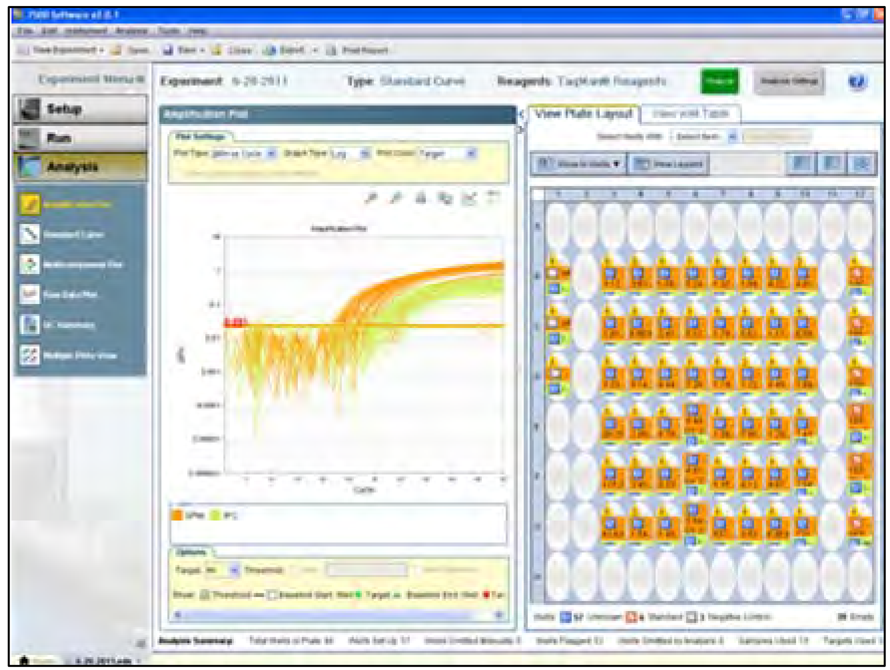


Manufactured by D&S Scientific, LSU Business and Technology Center

Materials and methods:
Spore Traps

DNA extraction
PowerSoil DNA extraction kit (Mobio)

Real-Time PCR* with specific primers** and probes*



Mahaffee *et al. *(in preparation)*

****Falacy *et al.***(2007) *Phytopathology*, 97 (10):1290-1297

Materials and methods: Bioindicator

Psyllobora vigintimaculata

Weekly sticky card sampling:

- ✓ presence
- ✓ density

RESULTS: Pathogen detection

2010

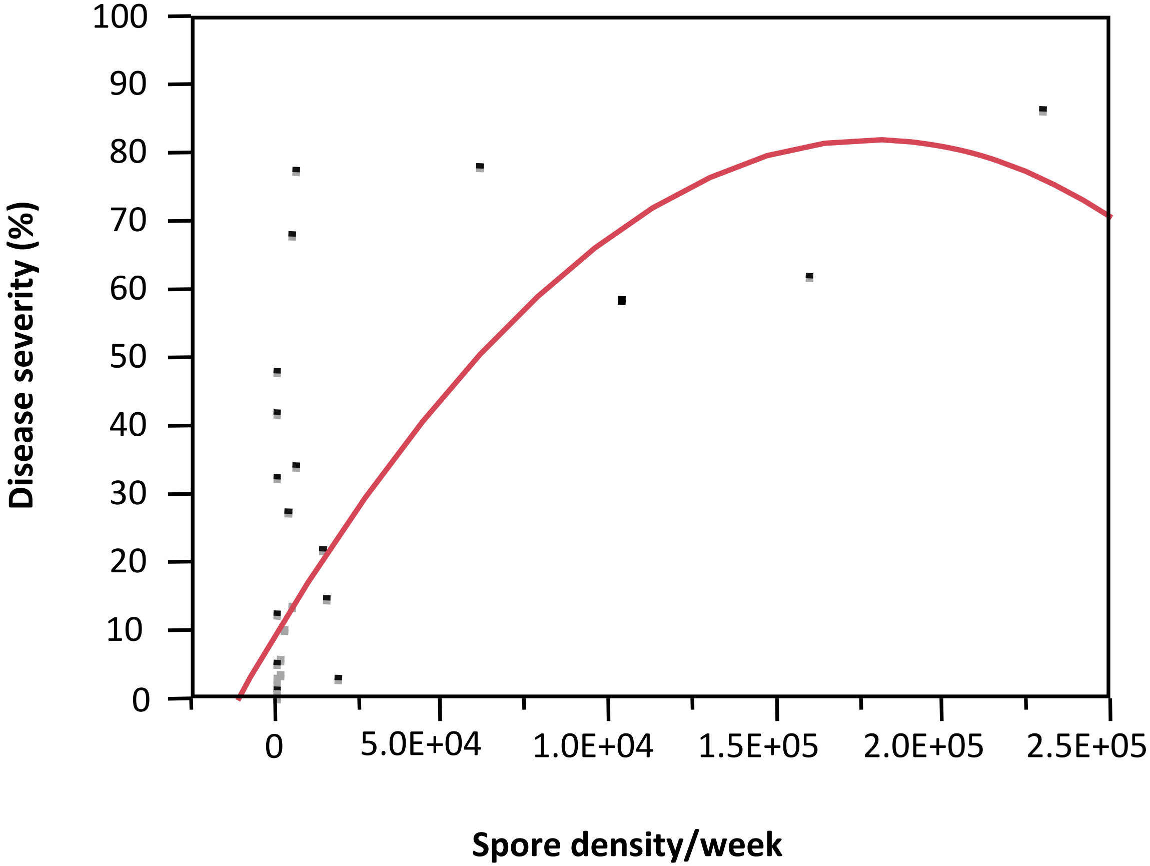
Vineyard Location	variety	Bud-break	Date first positive			
			rods	ionic	beetle	visual
Sacramento Co.	Chardonnay	3/19	5/6	…	$\boxed{4/22}$	5/5
Solano Co.	Thompson s.	3/22	$\boxed{6/10}$	…	…	6/25
Fresno Co. trial E	Thompson s.	3/15	5/10	…	…	$\boxed{4/28}$
Fresno Co. trial M	Thompson s.	3/16	$\boxed{6/23}$	…	…	7/19
Monterey Co.	Chardonnay	3/15	$\boxed{4/7}$	…	…	4/14

2011

Vineyard Location	variety	Bud-break	Date first positive			
			rods	ionic	beetle	visual
Sacramento Co.	Chardonnay	3/25	$\boxed{4/8}$	4/22	4/12	4/26
Solano Co.	Thompson s.	4/1	4/26	5/3	6/2	$\boxed{4/19}$
Fresno Co. trial E	Thompson s.	3/16	$\boxed{3/17}$	4/4	3/21	4/18
Fresno Co. trial M	Thompson s.	3/16	$\boxed{4/25}$	5/27	5/9	5/9
Monterey Co.	Chardonnay	3/16	$\boxed{3/28}$	4/21	$\boxed{n.d.}$	4/18

RESULTS: Polynomial regression

Rotorod spore traps at all locations - 2011



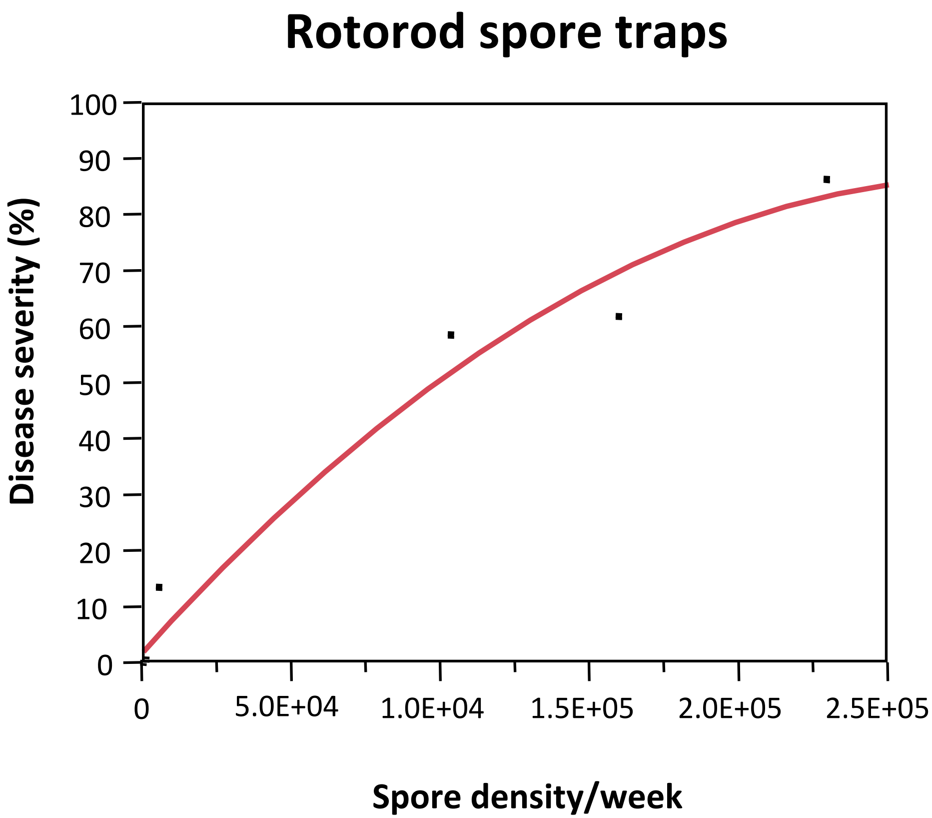
$y = 10.4 + 0.0007396x - 0.0000000226(x-15110)^2$

