ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL (EFA SAP)
CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

MEETING AGENDA

October 17, 2019
10 AM to 4 PM
The Lau Family Meat Processing Center Conference Room (map on page 2)
California Polytechnic State University (CalPoly)
1 Grand Avenue
Stenner Creek Road
San Luis Obispo, CA 93407

REMOTE ACCESS

Webinar information
Registration URL: https://attendee.gotowebinar.com/register/5903876465324100363
Webinar ID: 740-056-171
Presentation materials will be posted at the following link prior to the meeting:
https://www.cdfa.ca.gov/EnvironmentalStewardship/Meetings_Presentations.html

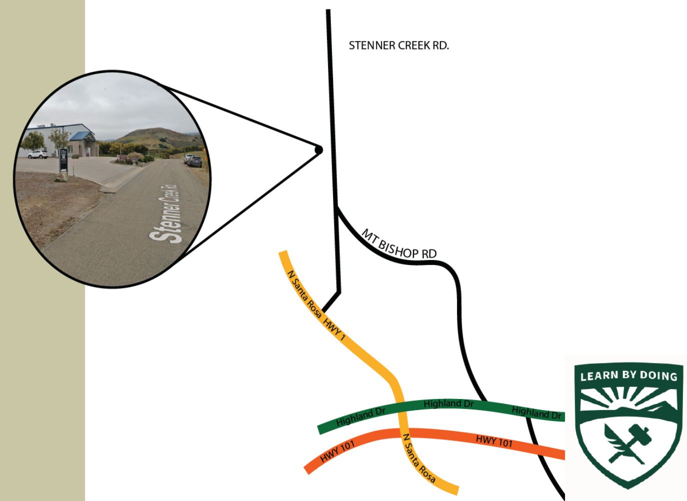
Topic	Presenter	Action Level
1. Introductions	Chair Bridson	Informational Item
2. Minutes	Chair Bridson	Action Item Requires EFA SAP Approval
3. SWEEP Update • Program Updates	Scott Weeks, CDFA	Informational Item
4. Healthy Soils Program (HSP) • August 23, 2019, HSP workshop results	Thea Rittenhouse, CDFA	Informational Item
5. Healthy Soils Program • Program Updates and Public Comment Period	Andrew Whitaker, PhD, CDFA	Informational Item
6. Technical Assistance Program • Program Updates	Carolyn Cook, MSc, CDFA	Informational Item
7. Whole Orchard Recycling • Discussion of DNDC modeling • Discussion of WOR • Proposal to add WOR to the HSP Incentives Program	Michael Wolff, PhD, CDFA Benjamin Nicholson, CARB	Action Item Requires EFA SAP Approval
8. Public Comments	Chair Bridson	Informational Item
9. Next Meeting and Location	Chair Bridson	Informational Item

DIRECTIONS TO PUBLIC MEETING LOCATION
THE LAU FAMILY MEAT PROCESSING CENTER CONFERENCE ROOM (CALPOLY)

DIRECTIONS:
(From HWY 101)

1. Turn onto Hwy 1/Santa Rosa
2. Turn Right on Stenner Creek Rd. (just past Highland Dr./main entrance to campus)
3. The Lau Family Meat Processing Center will be 1/2 mile up on the left

PARKING:
- Limited parking is available in the building parking lot
- Free parking is available on Stenner Creek Rd.



EFA SAP MEMBERSHIP

https://www.cdfa.ca.gov/oefi/efasap/

Jocelyn Bridson, MSc, Rio Farms, Member and Chair
Jeff Dlott, PhD, SureHarvest, Member and Co-Chair

Don Cameron, Terranova Ranch, Member
Vicky Dawley, Tehama RCD, Member
Judith Redmond, Full Belly Farm, Member
Doug Parker, PhD, Subject Matter Expert

Scott Couch, CalEPA, State Water Board, Member
David Bunn, PhD, Resources Agency, DOC, Member
Michelle Buffington, PhD, CalEPA, CalEPA, Member
Vacant, Resources Agency, Member

Tom Hedt, USDA NRCS, Subject Matter Expert

CDFA Liaison to the Science Panel - Amrith (Ami) Gunasekara, PhD,
All meeting facilities are accessible to persons with disabilities. If you require reasonable accommodation as defined by the American with Disabilities Act, or if you have questions regarding this public meeting, please contact Amrith Gunasekara at (916) 654-0433.
More information at: http://cdfa.ca.gov/Meetings.html and
http://www.cdfa.ca.gov/EnvironmentalStewardship/Meetings_Presentations.html

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE (CDFA)
ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL

California Department of Food and Agriculture
Auditorium
1220 N Street
Sacramento, CA 95814
July 18, 2019

MEETING MINUTES

<u>Panel Member in Attendance</u>

Jeff Dlott, PhD. Sure Harvest (Co-Chair and Member)
Don Cameron, Terranova Ranch (Member)
Emily Wimberger, PhD. CalEPA, ARB (Member)
Doug Parker, PhD. UC ANR (Subject Matter Expert)
Thomas Hedt, USDA NRCS (Subject Matter Expert)
Jeff Onsted, PhD, Resources Agency, DOC, (Alternate for Member Bunn)
Scott Couch, CalEPA, State Water Board, (Member)
Judith Redmond, Full Belly Farm (Member)
Vicky Dawley, Tehama RCD (Member)

<u>State Agency Staff and Presenters</u>

Carolyn Cook, MSc, CDFA
Geetika Joshi, PhD, CDFA
Stephanie Jamis, MSc, CDFA
Wesley Franks, CDFA
Amrith Gunasekara, PhD, CDFA
Thea Rittenhouse, CDFA

AGENDA ITEM 1 – Introductions

The meeting was called to order at 1:05 PM by the Co-Chair, Jeff Dlott. Panel members introduced themselves. Present at the meeting were all the members noted above under "Panel Members in Attendance." A quorum of at least six members was present at the meeting.

AGENDA ITEM 2 – Minutes
Chair Dlott introduced the April 18, 2019 meeting minutes. Member Dawley pointed an error to correct affiliation for Kristin Murphy, a commenter in the previous meeting. Ms. Murphy, with California Association of Resource Conservation Districts (CARCD) was incorrectly noted as being associated with the California Climate and Agriculture Network (CalCAN). Dr. Gunasekara noted the correction would be made. Member Cameron introduced the motion to approve the amended minutes and Member Couch seconded the motion. The motion was moved by all members present.

AGENDA ITEM 3 – State Water Efficiency and Enhancement Program (SWEEP) Update. Ms. Cook provided program updates on State Water Efficiency Enhancement Program (SWEEP). She presented a summary of the 2018 solicitation. She provided a background of Prop 68, the funding source for the current round of SWEEP, which was announced on December 28, 2018 until March 8, 2019. She clarified that SWEEP funding will be awarded in two solicitation rounds. Today's update covered the first around. SWEEP received 343 applications for $27.6 million in grant requests. SWEEP received 48 applications from Severely Disadvantaged Communities (SDACs) totaling $4 million in request. 34 technical assistance providers (TAPs) were available for SWEEP; they assisted through different approaches such as workshops and one-on-one assistance. 120 projects were selected for awards, totaling $10.3 million in awards. She explained the review process and presented data analysis on awarded projects by crop types and distribution across California counties.

Member Redmond asked a clarifying question if the main target for SWEEP was to provide SDAC benefits, and if other priorities were included and tracked. Ms. Cook explained that Prop 68 requirements included a target of 20% of the funds to benefit SDACs. CDFA also tracked the funds awarded to Socially Disadvantaged Farmers and Ranchers. Dr. Gunasekara further clarified that projects were scored and ranked during selection and prioritized based on SDACs status and Socially Disadvantaged Farmer and Rancher status, respectively. Chair Dlott asked if the change in SDAC participation from previous rounds could be determined. Ms. Cook responded that since SDAC requirements were not applicable to previous rounds of funding due to a different funding source, this determination cannot be made. She added that Socially Disadvantaged Farmers and Ranchers were also being tracked for the first time and this comparison would be available in future rounds. Member Cameron asked the main factors that led to disqualification of certain projects. Ms. Cook responded that main reasons for disqualification were incomplete applications, missing supporting information and incorrect attachments provided. Dr. Parker asked if the 20% SDAC target was based on number of funded projects or total funds awarded. Ms. Cook responded that the target was applicable to the total amount of funds awarded. Dr. Parker commented the target seems achievable with second round. He inquired if CDFA had decided the target date for the next round of SWEEP funding. Ms. Cook responded that this date was not yet final but OEFI team hoped to release the next solicitation for SWEEP in November, as post-harvest timeframe is preferred by farmers and ranchers. Member Couch asked about the technical reviewers; Ms. Cook responded that there were 19 irrigation experts across UCANR and CSU systems that served as technical reviewers for SWEEP. Member Couch also commented on the source of the graphic showing equivalence of GHG reductions through SWEEP with reduction in mileage driven in a car. Ms. Cook responded this calculation was based on the USEPA Greenhouse Gas Equivalencies Calculator. Chair Dlott noted that the disqualification percentage for SWEEP applicants was a little over 7%, and asked how it compared to previous rounds. Ms. Cook responded this percentage was lower than in previous rounds as more technical assistance has been made available to applicants in each subsequent round of SWEEP. Member Redmond commented that SWEEP represents a great story for farmer successes and a wide outreach is needed. Ms. Cook agreed with this comment.