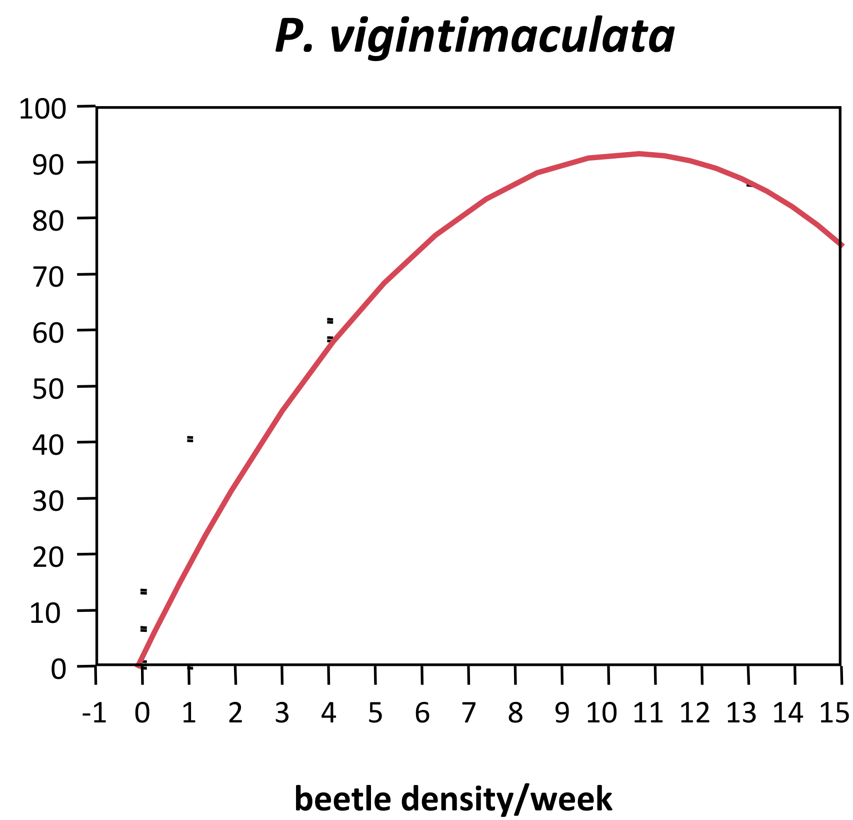
$R^2 = 0.48$

n = 43

RESULTS: Polynomial regression

Sacramento - 2011



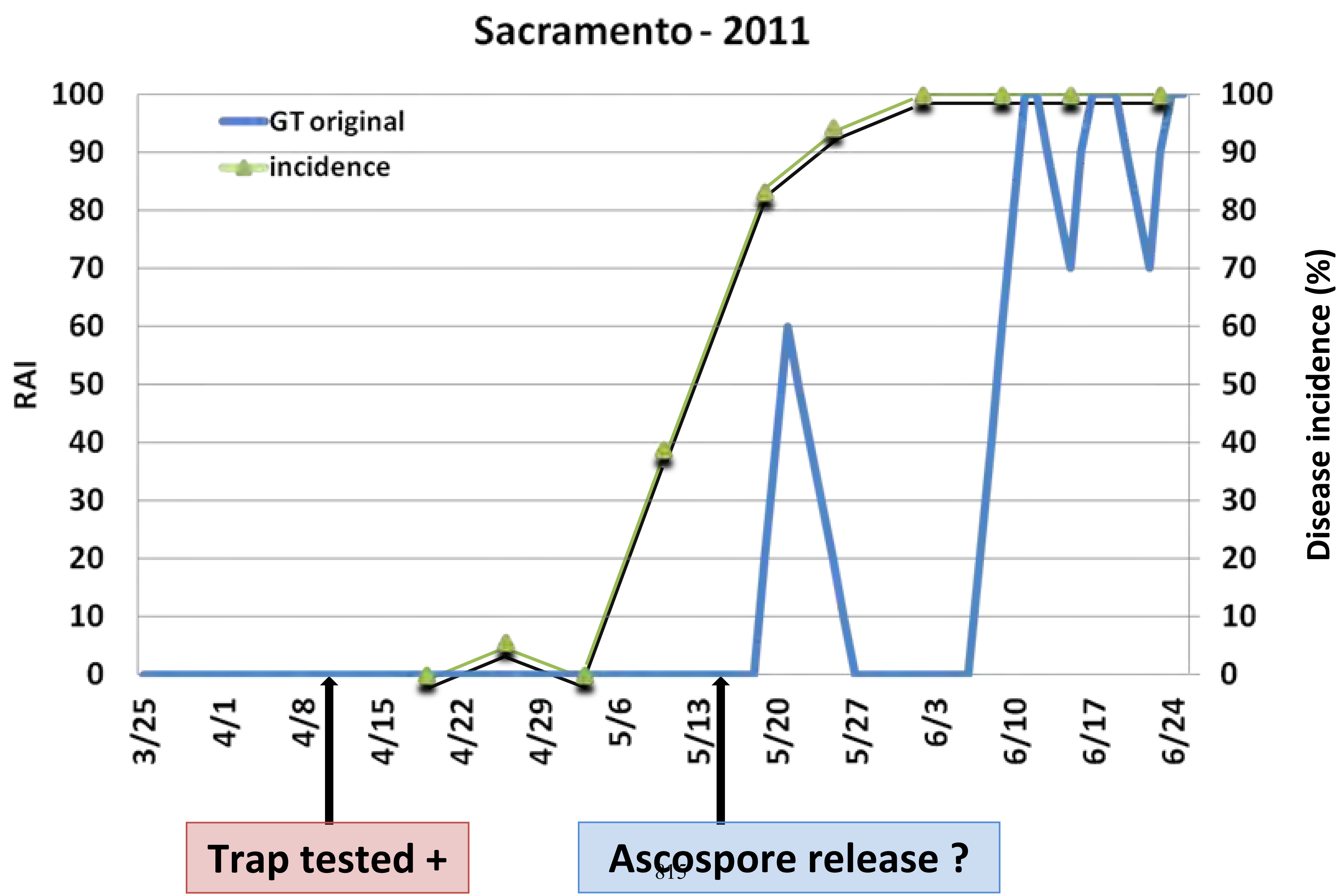


y= 6.2 + 0.0004611x – 0.00000000102(x-62230)^2
R^2 = 0.98
n = 8

y= 7.2 + 13.12x – 0.00811(x-15110)^2
R^2 = 0.86
n = 10

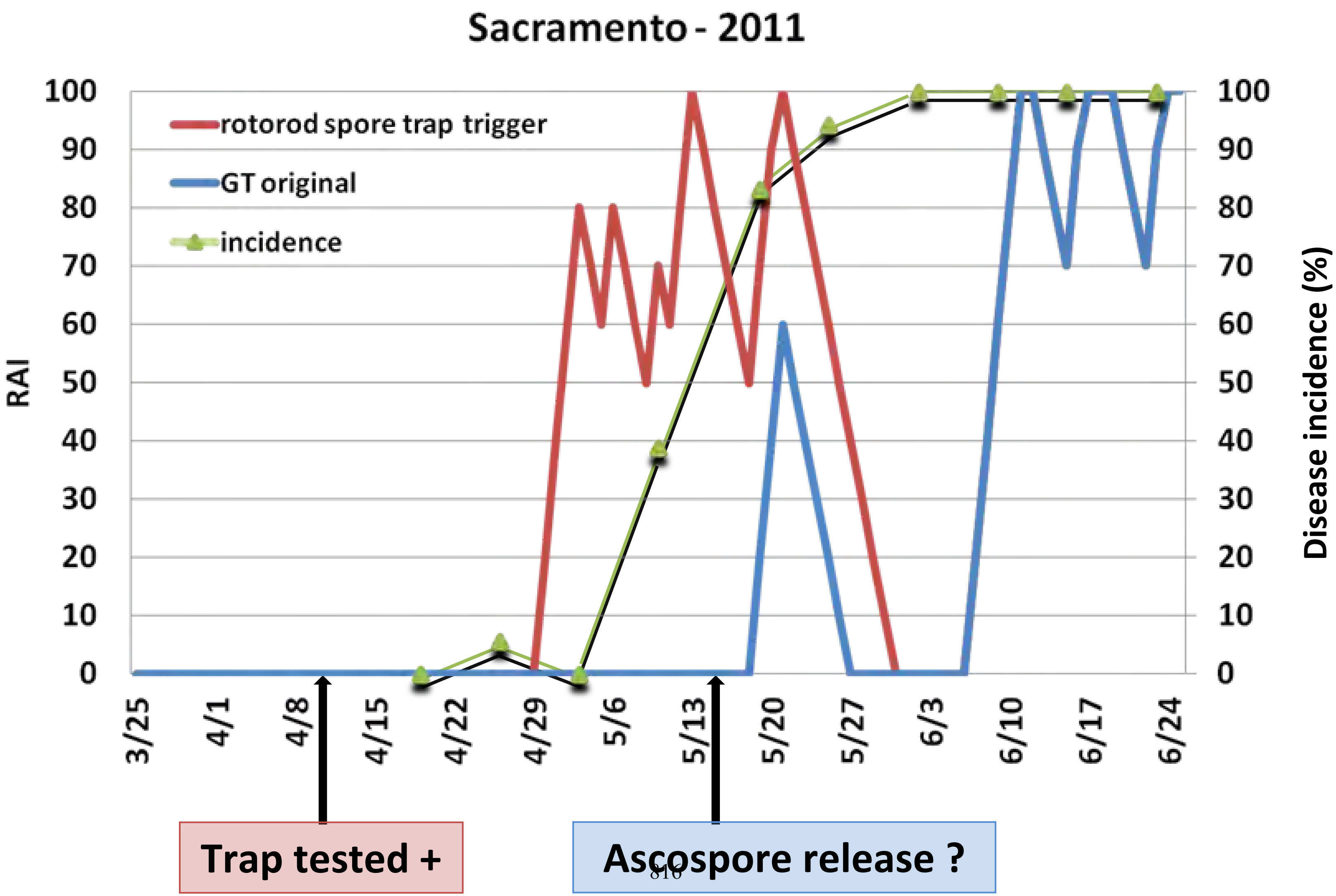
RESULTS: Ascospore release

Rotorod Spore Traps RAI trigger vs. Original GT model

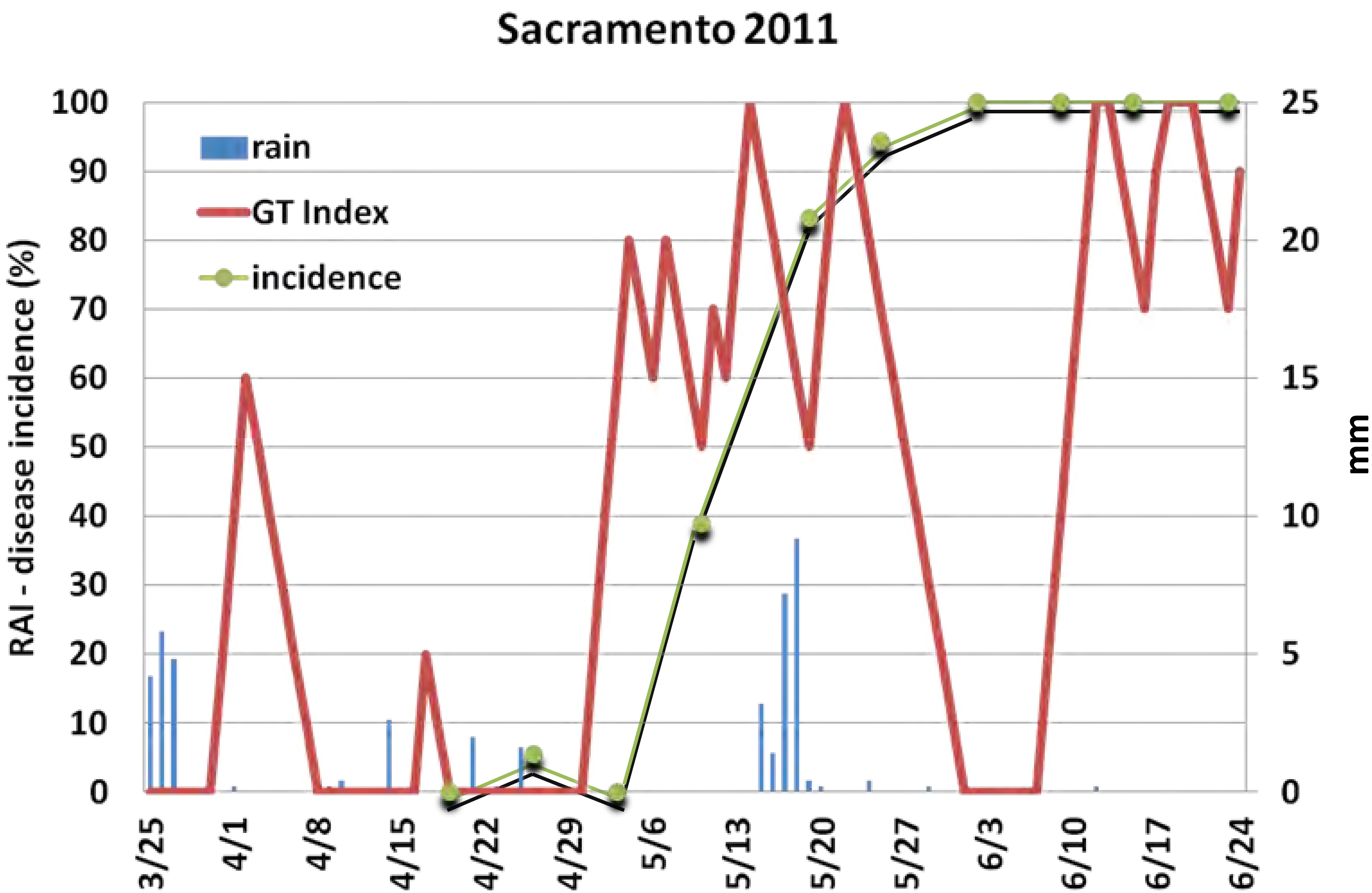


RESULTS: Ascospore release

Rotorod Spore Traps RAI trigger vs. Original GT model



RESULTS: Ascospore release



Trap tested +

Conclusions

- Rotorod spore traps coupled with qPCR were the most effective in detecting early season pathogen inoculum
- Suitability of Rotorod spore traps to improve the precision of GT ascospore release forecast
- There was a significant positive correlation between disease severity and:
    - estimated spore density caught by the Rotorod spore trap
    - *P. vigintimaculata* density
- In 1/5 cases, beetles were not detected on infected plants
- Ionic spore traps: functionality issues

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- The **Gubler lab**: L. Duffeau, L. Schiller, C. La Rue, S. Haack
- The **Mahaffee lab**: T. Neill, D. Martin

Title:

Diaprepes root weevil, a new California pest, will raise costs for pest control and trigger quarantines

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Author:
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Godfrey, Kris, California Department of Food and Agriculture

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Keywords:
Diaprepes, costs, citrus, avocado, nursery

Abstract:
This study presents an economic analysis of cost increases for citrus, avocado and nursery producers should the Diaprepes root weevil become established in California. First identified in Southern California in 2005, Diaprepres would mainly affect orange, grapefruit, lemon and avocado crops. The primary impacts would be increased production costs for pest treatments and increased harvesting costs to conform to quarantine regulations, in particular to ship ornamental plants out of infested regions. The estimated increase in production cost to treat Diaprepes was $609 per acre on average for citrus and avocado and $525 per acre for infested nurseries. The average increase in total cost as a share of revenues was 21.61% for oranges, 11.35% for avocados, 9.80% for grapefruit and 5.62% for lemons; for nursery growers it was less than 1%.

Diaprepes root weevil, a new California pest, will raise costs for pest control and trigger quarantines

by Karen M. Jetter *and* Kris Godfrey

This study presents an economic analysis of cost increases for citrus, avocado and nursery producers should the Diaprepes root weevil become established in California. First identified in Southern California in 2005, Diaprepres would mainly affect orange, grapefruit, lemon and avocado crops. The primary impacts would be increased production costs for pest treatments and increased harvesting costs to conform to quarantine regulations, in particular to ship ornamental plants out of infested regions. The estimated increase in production cost to treat Diaprepes was $609 per acre on average for citrus and avocado and $525 per acre for infested nurseries. The average increase in total cost as a share of revenues was 21.61% for oranges, 11.35% for avocados, 9.80% for grapefruit and 5.62% for lemons; for nursery growers it was less than 1%.


John Kabashima


Susan Sawyer

The Diaprepres root weevil, native to the Caribbean, was first identified in California in 2005. *Left*, an adult feeds on a Raphiolepsis leaf in Newport Beach. *Right*, adults on an Orange County crape myrtle leave irregular semicircular feeding notches on the leaves.

The Diaprepes root weevil was first identified in California in 2005 in urban areas of Orange and Los Angeles counties, and in fall 2006 it was found in San Diego County. These areas were initially subject to state-run eradication and quarantine programs in an attempt to eliminate existing populations of the weevil and to limit its spread to other parts of the state. In July 2008, the eradication program ended due to lack of funding, while quarantine efforts remain in effect. If the current quarantine program is not successful in containing Diaprepes root weevil (*Diaprepes abbreviatus* Coleoptera: Curculionidae) it will spread, causing economic losses to growers in all areas that can support infestations. This study presents an analysis of the economic effects for California citrus, avocado and nursery producers should Diaprepes become established.

The Diaprepes root weevil is long-lived and can thrive in agricultural and urban environments; more than 290 species in 59 plant families can support at least one life stage (Simpson et al. 1996). In California, the main vulnerable food crops are orange, grapefruit, lemon and avocado. A Diaprepes infestation primarily would increase production costs for pest treatments to maintain crop yields, and increase harvesting costs to conform to quarantine regulations. While a wide range of ornamental plants is affected by Diaprepes, the main economic impact on the nursery industry would be increased production costs to meet quarantine regulations when shipping plants out of infested regions. Failure to meet quarantine regulations could result in the loss of infested nursery plants, delays in shipping product to customers and possible market losses.

Diaprepes root weevil

Diaprepes root weevil is native to the Caribbean, where it is considered a pest of citrus, sugar cane and other economically important plants (Woodruff 1968; Martorell 1976). Adult weevils, which live for approximately 4 months, do little economic damage because they feed on leaf edges, leaving irregular, semicircular notches (Woodruff 1968; Knapp et al. 2000). Only rarely do adults feed on fruit — most commonly papaya and young citrus — again doing little economic damage. If not controlled, feeding damage by larvae on roots and other belowground plant structures causes the most significant economic losses. Larvae are difficult to detect because the aboveground portions of the plant may not show any symptoms until root feeding is extensive. The youngest larvae feed on the finest roots, moving to larger roots as they develop over 5 to 18 months. Their feeding activity destroys feeder and structural roots of the plant.

Larger larvae may girdle the crown of the host plant. Young trees may be killed by larval feeding, and mature trees will decline rapidly, resulting in yield reductions and a greater chance that they will be uprooted in strong winds (McCoy 1999; Stuart et al. 2006). In one infested lemon grove in San Diego County, most of the trees are declining and approximately 10% blew over during strong winds in 2007 (Gary Bender, UC Cooperative Extension San Diego County, unpublished data). Root damage also provides openings for the entry of *Phytophthora* root rot, compounding the effects of larval damage to roots. In agricultural crops, larval feeding negates the benefits of *Phytophthora*-resistant rootstocks (Knapp et al. 2001). Florida growers treat to prevent crop losses and have been spending $400 per acre annually to protect citrus against the combination of Diaprepes root weevil and *Phytophthora* (Muraro 2000).

In nursery containers, adult weevils will feed and oviposit (lay eggs) on a large number of ornamental species, and larvae may feed on the roots of these plants, hidden in container soil. Aboveground portions of infested plants may not show any symptoms, but will succumb to larval feeding. In controlled studies, the plant height and trunk diameter of green buttonwood and live oak trees were significantly lower in infested containers than those free of Diaprepes (Diaz et al. 2006).

Despite being capable of strong, short-duration flight, this weevil prefers to "hitchhike" — as adults on plants and as larvae in soil moved by people (Woodruff 1968). Historically, the weevil has moved between and within countries in infested nursery containers (McCoy 1999). In 1964, a single adult weevil was identified from a citrus nursery near Apopka, Fla. (Woodruff 1964). Since then, Diaprepes root weevil has spread to 22 counties in Florida. Much of that spread is attributable to the movement of infested plants by people, despite quarantine regulations in place in Florida since 1968. Enforcement of regulations to contain the Diaprepes root weevil was frequently difficult (Knapp et al. 2000; Nigg et al. 1998). In 2001, Diaprepes was accidentally introduced into citrus near McAllen, Texas (Skaria and French 2001).

Despite being capable of strong, short-duration flight, this weevil prefers to "hitchhike" — as adults on plants and as larvae in soil moved by people.

In 2005, Diaprepes was identified in Southern California. Currently, it can be found in five small areas in Orange County, two areas in Los Angeles County, and along the coast of San Diego County in numerous locations from approximately Oceanside to La Jolla. A climate-matching model based on two biological attributes of Diaprepes root weevil (the lower temperature thresholds for oviposition and larval development determined in constant temperature studies) and limited temperature data (11 sites in Orange, Los Angeles, Riverside, Imperial and San Diego counties) suggests that this weevil will only survive in limited areas of Southern California and parts of the San Joaquin Valley (LaPointe et al. 2007). However, the model does not take into account the weevils' ability to adapt to environmental conditions and California's many microclimates. The weevil is already found in areas of Southern California that the model predicted would not support Diaprepes. Strict and effective quarantines are required to prevent its spread into new areas of California via nursery stock.

California is the largest producer of fresh citrus, avocados and nursery products in the United States. Average farm-gate values are $593 million for orange, $86 million for grapefruit, $307 million for lemon and $332 million for avocado. With average annual receipts of $15.7 billion, the U.S. nursery industry ranks third among all agricultural commodities after corn ($26.8 billion) and soybeans ($18.3 billion) (NASS 2006). California alone accounts for 22% by value of all U.S. nursery production. All citrus and avocado production and most nursery production in Southern California and the San Joaquin Valley are potentially at risk for Diaprepes; if this weevil becomes established, production would be significantly affected.

Estimating production costs

Cost estimates begin with determining the appropriate Diaprepres pest controls for California growers, and their costs. Once the costs of individual pest treatments for adults and larvae are estimated, total costs for different treatment scenarios can be calculated and compared. Quarantine costs are then determined based on the interior state quarantine established by the California Department of Food and Agriculture.

Citrus and avocado. For the California citrus and avocado industries,

Photos: Beth Grafton-Cardwell

***Left*, root weevil larvae create "feeding galleries" on lemon tree roots; *middle*, damaged roots can provide entryways for root-rot organisms; *right*, a lemon tree infested by Diaprepres was defoliated and had a very small root system.**

David Kellum

Infested citrus plants in a San Diego County nursery are marked with red flagging tape.

Beth Grafton-Cardwell

The small, defoliated tree shown in a San Diego County lemon grove has numerous weevils infesting the roots.

we developed alternative Diaprepres pest-control treatments based on methods used by Florida growers. These treatments were then modified for California's agricultural and climatic conditions. Once the alternatives were determined, costs were estimated by contacting pest-control companies. For alternatives that can be custom applied, we obtained the total cost for materials and applications. For alternatives that are not custom applied, pest control companies provided material costs. The application costs to complete these pest treatment alternatives were taken from the Sample Costs of Production studies by UC Cooperative Extension (http://coststudies.ucdavis.edu/current.php). After treatment costs per acre were estimated, costs were compared to determine the options that California growers would most likely adopt, and an average value over the most likely treatments was calculated. Then the treatment costs per ton for citrus and avocado were estimated by dividing costs per acre by average tons produced per acre.

Quarantine protocols for the citrus and avocado industries were determined through interviews with county personnel from the agricultural commissioner's offices in affected counties, and industry representatives. Costs to meet the quarantine regulations were based on changes in harvesting costs per ton, taken from the Sample Costs of Production budgets for orange, lemon, grapefruit and avocado (O'Connell et al. 2005a; O'Connell et al. 2005b; Takele and Mauk 1998; Takele, Bender, et al. 2002; Takele, Faber, et al. 2002). Because the most recent budget for grapefruit was prepared in 1998, the cost to harvest grapefruit was inflated to 2005 values using the farm price index for prices paid by farmers (Council of Economic Advisors 2007). The total change in costs was then equal to treatment costs per ton plus quarantine costs per ton.

The effect of increased production costs on growers depends, in addition to the magnitude of the increase, upon its relation to current costs and revenues. A cost increase that represents only 1% to 2% of current revenues has different economic implications than one of 15% to 20%, because it is easier to pass on a 1% to 2% share of revenues than a 15% to 20% share. For this study, the relative magnitude of the cost increase was determined as a share of revenues by dividing the increased cost per ton by the price per ton. Revenues were used instead of costs at preinfestation levels because they provided a consistent comparison for all crops in this study. The price per ton is a 3-year average for California from 2004 to 2006 (NASS 2006). A 3-year average is sufficiently long to capture seasonal variations in output, but short enough to avoid capturing trend effects.

Nursery industry. Nursery production is made up of diverse operations including potted interior and exterior plants, cut flowers and foliage, bedding, starter flowering and vegetable plants, and Christmas trees. As a result, we estimated the quarantine costs for an "average" nursery that produces potted plants. However, average costs can vary widely. For example, a nursery that produces mostly bedding plants and small shrubs will have a smaller increase in costs than one that produces large landscape trees grown for several years before being sold.

Changes in nursery production costs were estimated only on a per-acre basis, since there was no consistent data on the quantities produced per acre. To place the cost increase due to Diaprepes in context, we also compared it to revenues received per acre. We used the *Floriculture and Nursery Yearbook* to compile data on revenues per acre (USDA 2006). Due to data limitations, revenues per acre for the affected items could not be separated from total revenues per acre (for example, this figure includes items such as Christmas trees, which are not a regulated host commodity). Consequently, the total revenues per acre for all floriculture and other nursery crops were used as the best approximation of revenues per acre for the items at risk from establishment of Diaprepes in California.

Because of the size of the industries potentially affected by Diaprepes, changes in production costs due to the establishment of an exotic pest may affect market prices as growers pass on higher costs or remove land from production. Higher prices would cause producers in California and the rest of the United States to increase production and consumers to reduce consumption. The establishment of Diaprepes in California would affect both consumers and producers through changes in

TABLE 1. Diaprepes treatment cost per application

Life stage	Chemical	Application rate	Applications	Materials	Application	Total
		per acre	*no.*	.... *$ per acre*	....	
Adult	Bifenthrin	40 ounces	2	68*	25*	93
	Carbaryl/oil	8 pounds	1	63*	25*	88
	Carbaryl/oil	1.5 gallons	1	68*	25*	93
Larvae	Imidacloprid	14 ounces	2.8	148*	5†	153
	S. riobravis	1.3 billion each	3	177*	5†	182

* Costs from pest control companies.
† Application costs from Sample Costs of Production budgets (http://coststudies.ucdavis.edu/current.php).

TABLE 2. Increase in production and quarantine cost if Diaprepes becomes established

Pest control/foliar spray treatment for adults	Ground treatment for larvae	Cost	Orange	Grapefruit	Lemon	Avocado
		$ per acre	....	*$ per ton*	....	
One spray carbaryl	*S. riobravis*	625*	52.8	38.0	36.7	189.2
Two sprays bifenthrin	*S. riobravis*	722	61.1	44.0	42.5	218.7
Two sprays carbaryl	Imidacloprid	599*	50.6	36.5	35.2	181.4
Two sprays bifenthrin	Imidacloprid	609*	51.5	37.0	35.8	184.3
One spray carbaryl, one bifenthrin	Imidacloprid	604*	51.1	36.7	35.5	182.8
Average treatment cost		609*	51.5	37.1	35.8	184.4
Standard deviations		(11.27)	(0.94)	(0.67)	(0.65)	(3.40)
Quarantine						
Cost per ton ($)			2.1	8.1	6.7	15.8
Total cost increase per ton ($)			53.6	45.2	42.5	200.3
Grower revenues before infestation per ton ($)			248.0	461.0	756.0	1765.0
Cost increase as share of revenues (%)			21.61	9.8	5.62	11.35

* Cost used to determine the average price per acre to treat Diaprepes root weevil.

the costs of production, market prices, market supply and consumption; these effects are estimated elsewhere (Jetter 2007). Urban landscapes would also be affected if Diaprepes continues to spread, due to larval feeding that damages the roots of host landscape plants, backyard citrus trees and avocado trees. While important and potentially significant, an estimation of these costs is beyond the scope of this study.

Pest-control alternatives

Treatments. Diaprepes control in California includes a treatment for adults that live on plant foliage to prevent egg laying, and a treatment for larvae that live in the soil and feed on plant roots (Stansly 2007; Duncan et al. 2007). In Florida's sandy soils, the treatment for Diaprepes is one foliar spray per year using carbaryl to control adults, and releases of a parasitic nematode, *Steinernema riobravis*, to control larvae (UC IPM Online 2007; Stansly 2007). If carbaryl is not used, then growers apply two sprays of bifenthrin. After 5 to 6 years, continual releases of *S. riobravis* cause natural enemies of the larvae to build up in the soil, and annual releases of *S. riobravis* may no longer be necessary (Duncan et al. 2007). In heavier soils, the success of *S. riobravis* is more variable. If parasitic nematodes are not as successful in the heavier soils of most citrus-growing areas in California, effective control of the larvae can be accomplished using soil applications of imidacloprid. Along with imidacloprid, two foliar sprays with carbaryl or bifenthrin are applied to target adult weevils.

Costs. The cost for one treatment of bifenthrin or liquid carbaryl plus oil is $93 per acre (table 1). Materials and application costs for both chemicals are the same. The cost to treat with the granular formulation of carbaryl plus oil is slightly lower than the liquid formulation due to the lower cost of materials, and the application costs are the same. Costs for single treatments of bifenthrin and carbaryl are similar, but because two treatments of bifenthrin are recommended, the total cost to use bifenthrin is greater than that of carbaryl.

The treatment cost per application for larvae is lower for imidacloprid than for *S. riobravis* (table 1). Both imidacloprid and *S. riobravis* are applied through the irrigation system during routine irrigation. The total cost and how well each treatment controls Diaprepes will determine which pest-control technique is finally adopted in California. Efficacy is determined by the total cost to treat Diaprepes and how well infestations are managed to prevent yield losses. For example, the cost for *S. riobravis* is greater than imidacloprid; however, if *S. riobravis* is better at controlling Diaprepes larvae and losses are lower, the net cost for *S. riobravis* may be lower. Due to inexperience in treating Diaprepes in California, however, net yield losses for all treatments are unknown; therefore, possible net changes in yields are not included in this analysis.

Evaluating treatment options

Adult and larva treatment options were paired to determine the alternative costs per acre to treat Diaprepes in citrus and avocado. The cost to use the most effective treatment in sandy soils — a single spray with carbaryl and three releases of *S. riobravis* — was $625 per acre (table 2). If two treatments of bifenthrin are used instead of one treatment of carbaryl, the cost increases to $722 per acre. It seems unlikely that growers would adopt this method unless pest resistance to carbaryl is a concern or other treatment considerations arise. If *S. riobravis* is not able to reduce Diaprepes larvae in California below damaging levels, growers may switch to imidacloprid; however, an additional treatment of carbaryl may be needed to manage adult infestations and reduce yield losses. Because the per-treatment costs of applying carbaryl or bifenthrin were similar, costs for the different imidacloprid treatment scenarios were similar. Except for the two sprays of bifenthrin/release *S. riobravis* alternative, control costs for the different treatments were close and ranged from $599 to $625 per acre. Given this similarity, the average of all treatment alternatives, excluding bifenthrin/*S. riobravis*, was $609 per acre, calculated to represent the potential increase in production costs for citrus and avocado growers in the United States.

Dividing the increase in cost per acre by average yields provides the average increase in cost per ton. Yields (tons) per acre varied by crop: orange, 11.8; grapefruit, 16.4; lemon, 17; and avocado, 3.3. With the highest yields per acre, grapefruit and lemon had the lowest increase in cost per ton for pest treatments due to Diaprepes infestations. The increase in average cost per acre would be $37.10 per ton for grapefruit and $35.80 per ton for lemon (table 2). The cost to grow oranges increased by $51.50 per ton. The cost to grow avocados, with the lowest yields per acre, increased $184.40 per ton.

Quarantine costs. In addition to treating infestations of Diaprepes, growers will have to meet quarantine regulations to market harvested fruit. Because Diaprepes weevils feed and oviposit on the leaves rather than fruit of susceptible plants, quarantine regulations for citrus and avocado only require that fruit leaving the orchard be free of leaves, twigs and Diaprepes adults in bins of fruit (Nigg et al. 1998). Fruit leaving quarantined areas is subject to inspection. Currently, citrus and avocado are hand-harvested into sacks, and the sacks are then carefully emptied into bins outside the orchard. Leaves that are picked during harvesting of the fruit also end up in the sack. Extra labor can be hired to carefully pick and load the fruit in a manner that does not cause leaves or weevils to fall into the sacks or bins. The extra labor was estimated to increase harvesting costs by 5% in order to meet postharvest quarantine regulations; the increase in harvesting costs per ton was $2.10 for orange, $8.10 for grapefruit, $6.70 for lemon and $15.80 for avocado (table 2).