AGENDA ITEM 4 – Healthy Soils Program (HSP) Update

Dr. Joshi of CDFA provided an update on the Healthy Soils Program. She noted that CDFA has received funding in the amount of $28 million from the Greenhouse Gas Reduction Fund (GGRF) for 2019-20. She updated the panel that 194 incentives and 23 demonstration projects were selected for a total of $12.5 million in awards through 2018 HSP. She highlighted the statewide distribution of the funded projects, and that the level of funding in SDACs was sufficient to meet the 15% target required by SB-5 for expenditure of Prop 68 funds.

Member Couch asked the definition of AB 1550 Priority Populations. Dr. Joshi responded that this term was defined for all programs funded through the GGRF and was based on several criteria, including CalEnviroScreen 3.0 score, 2016 State Income Limits, and within ½ mile of disadvantaged communities as defined through SB 535. Dr. Parker asked a clarifying question if the Prop 68 SDAC targets were different for SWEEP and HSP. Dr. Joshi explained that since the two programs had received funding authority through two different chapters within the SB-5 legislation, the targets were different; 20% for SWEEP and 15% for HSP.

AGENDA ITEM 5 – AB 2377 Climate Smart Agriculture Program Technical Assistance Grants

Ms. Carolyn Cook presented the final draft of the Request for Proposals (RFP) for the new TA program mandated by AB 2377 (2018, Irwin). She provided a background of funding including key legislative requirements. She also provided a timeline for program development that has been followed thus far, including the last EFA-SAP meeting and public comment periods. She explained major comments submitted, CDFA responses to the comments, and, changes to the RFP in response to comments.

Member Dawley commented on indirect rates. She acknowledged the changes made by CDFA staff in responses to comments, including increasing the indirect rate to 20%. She noted that the process of statewide indirect rates across all State agencies was in need of revision, and that rates ranged between 10-15% for most agencies. She noted that the 20% rate now allowed by CDFA is among the highest among State agencies. She further explained that the process of negotiation of federal rates can be done through multiple ways, including based on personnel costs, personnel costs plus first $25,000 for the first sub-contractor costs, or based on total direct costs. In each case, the negotiated rate can be different. She acknowledged a State agency may not have the capacity to conduct a similarly detailed negotiation process at different rates as the federal government does. She thanked the CDFA for increasing the indirect to the 20%.

Dr. Parker noted that on page 3 of the RFP, grant award amounts were explained using examples of all three programs, HSP, SWEEP and AMMP. He asked if it will be clarified in the RFP that SWEEP will not be included in this year's funding since the program has not received funding this year. Ms. Cook explained that while SWEEP had not been funded and will not be included in this RFP this year, CDFA has 2018-19 contracts with SWEEP TA providers which would be utilized for the second round of SWEEP funding this year. Therefore, applicants can still expect to receive technical assistance when applying for next round of SWEEP.

Member Dawley asked a question to clarify if a justification was needed when submitting an application with 20% indirect rate. Ms. Cook responded that a justification would not be needed.

AGENDA ITEM 6 - Public Comments

Mr. Brian Shobe CalCAN acknowledged the usefulness of listening sessions and CDFA's responsiveness to comments. He asked if there would be an opportunity for flexibility to charge a higher indirect rate if a justification was provided.

Mr. Rex Dufour of National Center for Appropriate Technology commended that they have served as TA providers for Socially Disadvantaged Farmers and Ranchers, providing multi-lingual services including Spanish, Lao and Thai. They noted that the 20% indirect rate was insufficient to cover their costs and may result in a loss of $10,000-$20,000. He requested the Panel to consider increasing the indirect rate to 25% or greater.

Ms. Kristin Murphy of CARCD acknowledged the public comments process and CDFA's responsiveness to comments. She commented that at least two months should be allowed between finalizing of contract for the grant award and start of application submission for HSP and AMMP. She commented that 20% indirect rate was generous among State agencies; while it may be low for some organizations but expressed appreciation for the increase.