Total cost changes. The total increase in costs per ton due to the establishment and spread of Diaprepes root weevil in California would be $53.60 for orange, $45.20 for grapefruit, $42.50 for lemon and $200.00 for avocado. While the absolute increase in cost per ton was higher for avocado than orange growers, the increase as a share of revenues was lower for avocado (11.35%) than for orange growers (21.61%) (table 2). The share for avocados was lower than for oranges because the original cost to produce avocados is higher. Grapefruit and lemon have both the lowest increase in cost per ton and the lowest share of revenues. The increase in production cost as a share of revenues was 9.80% for grapefruit and 5.62% for lemon.

David Kellum

Citrus growing in Southern California orchards and nurseries is at greatest risk of economic damage from Diaprepres. Nurseries infested with the weevil will pay an estimated $525 per acre to comply with state-imposed quarantines. *Above*, the soil of nursery plants is inspected for weevils.

Nursery treatment and quarantine

Quarantine regulations vary depending on whether a nursery is infested with Diaprepes. Nurseries within the quarantine area but without infestations are required to incorporate the granular insecticide bifenthrin into the soil before plants are potted. The granular treatment is good for 2 years, then growers are required to use a soil drench every 6 months. No data was available on how many acres of potted ornamental plants were sold within two years of being potted and after two years; for this analysis, only the initial granular treatment costs were included. Additional costs could be incurred for treatments to meet quarantine regulations for potted plants more than 2 years old, or for repotting into larger pots. We estimated the average cost to meet quarantine regulations for nurseries in the quarantine area — but free of Diaprepes — to be $300 per acre.

If a nursery is inspected and found to be infested with Diaprepes, an additional foliar spray treatment with carbaryl is required before plants can be

TABLE 3. Effect of Diaprepes on the nursery industry

	Clean nursery			Infested nursery		
	Floriculture	Other	Combined	Floriculture	Other	Combined
Revenue per acre ($)	93,914	41,158	66,709	93,914	41,158	66,709
Cost of quarantine protocols per acre ($)	300	300	300	525	525	525
Cost increase as share of revenues (%)	0.32	0.73	0.45	0.39	0.88	0.55

shipped. All plants must be sprayed. The additional cost for a nursery infested with Diaprepes was an estimated $225 per acre and the total cost to meet quarantine regulations was $525 per acre.

Total average revenues per acre are $93,914 for floriculture industries and $41,158 for other nursery production (table 3) (USDA 2006). The weighted average revenue of both nursery industries is $66,709 per acre. The increase in total cost as a share of revenues, to meet quarantine regulations for nurseries in a quarantine area but free of Diaprepes, is 0.32% for floriculture and 0.73% for other nursery industries, for an average of 0.45%. The cost increase for infested nurseries as a share of revenues is larger due to foliar treatments. The $525 increase in production cost for infested nurseries is 0.39% of total revenues for floriculture, 0.88% for other nurseries and 0.55% for the industries combined (table 3). While growers with infestations pay more, higher costs as a share of revenue are still less than 1%.

Implications for growers, consumers

Since the eradication program was discontinued, the quarantine program is critical to keep Diaprepres from spreading to other parts of California. If left untreated, this destructive weevil — a "hitchhiker" in plants, bins of fruit, and even inside cars and trucks — could cause serious production declines for the California citrus, avocado and ornamental nursery industries, as well as kill plants in urban, public and natural areas. Rather than let plants die or production decline, growers in Florida treat for Diaprepes, and growers in California will also need to treat.

To protect crops and meet quarantine regulations, producers of citrus, avocado and ornamental plants will need to pay hundreds of dollars in treatment costs per acre or switch to different crops or economic activities. The final effect on each industry will depend upon the magnitude of the cost changes relative to current costs and revenues. Industries for which the change in costs is large relative to current revenues will have to make greater adjustments in price and acreage than industries with smaller increases. Ultimately, given the size of these industries and their contribution to total U.S. production, product markets will also be affected, causing consumers to pay more for fresh citrus, avocado and landscaping plants.

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Diaprepes abbreviatus - Diaprepes root weevil or Citrus root weevil Fact Sheet

- Native to the Caribbean
- More than 270 identified host plants, including citrus and avocado
- Larvae feed on roots, weakening or killing the plant, adults feed on leaves
- Accidentally introduced into Florida in 1964 from Puerto Rico; eradication not pursued
- More than 100,000 acres in Florida now infested, $70 million in annual damage
- Discovered in Newport Beach, October 2005, Long Beach, November 2006, La Jolla, May 2006, and 14 additional locations discovered in coastal San Diego County, June through December 2006
- California introductions likely from un-inspected plants brought from Florida
- Continued dissemination of pest primarily through commercial and homeowner movement of green waste and infested plants and plant parts
- Growers of permanent crops should expect reduced production, tree losses, loss of markets, and permanent need for pesticide applications
- Growers of nursery crops should expect extreme delays in shipping schedules due to protocols, loss of markets, and permanent need for pesticide applications
- Organic growers should expect dramatic losses to their business because no organic treatment regime is available
- Residents should expect loss of landscape plants and the need to personally apply pesticides or hire pest control professionals for regular pesticide applications
- The greater community should expect a monumental increase in the amount of pesticides used in the urban landscape and on farms
- By University of California estimates, annual usage of pesticides on nurseries alone in San Diego County would go from 4 pounds to 36,000 pounds of active ingredient per year should eradication strategy be abandoned
- Science Advisory Panel assembled by CDFA agreed eradication is preferred strategy
- CDFA reports sizeable reductions in adult populations to date from pesticide applications in eradication program
- CDFA economic analysis sets losses to consumers and producers from an established DRW population as high as $3 billion per year
- California eradication program for 2008-2009 set at $4.9 million ($4.1 million eradication, $.8 million regulatory)

Table 1. Treatment regimens at 3 field sites in 2010. The number and type of applications varied by field site according to VMB pressure. Field site 3 was the most heavily infested and required supplemental treatments outside of the reduced-risk regimen to suppress VMB, except for the Movento treatment that stood on its own..

Vineyard	Treatment Regimen and Date of Application				
	1	2	3	4	5
Field Site 1	Lorsban 19-Feb Applaud 29-Apr Admire 19 May	Lorsban 19-Feb	Admire 15-Apr	Movento 29 Apr	——
Field Site 2	Lorsban 19-Feb Applaud 29-Apr Admire 19 May	Lorsban 19-Feb	Admire 5-Apr	——	——
Field Site 3	Lorsban 19-Feb Applaud 29-Apr Admire 19 May *Clutch+Lannate 29-Jun	Lorsban 19-Feb Applaud 29-Apr *Movento+Lannate 29-Jun	Admire 6-Apr *Movento 29-June	Movento 29-Apr	*Movento+Lannate +Clutch 29 Jun

* Rescue treatments applied outside of experiment to prevent economic damage

Fig. 1. Mean (±SEM) densities of VMB under 5 treatment regimens (no. 5 is UTC) in 2010. Note the high numbers of VMB at Site No. 2, but all treatment plots were brought to non-economic injury levels at harvest.

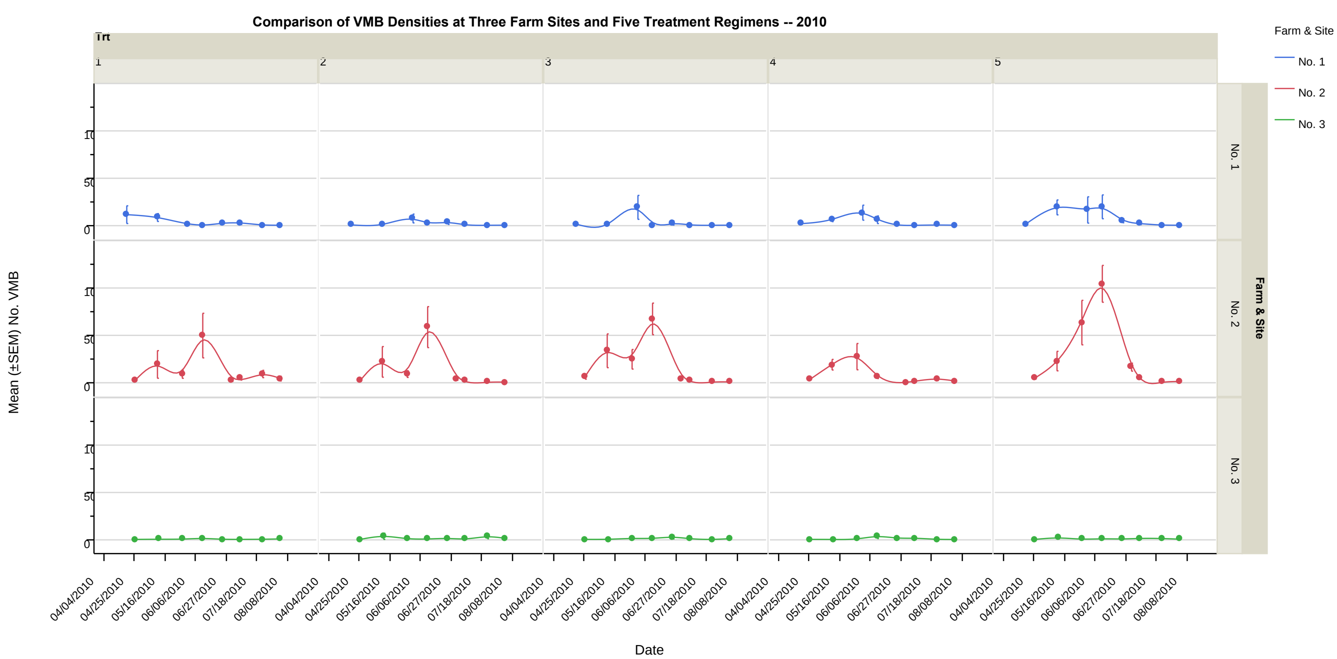
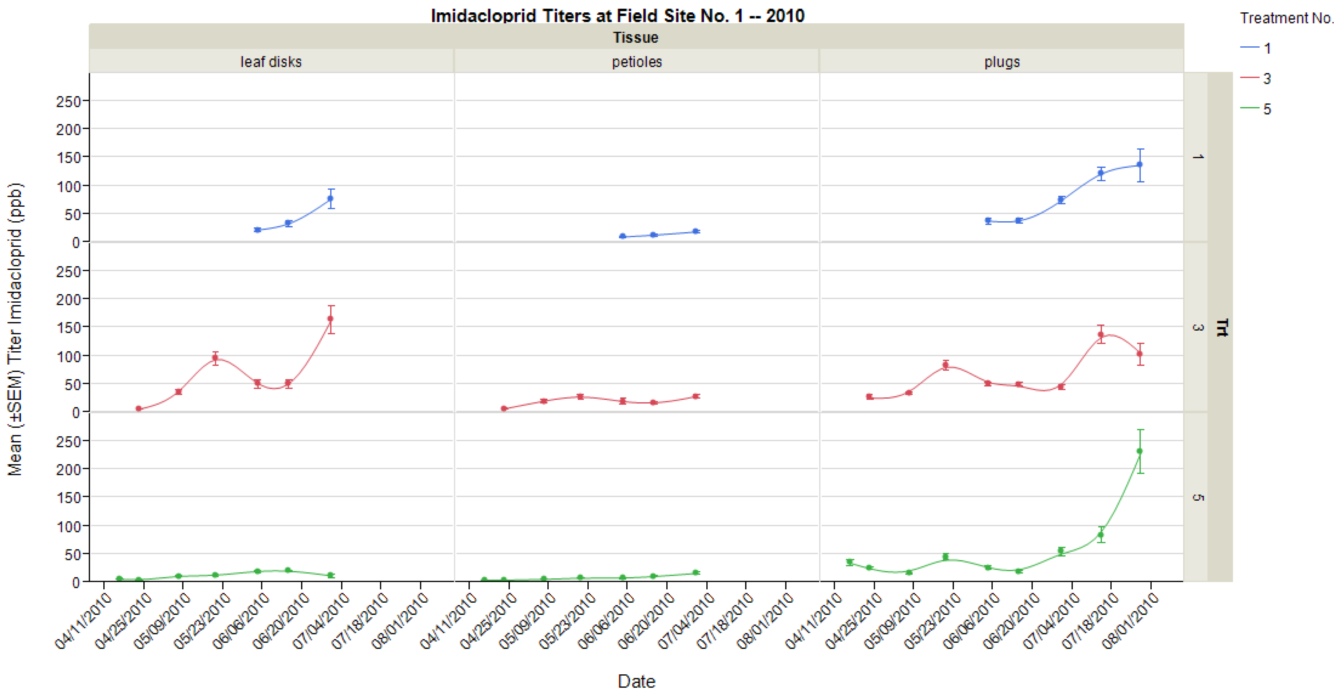
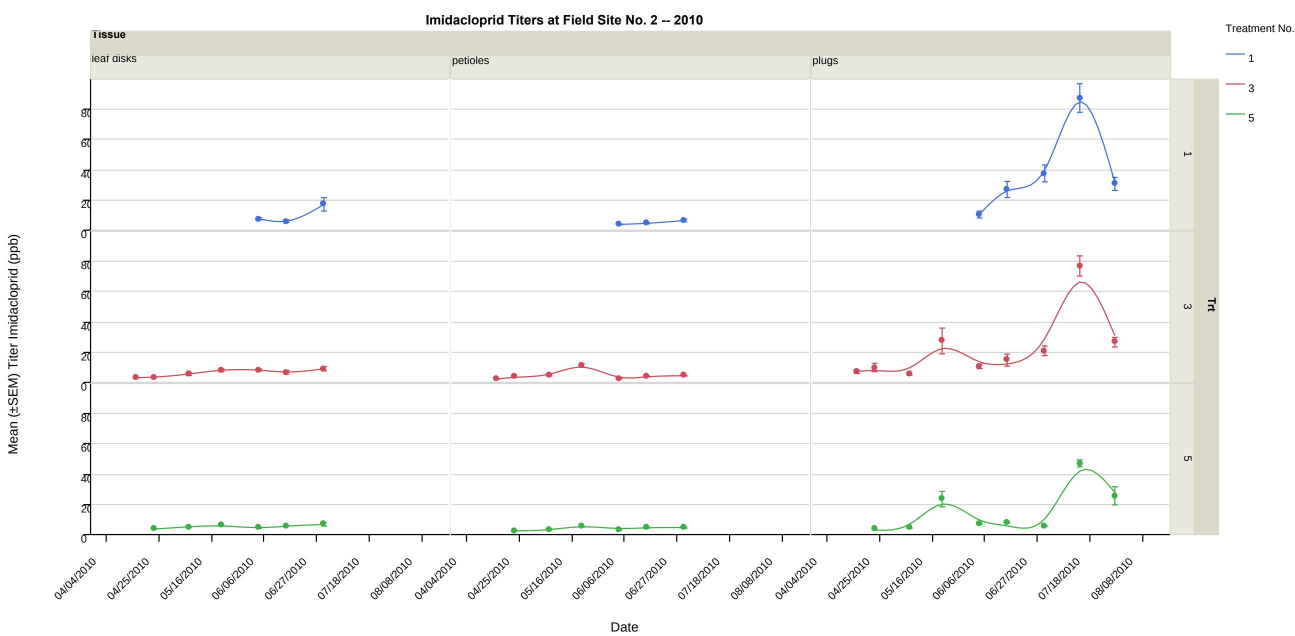


Fig. 2. Mean titers of imidacloprid in three grapevine tissues under three treatment regimens: 1) imidacloprid applied 19 May; 3) imidacloprid applied 15 April; 5) untreated control (but overtreated by grower on 15 June at field site 1). Note the much lower titers (and different vertical scales) at field sites 2 (panel B) and 3 (panel C).

A.



B.



C.

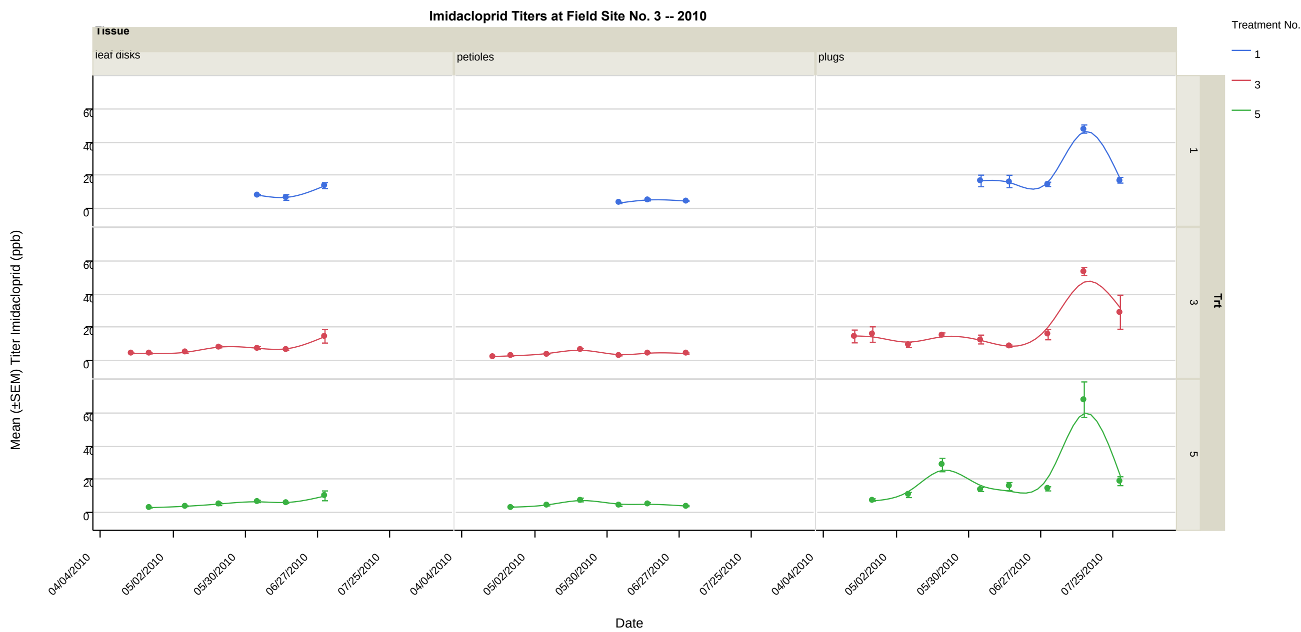


Table 2. Experimental treatments applied to Kern Co. table grapes in 2011.

Field Site	Regimen	Treatment	Application Rate (per acre)	Application Date
No. 4	1	Lorsban Applaud DF Admire Pro	4 pts 24 oz. 14 oz.	28 Feb 10 May 17 May
	2	Movento	8 oz.	10 May
	3	Clutch WDG	3 oz.	28 June
	4	Admire+Platinum	14 oz. + 5.67 oz.	17 May
	5	UTC	--	--
No. 5	1	Lorsban Applaud DF Admire Pro	4 pts 24 oz. 14 oz.	28 Feb 10 May 17 May
	2	Movento	8 oz.	10 May
	3	Clutch WDG	3 oz.	28 June
	4	Admire+Platinum	14 oz. + 5.67 oz.	17 May
	5	UTC	--	--

Fig. 5. Mean (±SEM) densities of VMB under 5 treatment regimens (no. 5 is UTC) in 2011. Note the high numbers of VMB at Site No. 4, but all treatment plots were brought to non-economic injury levels at harvest.

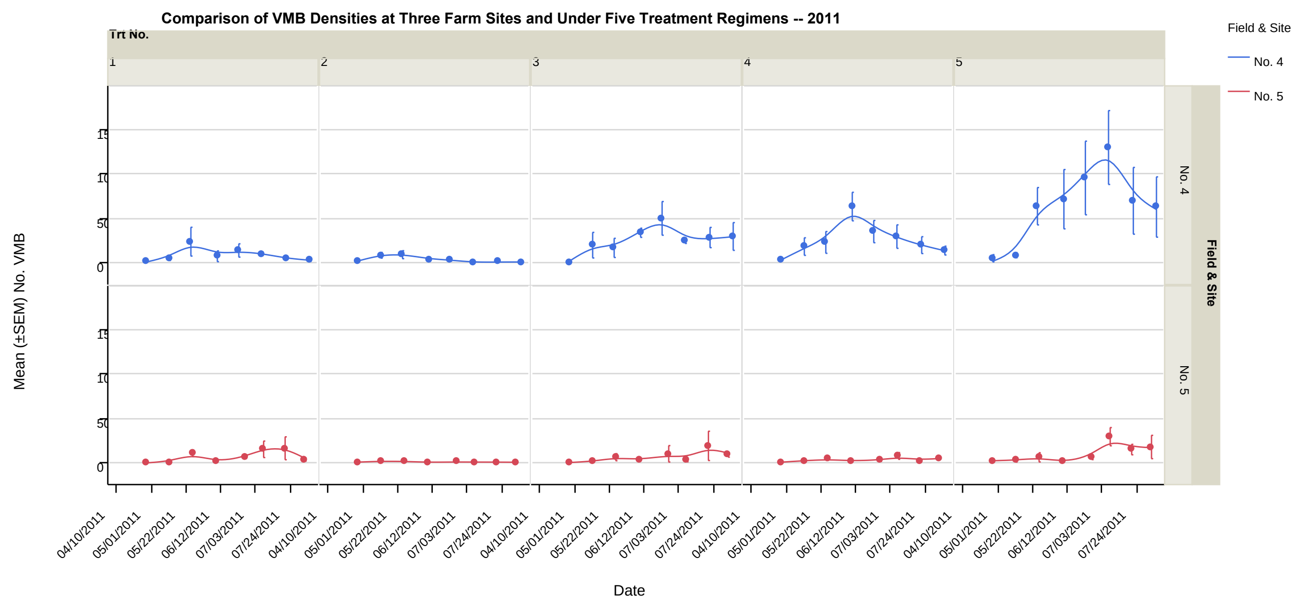
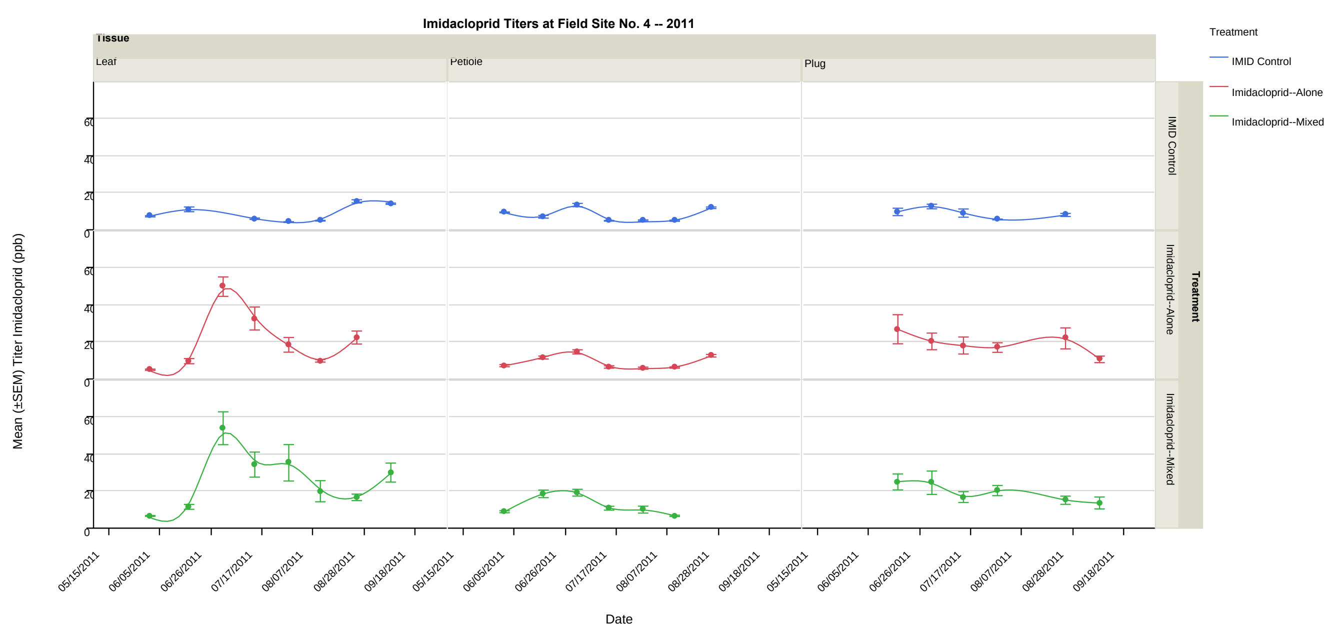
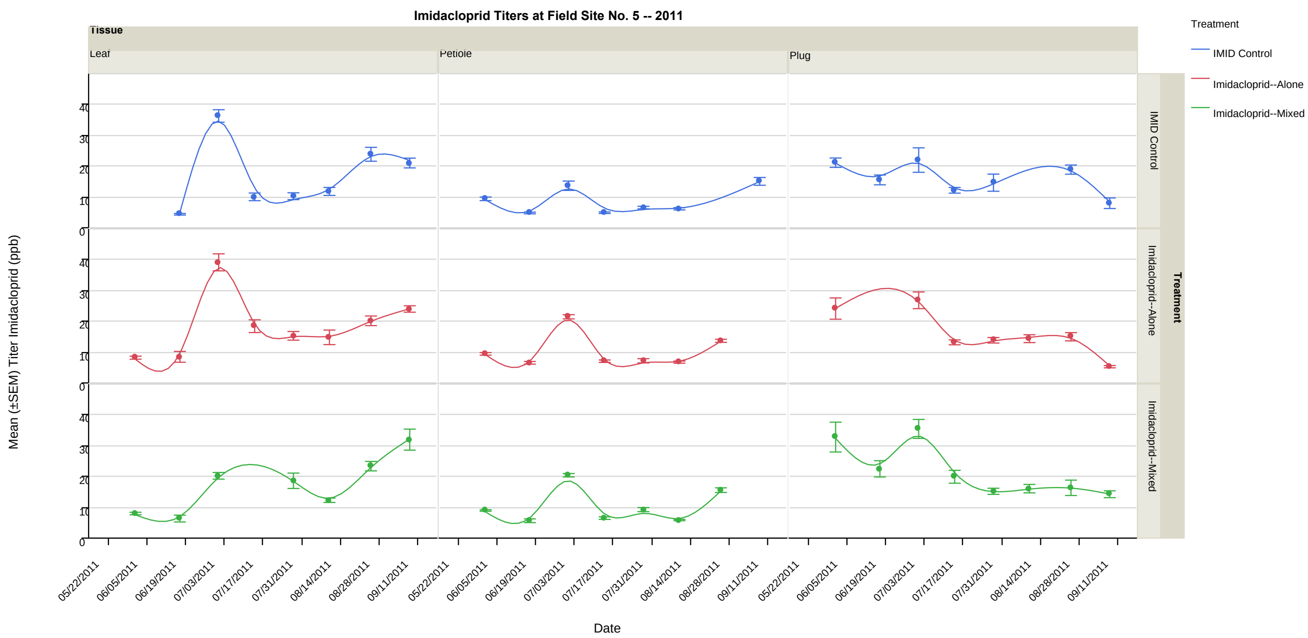


Fig. 3. Mean titers of imidacloprid in three grapevine tissues under three treatment regimens in 2011.

A.



B.

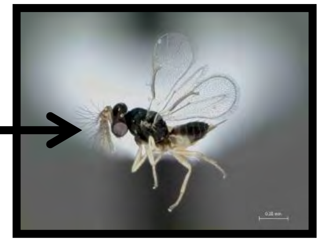


Imidacloprid Titers at Field Site No. 5 -- 2011
Tissue
Leaf
Petiole
Plug
Treatment
IMID Control
Imidacloprid--Alone
Imidacloprid--Mixed
Mean (±SEM) Titer Imidacloprid (ppb)
Date

<u>Figure 1.</u>
T. radiata are very small parastioids, approximately 2mm in length. Males and females are sexually dimorphic and can be easily separated under a dissecting microscope by examining the antennae. The sex ratio tends to be female biased with about 1.5-2.0 females for every male.

Female *T. radiata* have clubbed antennae

Male *T. radiata* have plumose antennae



<u>Figure 2.</u> Adult ACP and non-target psyllids tested as potential hosts for *T. radiata*.

Asian citrus psyllid

Fremontia psyllid

Olive psyllid

Rhus psyllid

Acacia psyllid

Potato psyllid

Scotch broom psyllid

Honey mesquite psyllid

Figure 3. Arrangement of test cages (“cone-tainers”) on a tray containing water which was provided moisture required for plant survival. The inverted clear plastic vial caged the parasitoid on host plants with non-target psyllid species.

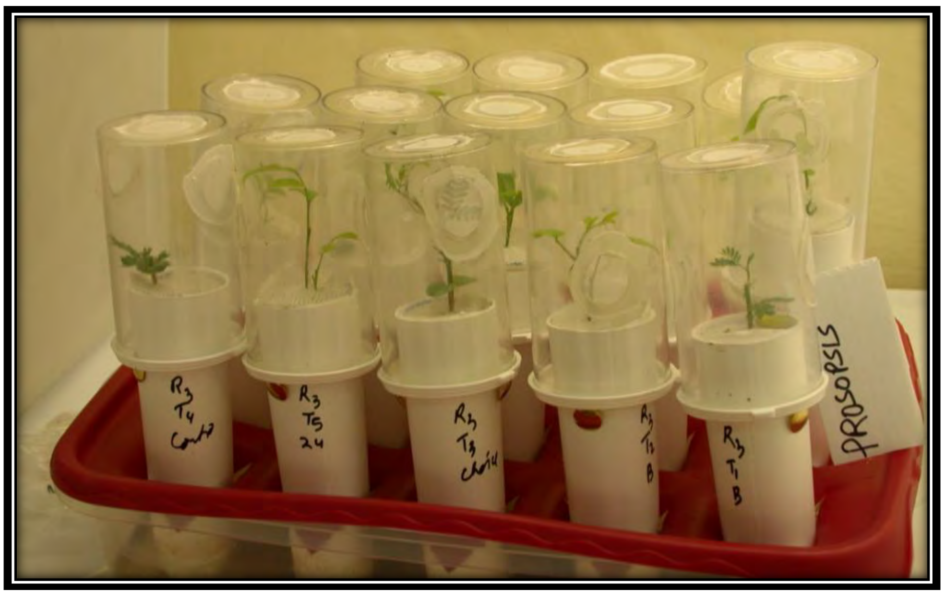


Table 1. The six selection criteria and selected species of non-target psyllids used for host specificity testing of *Tamarixia radiata* in Quarantine.

Selection criteria	Selected species
Close phylogenetic relatedness to ACP	Fremontia psyllid, *Dichlidophlebia fremontiae* Olive psyllid, *Euphyllura olivina**
Close host plants relatedness to citrus (Sapindales)	Rhus psyllid, *Calophya californica*
High probability of occurrence in native vegetation outside of citrus groves	Honey mesquite psyllid, *Heteropsylla texana* Acacia psyllid, *Heteropsylla* sp.
Native pest psyllids	Potato psyllid, *Bactericera cockerelli*
Invasive pest psyllid	Olive psyllid, *Euphyllura olivina**
Beneficial psyllid attacking a noxious weed	Scotch broom psyllid, *Arytainilla spartiophylla*

*Invasive olive psyllid is phylogenetically very closely related to ACP
Photographs of adult psyllids are shown in Fig. 1.

Table 2. Treatment summary for exposure tests of female *T. radiata* to Asian citrus psyllid (ACP) and non-target psyllid species (NTP)

<table>
<tr><td colspan="2" rowspan="2">Treatments</td><td colspan="2">Day 1</td><td>Night</td><td colspan="2">Day 2</td></tr>
<tr><td>4 hr</td><td>4 hr</td><td></td><td>4 hr</td><td>4 hr</td></tr>
<tr><td>T1</td><td>Sequential (ACP first)</td><td>[ACP]</td><td>►[NTP]</td><td>rest</td><td>►[ACP]</td><td>► [NTP]</td></tr>
<tr><td>T2</td><td>Sequential (NTP first)</td><td>[NTP]</td><td>►[ACP]</td><td>rest</td><td>► [NTP]</td><td>►[ACP]</td></tr>
<tr><td>T3</td><td>Choice test</td><td>[ACP+NTP]</td><td colspan="4"></td></tr>
<tr><td>T4</td><td>Control</td><td colspan="5">[ACP] / [NTP]
No parasitoid exposure to measure natural nymph mortality under prevailing experimental conditions</td></tr>
<tr><td>T5</td><td>Prolonged exposure</td><td colspan="3">[ACP] or [NTP] (24 hr)</td><td colspan="2"></td></tr>
</table>

► *T. radiata* movement to new psyllid hosts, rest = containment of test female *T. radiata* in a ventilated 2 ml O-ring vial with honey and no psyllid exposure for about 16 hours.

Signficant effort has been invested in extending the results of this project to intended stakeholders. The following is additional information available regarding this project:

Professional Journals:

Hoddle, M.S. 2012. Foreign exploration for natural enemies of asian citrus psyllid, *Diaphorina citri* (Hemiptera: Psyllidae), in the Punjab of Pakistan for use in a classical biological control program in California USA. Pakistan Entomologist 34: 1-5.

Professional talks and poster presentations on this results of this project:

Goldmann, A. and M.S. Hoddle. Asian citrus psyllid in southern California: an agricultural pest in the urban landscape. Annual UCR-CAPCA Ventura Entomology Meeting, Santa Paula Community Center, Santa Paula CA. November 9 2011.

Hoddle C.D., and M.S. Hoddle. Foreign exploration in Pakistan for natural enemies of Asian citrus psyllid. Annual UCR-CAPCA Ventura Entomology Meeting, Santa Paula Community Center, Santa Paula CA. November 9 2011.

Hoddle, M.S. In search of natural enemies for biocontrol of Asian citrus psyllid. 48th Annual Meeting of Association of Applied IPM Ecologists. Oxnard Embassy Suites February 7 2012.

Hoddle, M.S. ACP Biocontrol and *Tamarixia* Release Plan for LA, San Bernardino, and Riverside Counties. Citrus Pest and Disease Prevention Program, Hilton Ontario, 21 December 2011.

Hoddle, M.S. Three new pest problems for Southern California. Riverside Master Gardener Class, Western Municipal Water District Office, 14205 Meridian Parkway, Riverside CA 92518.

Hoddle, M.S. Tracking down natural enemies of Asian citrus psyllid for release in southern California. UC Hansen Trust Ventura County Research Symposium on Invasive Species, Marriott Courtyard, Oxnard, November 16 2011.

Hoddle, M.S. Updates on biocontrol efforts for Asian citrus psyllid in California. Ventura County ACP-HLB Taskforce Meeting, Santa Paula Community Center, May 15 2012.

Pandey, R. and M.S. Hoddle. "*Tamarixia radiata* poses low risk to native California psyllids" 2nd Annual Citrus Health Research Forum, Embassy Suites Denver - International Airport, 7001 Yampa Street, Denver, Colorado, United States 80249, October 4-6, 2011, poster presentation.

Pandey, R. and M.S. Hoddle. *Tamarixia radiata* poses low risk to native California psyllids. Poster Display Presentations, P-IE I. The 59th Annual Meeting of the Entomological Society of America, Nov. 13-16, Reno-Sparks Convention Center, Reno, NV. Nov 15 2011.

Pandey, R. and M.S. Hoddle. Progress update on safety tests for Asian citrus psyllid natural enemies and testing of organic pesticides. Annual UCR-CAPCA Ventura Entomology Meeting, Santa Paula Community Center, Santa Paula CA. November 9 2011.

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Asian citrus psyllid: http://cisr.ucr.edu/asian_citrus_psyllid.html

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USING LEAFY GREEN MARKETING AGREEMENT AUDIT DATA TO DETERMINE NON-COMPLIANCE AREAS AND PREPARATION OF TRAINING AND RECOMMENDATIONS FOR IMPROVEMENTS IN FUTURE GROWING SEASONS

LGMA TRAINING APPENDIX

Prepared for:

THE CENTER FOR PRODUCE SAFETY
CALIFORNIA LEAFY GREEN MARKETING AGREEMENT

June 30, 2012

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EXECUTIVE SUMMARY

In June 2012, the California Leafy Green Marketing Agreement (LGMA) conducted training sessions for pH, chlorine and water testing in Salinas, Santa Maria, and Oxnard, California. The course content incorporated findings from the February 29, 2012 California Department of Food and Agriculture (CDFA) grant report entitled, “Using Leafy Green Marketing Agreement Audit Data to Determine Non-Compliance Areas and Preparation of Training and Recommendations for Improvements in Future Growing Seasons.” Funding for the training was provided in part by a CDFA Specialty Crop Block Grant through the Center for Produce Safety (CPS). The 2009 grant proposal included a goal to” prepare training tools and use them to conduct region-specific producer workshops sponsored by the LGMA and CPS;” the June 2012 training sessions complete the training goal for the grant.

One of the recommendations in the grant report was for the LGMA to provide worker-related training that addressed sanitization issues and proper storage of knives and gloves. The LGMA, in conjunction with their annual training, was able to modify a course planned on pH and chlorine testing to include modules on knife and glove sanitization. Other recommendations such as the need for supply-chain training (e.g. handlers, growers, harvesters) and the use of quality circles were also incorporated into the training sessions.

Eight training sessions were conducted during the week of June 11, 2012 in various locations along the central coast of California. Attendee feedback was positive and there was wide support for additional training sessions similar in format to the June sessions.

The observations made during the interactive components of the sessions (hands on testing and breakout sessions) provide opportunities for the industry to focus on and resolve common issues facing many companies.

1.0 AUDIT DATA RESEARCH TRAINING RECOMMENDATIONS

As part of the grant "Using Leafy Green Marketing Agreement Audit Data to Determine Non-Compliance Areas and Preparation of Training and Recommendations for Improvements in Future Growing Seasons," non-compliant audit results were scored and ranked by audit question. Then Pareto analyses were conducted to understand which factors contributed most significantly to the non-compliant areas using individual audit data details and auditor comments. Based on the ranking, the highest non-compliance rate was for audit questions related to worker practices (26%). Based on the Pareto analysis, the factors contributing most significantly to this non-compliance rate included knife sanitization and testing issues, harvest worker clothing standard operating procedure (SOP) violations, gloves sanitization and testing issues, harvest equipment cleaning and sanitization issues, and produce containers and traceback issues.

In the final grant report, a recommendation was made encouraging the industry to develop training programs centered on supply chain (e.g. handlers, growers, harvesters) and functional (where the emphasis is on specific functions or processes) issues. Recommended functional training topics included knife and glove sanitization SOPs and knife dip tests. Several of the recommendations in the final report were incorporated in the June 2012 training program. (A more thorough discussion of the training recommendations can be found in the final grant report and in the LGMA presentation on February 2, 2012.)

2.0 THE LGMA'S MOTIVATION AND GOALS FOR THE JUNE 2012 TRAINING PROGRAM

LGMA's motivation for the June 2012 training program was to address deficiencies noted as auditor observations, documented as audit results, or identified in conversations with industry food safety managers. The LGMA's goals for this training program were to train LGMA certified handlers and their growers and harvesters to improve field and supervisory personnel confidence in managing knife and glove sanitization and water sampling procedures and ultimately to improve LGMA members' and associated companies' testing and sampling audit results.

3.0 COURSE CONTENT

The LGMA Technical Director developed the classroom course "Testing and Sampling Procedures: chlorine, pH, and irrigation water." The primary topic covered was sanitization, including objectives of sanitization, a review of the various types of sanitizers, how to prepare and test sanitizers and interpret test results, knife and glove dip sanitization, and how to collect direct contact water samples. An additional module on source dependent irrigation water focusing on water sampling SOPs and sampling techniques was presented if a class included attendees responsible for or involved with irrigation water testing. The course material included a PowerPoint presentation with photos of actual in-field demonstrations of the course content and copies of the PowerPoint slides bound and available in both English and Spanish.

4.0 WORKSHOP DETAILS

Training sessions were offered as a service to LGMA members and their growers and harvesting companies. Attendance was free of charge. Course announcements were emailed to LGMA members and details were made available on the LGMA website. Registration was provided online and by phone. Eight training workshops were conducted between June 11th and June 15th, 2012 in the central coast area of California (Salinas, Santa Maria and Oxnard). Each session lasted approximately three hours and consisted of classroom, hands on, and breakout session components.

Intertox supplemented the LGMA-developed classroom training with hands on demonstrations (functional training) and a breakout session for cross company problem solving or quality circles. The goal of the hands on session was to simulate in field environments, and then to use breakout sessions as quality circles to identify solutions for common issues. In the breakout sessions, attendees were placed with employees of other companies to facilitate sharing about food safety procedures, issues, and issue resolution.

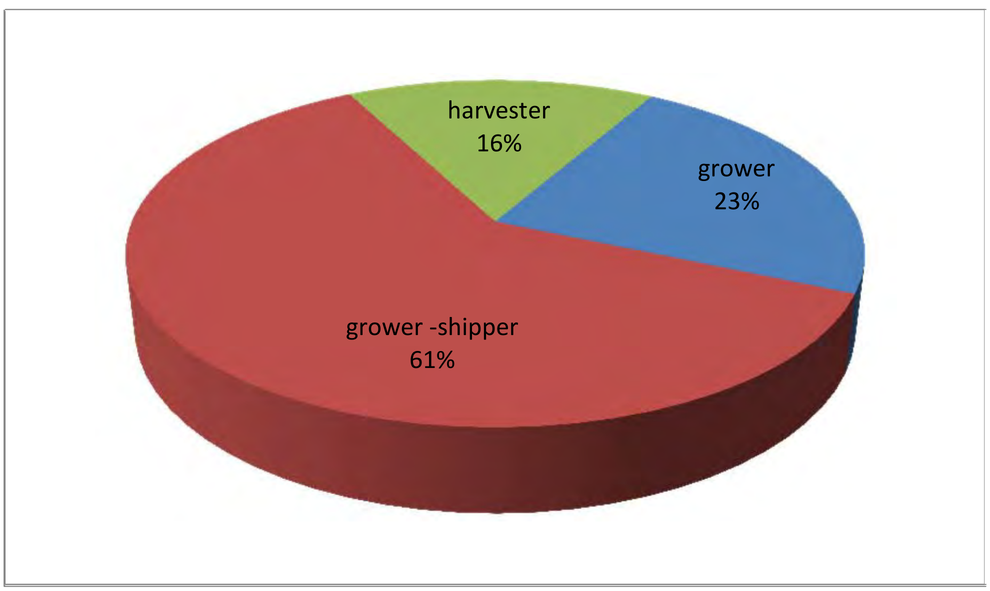
In summary, attendees were asked to do the following:

- Describe their company's SOPs for knife and glove sanitization.
- Perform a pH and chlorine test (start of the course)
- Watch a PowerPoint presentation
- Participate in a breakout session
- Perform a pH and chlorine test (end of the course)
- Complete a brief quiz and course evaluation

5.0 COURSE ATTENDEES

A total of one hundred and thirty seven individuals from fifty six companies attended the eight sessions from June 11 through June 15. Three classes were conducted in Spanish and five classes in English. Companies included grower-shippers, growers, and harvesters (Figure 1). For many of the companies, this was the first LGMA training session they had attended.

FIGURE 1. Companies Attending Training Sessions



Experience levels ranged from an employee on the first day of her job to an individual who had worked with his company for more than forty years. Attendee responsibilities in their companies ranged widely from human resources coordinators to crew foremen to handler food safety directors. The differing perspectives arising from the diversity in experience levels and job responsibilities was evident particularly in the hands on and breakout components of the course, as well as in the recommendations for future course offerings.

6.0 pH AND CHLORINE TEST RESULTS

At the beginning of the course, participants performed pH and chlorine tests to simulate knife and glove dip testing. Results were valuable not only as a measure of the change in participant knowledge before and after the training course, but also as feedback to the industry on potential causes of audit issues and/or SOP compliance difficulties.

The tests were conducted by placing small buckets of an identical water-based solution along with pH and chlorine testing equipment on every table. Each individual or group was asked to test the solution's pH and chlorine levels and record the results. Several test strip brands were provided including Micro Essential Laboratory's pHydrion papers (pH), pHydrion micro chlorine test papers (chlorine tests), Control Testing's Precision Chlorine Test Paper, and EMD Color test.

The pH and chlorine test results for each group are summarized in Tables 1 and 2. Of note, although each class was provided an identical water-based solution for testing (the solution was the same within the classes but not across classes), standard deviations of the pH readings varied greatly. For example, in Class B, the minimum pH reading was 5.5 and the maximum reading was 25.0 (using incorrect test strips) with a standard deviation of 5.3. In Class H the minimum reading was 4.5 and the maximum reading was 10.0 with a standard deviation of 1.6. Given that pH scale is logarithmic, the deviations are significant.

The differences in the chlorine test results are similar to the pH test results. In Class F, chlorine level readings ranged from 10.0 to 200.0 ppm with a standard deviation of 82.7. One class, Class D, appeared to be reading free chlorine and not total chlorine, reported a minimum of 2.5 and a maximum of 10.0.

Some of the deviations in the pH and chlorine readings can be explained by user error. In particular, for many participants, test equipment used in the hands on demonstration differed from the equipment they use on a daily basis. The brand name "pHydrion" was in particular confusing for some individuals: when seeing "pH" on the label, the assumption was that the test equipment was for measuring pH not chlorine. The significance of this observation is that if a crew runs out of test equipment, the company needs to ensure the same pH and chlorine reading test equipment is purchased and used. When deviating from frequently used equipment, the potential for human error will increase.

Other deviations in the readings occurred because of variability in test equipment itself. When conducting a test on the same liquid using equipment from different manufacturers, the results may vary across equipment.

Table 1. Summary of pH Results from LGMA Training Taken at Beginning of the Class

	Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H
Avg pH	7.1	8.3	6.9	6.5	7.0	7.4	9.0	5.7
Std dev	0.7	5.3	0.8	0.5	1.8	1.3	10.6	1.6
Min pH	6.0	5.5	5.5	5.5	5.5	6.0	5.5	4.5
Max pH	8.4	25.0	8.0	7.0	10.5	10.0	50.0	10.0

TABLE 2. Summary of Chlorine Results from LGMA Training Taken at Beginning of the Class

	Class A	Class B	Class C	Class D	Class E	Class F	Class G	Class H
Avg chlorine	64.4	40.1	30.5	5.5	95.5	118.3	24.4	24.2
Std dev	40.6	34.2	24.2	3.7	43.7	82.7	16.8	30.0
Min chlorine	10.0	3.0	10.0	2.5	50.0	10.0	7.0	0.0
Max chlorine	100.0	100.0	100.0	10.0	200.0	200.0	50.0	100.0

When conducting the second round of chlorine and pH readings at the end of the course, the standard deviations were lower yet still significant.

Overall, examination of the pH and chlorine test results suggests the following. First, after the second set of readings, most individuals were able to read the pH and test strips even if they had no prior experience with the equipment. Second, individuals reading test strips that require a distinction among colors and especially shades of one color will frequently disagree with one another on the color identity. Third, the color and hence pH and chlorine readings vary greatly across test equipment manufacturers.

Of particular significance for the industry is the finding that chlorine and pH test methods which rely on color ranges are subject to individual interpretation. In an audit situation, the tester and the auditor may not agree on the results. More significantly, individuals taking chlorine readings have a higher probability of reading the strips incorrectly or at least recording readings that may not be verifiable potentially resulting in accepting pH and chlorine levels that are outside of SOP levels. For these reasons, a focused analysis evaluating the effectiveness of sanitizer test equipment, costs, and ease of use would benefit the industry. (A few of the companies attending use ORP (oxidation reduction potential) readers. Given the cost of these handheld readers, they may not be practical for in field use; however, the digital display provides a reading that can be easily verified across individuals.)

7.0 KNIFE AND GLOVE SANITIZATION

After completing the classroom training component, attendees were divided into groups for the breakout session. If group members were from the same company, they were split up in order to diversify company participation in each group. Once in the breakout groups, individuals were asked to describe their company's knife and glove sanitization SOPs in order to identify similarities and differences among companies and their approaches to sanitization. Then each group was given two discussion items for the breakout session—the first was a question and the second was a series of situational issues for problem-solving (Table 3). The question covered experiences individuals/ companies have or have had with knife and glove sanitization. The situations considered were actual situations described in the audit data results. Group members discussed what they would do if faced with this situation and how they could prevent it from happening in the future.

TABLE 3. Breakout Discussion Topics

What problems do you experience with knife and glove sanitization? Think about test equipment availability, frequency of testing, recording test results, storage of equipment, glove replacement, etc.
Describe how you would handle the following situations and how you would prevent these situations from occurring.
1. The person trained to take pH readings is out for the day.
2. An employee was observed putting his knife in the dirt and then using the knife to cut lettuce.
3. Scheduled pH readings were missed.
4. At the end of the day, your test results were outside the stated range.
5. You are missing test equipment and need to take a test.

At the end of the breakout session, each group was asked to briefly summarize their group's discussions and/or conclusions. Discussion areas included:

- Because of cultural differences, there are cases where workers are concerned if they train another individual to do their job, then the individual trained will take the trainer's job. With this observation, individual companies may want to re-evaluate their train-the-trainer programs to ensure this cultural issue is addressed.
- Knives frequently contact the dirt when a worker is cutting leafy green heads. In fact, avoiding the dirt is probably impossible. For these cases, no additional sanitization is performed. However, when a worker is observed sticking his knife in the dirt or using it to scratch his head, etc. action is taken to sanitize the knives. Even with protective holders, knife sanitization issues still arise. The response the groups recommended is more training. Groups also recommended that LGMA revisit the requirement relating to knife soil contact.
- When scheduled pH readings are missing, the consensus was to make a note of the omission in the records and continue with the readings as scheduled. This should be an exception policy and not a change in SOPs (i.e., train to reduce omissions and not present omissions as part of standard practice). Not all companies have a policy for handling omissions; those that do not may want to revisit what they do in case a SOP is violated.
- Companies using chlorine in their operations find it difficult to effectively manage chlorine levels. For these companies, the suggestion was made to baseline their chlorine levels over several weeks by taking readings throughout the day and noting factors that could affect test results, e.g., the crew size, ranch location, time of day, temperature, etc. With the baseline

information, companies can then modify their testing SOPs to reflect the actual field situation(s). (One example is a company that does contract work for multiple handlers and receives different mixtures from each company.)

- To avoid the issue of running out of test equipment, some companies assign the equipment sourcing responsibility to one individual and that individual ensures every crew has the supplies they will need for the day. If the crew runs out of supplies during the day, the sourcing individual has inventory and can re-stock as required. Assigning one person responsibility for all supplies can alleviate pH and chlorine testing issues arising from the use of unfamiliar test equipment and also minimize any variability in test results associated with the use of different types of equipment.

Other recommendations and suggestions were:

- Chlorine testing should be standardized on free chlorine and not total chlorine.
- The industry should adopt a common SOP for knife and glove sanitization that companies could customize.
- Auditors need to standardize what they are looking for in terms of chlorine testing. Even if not required by a company's SOP, some auditors are asking for an exact chlorine level reading as opposed to a range. Attendees believe they would have better audit results if they are asked to meet their SOP requirements.

Individuals also discussed and commented on the perspective that in-field food safety results are regarded as the foreman's responsibility, underlying the need to understand the value of shared/individual responsibilities. An assessment of shared/individual responsibilities could be incorporated into the LGMA's continuous improvement plan.

Finally, as a result of the breakout sessions, individuals began to share methods they had developed to help them comply with the LGMA food safety audit requirements. One food safety individual shared how he developed a method for collecting water samples using a golf ball retriever in order to capture water at a distance of six to seven feet out in the canal (free flow).

8.0 EVALUATING PROGRAM EFFECTIVENESS

The overall goal of this training program was to improve sampling and testing audit performance and compliance. In order to measure the effectiveness of the training, two methods were used. First, attendee reaction and feedback was captured in a course evaluation form. Second, to measure post-course knowledge, a test instrument was developed which attendees completed at the conclusion of the course. However, since no information was available on attendee prior knowledge, the test results are not reliable measures of course effectiveness. A third method— analyzing future audit results and auditor comments for attendees/companies to identify performance improvements and results —was not feasible during the grant period.

Based on attendee evaluation responses, the overall reaction to the course was very positive. Of the 102 attendees completing an evaluation form, 101 or 99% requested that LGMA host "more workshops like this" (one individual (1%) was unsure if they wanted additional workshops). Attendee rating of the course content and format is summarized in Tables 4 and 5. In terms of course content and format, top responses (ratings of 4 and 5) were 89.2% for both.

TABLE 4. The Content of the Course was:

	Score	Respondents	%
Very valuable	5	68	66.7%
	4	23	22.5%
	3	5	4.9%
	2	0	0.0%
of lesser value	1	1	1.0%
	Blank	5	4.9%
	Total	102	100.0%

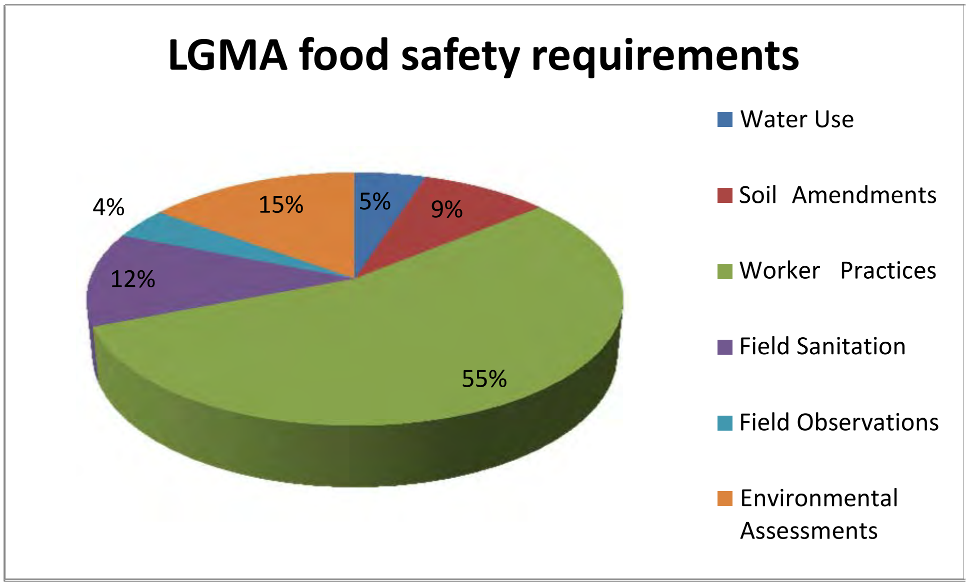
TABLE 5. The Format of the Course was:

	Score	Respondents	%
Very valuable	5	67	65.7%
	4	24	23.5%
	3	5	4.9%
	2	0	0.0%
of lesser value	1	1	1.0%
	Blank	5	4.9%
	Total	102	100.0%

9.0 FUTURE COURSE RECOMMENDATIONS

As part of the course evaluation process, attendees were asked to identify those LGMA food safety requirements with which they have the most difficulty complying. More than half of the attendees completing the evaluation identified worker practices (55%) as their most difficult compliance area (Figure 2). Other difficult compliance areas included environmental assessments (15%), field sanitation (12%), and soil amendments (9%).

FIGURE 2. What part of the LGMA food safety requirements do you find more difficult to comply with?



Attendee diversity was highlighted when individuals were asked to recommend future course topics. With regard to a follow-up course on pH, chlorine and water testing, it was recommended that the course go into greater detail on:

- Expanded pH and chlorine details
- Test strips
- Sanitizers
- Chlorine bottles
- Hands on training of how to read pH/chlorine strips
- Knives – how to sanitize and use properly
- Organic sanitization methods and auditor support for methods

Attendees also recommended topics for future courses in nine different areas ranging from how to train crews to dealing with leading scientific issues such as nitrogen leaching and pathogen testing (Table 6). Field level topics included crew training, hazard assessments (pre-harvest and environmental assessments), equipment selection and cleaning, and methods for improving audit performances. Interest was expressed in learning more about state and federal regulations and programs.

TABLE 6. Future Course Recommendations

Training • Crew training • Foremen training (basic class show/explain importance) • Training methods • Training content development • Train-the-trainer	**Pathogen Testing** • Sampling • Ranch oriented • How to product test • Field crop testing	**Audit Performance** • Audit tips • Audit scenarios • Field observation violations – how to prevent • What do auditors look for • Other audit observations • Audit paperwork	**Hazard Assessment and Risk Management** • Environmental assessments • Pre-harvest assessments • Animal events • Adjacent land evaluation • Potential risks and how to manage (e.g. water risks such as a reservoir floods)
Soil Amendments • Compost • Nitrogen leaching issues **Other** • Bathroom sanitization – what is required/expected	**Equipment** • Gloves- types to use for various commodities (twists) • Equipment cleaning • Gloves, sleeves and aprons appropriate material	**Regulations and Standards** • Food Safety Modernization Act • CA laws • How LGMA can help with other food safety programs (GlobalGAP, GFSI)	**Food Safety Program Support** • SOP, SSOP development • SOP procedures • Form development • Streamlining production crew documentation • Transportation food safety (field to processing plant)

10.0 SUMMARY AND CONCLUSIONS

Discussions, recommendations, and course evaluations from the “Testing and Sampling Procedures: chlorine, pH, and irrigation water” course offered in California in June 2012 validated the “Using Leafy Green Marketing Agreement Audit Data to Determine Non-Compliance Areas and Preparation of Training and Recommendations for Improvements in Future Growing Seasons” study findings. In particular in the grant study findings identified the need for further training specifically related to in-field practices such as knife and glove sanitization and pH and chlorine testing. Course attendees came from grower-shipper, grower, and harvesting companies and varied greatly in terms of individual experience and job responsibilities, demonstrating broad interest in the course content. Evaluation forms completed at the end of the course demonstrated support for the specific training topic and course format.

Discussions during the “quality circles” or breakout sessions identified other opportunities for industry improvement and/or additional research. The findings include:

- The industry could benefit from a cost-benefit evaluation of sanitizers that covers their effectiveness but also considers their ease of use and cost. Having a list of recommended commercially available products for companies to use would benefit companies that harvest products.
- The extent of cultural differences affecting the train-the-trainer programs warrants further investigation.

Session participants found the course “Testing and Sampling Procedures: chlorine, pH, and irrigation water” to be valuable and indicated interest in attending future training programs covering a variety of topics.

California SMALL FARM Food Safety Guidelines

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Small Farm Food Safety Guidelines

Fruit and vegetable consumption has grown significantly in the past two decades as the health benefits of these crops have been emphasized. Unfortunately, the incidence of foodborne illnesses has also increased. In some cases, the financial impact on the growers of the crops associated with these incidents has been devastating. This means that it is important for all growers to be aware of food safety practices that minimize contamination of their crops with human pathogens. The most important disease organisms are *Salmonella*, *E. coli* O157:H7, *Listeria*, *Shigella* and *Bacillus cereus*. The primary pathways for these pathogens to enter the field or packing shed are: contaminated irrigation or processing water, poor field/packing shed worker hygiene, improperly aged or treated organic soil amendments (manure, etc.), domestic or wild animals entering the field, contaminated harvest equipment, inadequate or unsanitary processing and storage conditions and improper transportation.

The following checklist of recommendations should be considered during crop production, harvest, processing and transport.

2012

Prior to Planting

- ☐ Keep records of all farm activity, especially food safety practices.
- ☐ If manure will be used as a fertilizer, apply untreated manure in the fallow period after the last harvest and incorporate it as soon as possible.
- ☐ Be sure that there is a buffer between the production field and manure/compost storage, concentrated animal feeding operations, grazing or open range areas, surface water, sanitary facilities and composting operations.
- ☐ Test irrigation water and, if contaminated, find the source and fix it or request that your water supplier do so.
- ☐ Train your employees about hygiene (handwashing, etc.) and other aspects of food safety that apply to them. Do follow-up training during the growing season.
- ☐ Evaluate fields for evidence of animal entry. If you see animal signs use mitigation procedures (fences, noisemakers, etc.).
- ☐ Assess adjacent lands for possible sources that might contaminate the production field, and take corrective actions if needed.

During the Growing Season

- ☐ Provide proper sanitation and hand-washing facilities in an area outside of the field.

- ☐ Provide an area outside of the field for eating, breaks, smoking and storage of personal items.

- ☐ Do not allow pets or other domestic animals to wander in the field and continue to look for signs of wild animals. Minimize standing water in the field because it attracts wildlife.

- ☐ If you sidedress with composted manure try to minimize manure contact with the crop and incorporate it, if possible.

- ☐ Clean and sanitize tractors and other implements that were used in manure application and incorporation prior to entering the field.

- ☐ Test irrigation water as close to point-of-use as possible at least once during the growing season, and more often if you use surface water.

- ☐ Ensure that water used for spray applications of pesticides and fertilizers is not contaminated.

- ☐ Consider using drip irrigation wherever possible. It minimizes the risk of contamination because above-ground plant parts are not directly wetted.

- ☐ Sick employees should not have direct contact with produce. Assign them other duties while they are sick or send them home. Employees who cut themselves should wear gloves and use bandages until the wound is healed.

Harvest

- Continue to emphasize worker hygiene, monitor employees for symptoms of illness and for wounds.
- Clean and sanitize harvesting equipment at least once a day or more often, if needed.
- High-pressure wash, rinse and sanitize all crop production bins.
- Cover clean bins to avoid contamination.
- Do not allow workers to stand or place personal items in bins.
- Remove field soil from the outside of bins prior to moving them into packing areas.
- Emphasize hygiene to U-Pick customers.
- Use clean water and ice made from clean water during field processing.
- Remove or prevent the harvest of any potentially contaminated produce if signs of animal intrusion are detected.

Postharvest Processing and Storage

- ☐ Clean facilities, equipment and food contact surfaces thoroughly and then sanitize just before the first use and then once a day during use or more often, if needed.
- ☐ Provide sanitary and hygiene facilities and an area for smoking, meals, breaks and personal item storage for employees away from processing and storage areas. Continue to monitor use.
- ☐ Use a potable water source for processing and use ice made from potable water.
- ☐ Wash, rinse and sanitize storage facilities.
- ☐ Fix or fill in any cracks or defects in the processing and storage building to keep out pests.
- ☐ Establish an ongoing pest control program (rodents, birds etc.).
- ☐ Ensure that refrigeration equipment is working properly. Measure and record temperatures at least once daily.
- ☐ Do not wear field clothes, especially shoes and boots, in the packinghouse.
- ☐ Use chlorinated water and other labeled disinfectants to wash produce.
- ☐ Store packaging materials in a clean, covered area.
- ☐ Do not load refrigeration rooms beyond their cooling capacity.

Transportation

- ☐ Ensure that transport vehicles are clean and sanitary.
- ☐ Be sure that vehicles that have carried live animals or harmful substances (pesticides, etc.) are thoroughly washed, rinsed and sanitized before shipping produce.
- ☐ Use refrigerated trucks when possible.
- ☐ Be sure that each package leaving the packing area can be traced to the field of origin and date of packing.

ADDITIONAL INFORMATION

Recordkeeping

This is very important in documenting the steps you take to ensure that you have complied with food safety recommendations. Some of the important things that need to be recorded are:

- ☐ Planting date(s) – varieties, suppliers, etc.
- ☐ Applications of fertilizer, pesticides or any other inputs.
- ☐ Water testing dates and results.
- ☐ Employee training – type of training (general safety, food safety etc.), dates, who was trained, follow-up training.
- ☐ Animal entry – dates when checked or observed, type(s) of animal signs, what action(s) you took to try to solve or mitigate the problem.
- ☐ Equipment maintenance – dates, type of maintenance, which piece of equipment, cleaning.
- ☐ Harvest date(s) – sanitation of harvest implements and harvest containers.
- ☐ Cleaning schedule for processing and storage facilities.
- ☐ Pest control program in processing and storage facilities – who does the program, treatment or trapping dates.
- ☐ Maintenance of refrigeration equipment and temperature of storage rooms.
- ☐ Dates of farmers' markets or other marketing options.
- ☐ Package identification.

Hygiene

To prevent field and packing shed workers from contaminating crops:

- ☐ They should be trained in hand washing - use plenty of soap and water, wash for at least 20 seconds, clean under fingernails and between fingers, rinse under clean water and dry hands with a single-use towel. Wash hands before they start work, after each break, after handling unsanitary items such as animals, manure, etc. and after using the toilet.
- ☐ They should not eat, chew gum, use tobacco, spit, urinate or defecate while in growing/processing areas.
- ☐ They should use the toilet/hand washing facilities and use them properly.
- ☐ Workers who show signs of diarrhea, vomiting, fever, jaundice or infected wounds should not handle fresh produce.
- ☐ They should use single-use cups or fountains for drinking water.
- ☐ The grower, packer or labor contractor should also provide signs that reinforce good hygiene, both in the field and in the packing shed.

Water Testing

Water needs to be tested to know whether it is contaminated with unacceptable levels of bacteria. While there is no standard for food safety testing levels, a number of commodity groups have used the recreational water standard as a safe level. Water should be tested as near to the point-of-use as possible. All of the water used to produce and process crops should be tested (pesticide spray water, water used in processing, etc.).

Manure

Unprocessed manure is a perfect medium to support bacterial growth. Many food safety programs do not allow the use of unprocessed manure. Only properly composted or aged manure can be used. They also require that root crops not be grown for one year after manure application. If untreated manure must be applied shortly before planting, apply and incorporate at least two weeks before planting and don't harvest the crop for 120 days after application. If the 120 day waiting period is not feasible, apply only properly composted or aged (at least one year) manure. Composted manure use as a sidedressing is very difficult. If you must use it this way, do all you can to reduce manure-crop contact and, if possible, incorporate it as soon as you can.

Other sources of information

The following web sites have additional information on food safety:

http://sfp.ucdavis.edu/pubs/articles/foodsafetybeginsonthefarm.pdf

http://www.caleafygreens.ca.gov/food-safety-practices/downloads

http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/FruitsVegetablesJuices/GuidanceComplianceRegulatoryInformation/ucm171695.htm

http://agr.wa.gov/inspection/FVinspection/docs/GHP_GAP_Presentation.pdf

http://agr.wa.gov/inspection/FVinspection/GAPGHP.aspx

http://www.gaps.cornell.edu/Eventscalendar/USDA_GAP_GHP_Audit_Matrix_PP.pdf

http://oregon.gov/ODA/ADMD/gap_ghp.shtml

http://datcp.wi.gov/OnFarmFoodSafety/ResourcesTools/index.aspx

http://www.kimberly.uidaho.edu/potatoes/gap.htm

http://www.miffs.org/tools/GAPAuditVerification.pdf

References

U.S. Food & Drug Administration Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Tomatoes: Draft Guidance. July, 2009

Commodity Specific Food Safety Guidelines for the Production and Harvest of Lettuce and Leafy Greens. California Leafy Green Handler Marketing Board. January, 2012

Food Safety Begins on the Farm: A Growers Guide. Cornell University. 2000

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CALIFORNIA DEPARTMENT OF
FOOD & AGRICULTURE

FOOD SAFETY GUIDELINES

PATHOGENS

1. What disease organisms may be found in the field or packing shed?
   A. Salmonella
   B. Foot and mouth disease
   C. E. Coli 0157:H7
   D. A and C
   E. B and C

2. What primary pathways are used for pathogens to enter the field or packing shed?
   A. Contaminated water
   B. Poor worker hygiene
   C. Un-sanitized vehicles and tools
   D. A and B
   E. A, B, and C

PRIOR TO PLANTING

3. What is true about untreated manure?
   A. It should always be stored with a buffer between it and the production area.
   B. It should be applied only after final harvest when crops are fallow.
   C. It should be treated with chlorine before used.
   D. It should never be used.
   E. A and B

4. It is impossible to keep all animals out of a field that is soon to be harvested, so time is better spent on other food safety issues.
   True_____ False_____

5. You do not have to take corrective actions if property next to your farm or packing area has issues concerning food safety and is not under your control.
   True_____ False_____

DURING THE GROWING SEASON

6. Where should sanitation and hand washing facilities be?
   A. They must be accessible within 100 feet of work.
   B. They may be placed within the area being harvested if that area has already been picked.
   C. They are to be placed in an area outside the field.

7. Eating, smoking, and storage of personal items are restricted to designated location(s) outside of growing/processing areas.
   True_____ False_____

8. Standing water is common on a farm and there is not a way to reduce food safety issues related to it.
   True_____ False_____

9. If irrigation water is from a ditch, it needs to be tested more often during the season than well water.
   True_____ False_____

10. Irrigation water from a well is not required to be tested.
    True_____ False_____

11. Drip irrigation, sprinklers, or furrow irrigation are equally safe.
    True_____ False_____

HARVEST

12. How often should harvest equipment be cleaned and sanitized?
    A. Weekly or more often if needed.
    B. Daily or more often if needed.
    C. Before the beginning of the day and after work breaks or more often as needed.
    D. Only if they look dirty.

13. What should you do if you detect signs of animal intrusion?
    A. Thoroughly wash product harvested near intrusion.
    B. Thoroughly wash product harvested near intrusion with chlorinated water.
    C. Remove or prevent harvest of potentially contaminated product.

POST HARVEST PROCESSING AND STORAGE

14. How often should packing facilities, equipment, and food contact surfaces be disinfected?
    A. At least weekly or more often as needed.
    B. Prior to the season or more often if needed.
    C. Once a day during use or more often if needed.
    D. Whenever a different product is to be packed.

15. Refrigeration equipment should have temperatures checked and recorded at least once per week.
    True_____ False_____

FOOD SAFETY GUIDELINES

TRANSPORTATION

16. What is true when transporting product to the market?
    A. Transport vehicle must be clean and sanitary.
    B. Driver shall have a copy of the manifest.
    C. Each package can be traced to date and field that product was packed.
    D. A and C
    E. B and C

ADDITIONAL INFORMATION – RECORD KEEPING

17. What additional record keeping documentation in regard to food safety is important?
    A. Sale price and destination of product
    B. Employee training
    C. Equipment maintenance
    D. B and C
    E. A, B, and C

HYGIENE

18. Employees should wash their hands for a minimum of 60 seconds after taking a work break.
    True_____ False_____

WATER TESTING

19. The official minimum standard for water used to produce and process crops, is the "recreational water standard."
    True_____ False_____

20. Untreated manure, if used, should be applied and incorporated into the soil at least two weeks before planting and 120 days before harvest.
    True_____ False_____