Ms. Sheryl Landrum of San Diego RCD agreed with comments from Mr. Shobe and Ms. Murphy. She noted that 20% is the rate used at San Diego RCD and their federally approved indirect rate is 47%. She acknowledged that other RCDs may need higher indirect rates, although San Diego RCD committed to an expense of extra 47 cents for each dollar received by CDFA. She thanked CDFA for the increase in indirect rate and encouraged flexibility for those that need a higher rate.

Ms. Valerie Quinto of Sonoma RCD expressed gratitude for the ability to attend remotely. She acknowledged the positive engagement of stakeholders and TAPs in the public process. She acknowledged that the 20% indirect rate was generous among State agencies, however for their organization it presented a challenge. She noted their organization had a federally negotiated indirect rate of 35%. She expressed challenge in participating in a grant program that would not cover their costs and encouraged CDFA to consider a process similar to the federal negotiation process.

Mr. Brian Kolodji of Black Swan LLC acknowledged receiving a SWEEP grant award. He asked the Panel if SWEEP funds would count towards federal tax benefits for carbon reductions.

Panel members discussed the comments further. Member Wimberger asked if there is room in the future rounds of funding to make changes to the indirect rate. Dr. Gunasekara answered that the program will undergo public comment process each time before release of subsequent future rounds, similar to CDFA's other programs, where the Panel may consider such comments and make recommendations to CDFA Secretary.

Chair Dlott inquired of the panel members if indirect costs were included in the case of fundraising by RCDs. Member Dawley responded that raised funds or donations may be tax deductible. She noted that the request to allow a higher indirect rate from organization as understandable, while also acknowledging that CDFA may not have resources currently to conduct negotiations similar to the federal process of working through many different rates. She acknowledged that making such a decision would be challenging for CDFA.

Member Couch inquired if the Panel or CDFA staff has an idea of how many organizations might be impacted due to the lower indirect rates. Member Dawley responded this would be difficult to evaluate since it is not known how many RCDs have received tax dollars.

Chair Dlott request the panel member to please introduce a motion to approve the RFP for the Technical Assistance Program. Member Wimberger introduced the motion to move the RFP without further changes and Member Onsted seconded the motion. All members present approved the motion.

AGENDA ITEM 7 – Next Meeting and Location.

Dr. Gunasekara announced that the next meeting of the Panel would be on October 17, 2019. The location of the meeting is yet to be determined.

Meeting was adjourned at 2: 33 p.m. by Chair Dlott.

Respectfully submitted by:

____

Amrith Gunasekara, Ph.D.
Liaison to Science Advisory Panel

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

State Water Efficiency and Enhancement Program

ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL UPDATE
OCTOBER 17, 2019

Proposition 68

On June 5, 2018 California voters approved Proposition 68.

$4 billion in bond funding was authorized for environmental protection project, water infrastructure, and flood protection.

CDFA's SWEEP program received $20 million.

Two solicitations for the $20 million

- The first application period was announced in December of 2018
- Projects began September 1, 2019
- Second solicitation to be held fall 2019

PROP 68
State of California
Parks & Water Bond 2018

Project Types

Water Conservation

- Sensors for Irrigation Scheduling *(weather, soil or plant based)*
- Micro-Irrigation or Drip Systems

AND

GHG Reductions

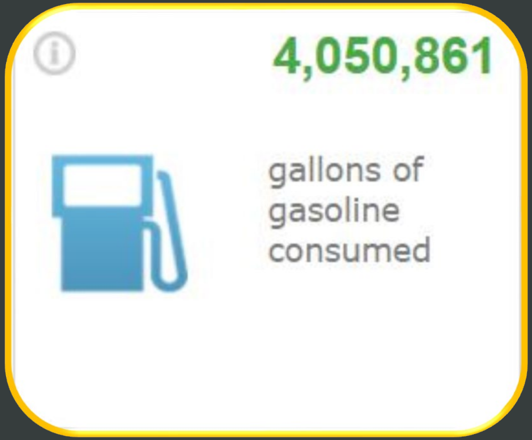
- Fuel Conversion
- Improved Energy Efficiency
- Low Pressure Systems
- Variable Frequency Drives
- Reduced Pumping

Pre-Project Consultation

SWEEP staff contacted each of 120 applicants selected for an award to review application information and clarify all project components and timeline.

111 project that accepted the award

- $9.5 million awarded
- $7 million in matching funds
- $3.2 million going to 37 projects benefitting Severely Disadvantaged Communities
- 13,000 acres impacted
- 29 billion gallons of water saved over 10 years
- 36,000 MTCO2e saved over 10 years



Upcoming Request for Grant Applications and Timeline

- No changes to the Request for Grant Applications
- Approximately $7 million available

Item	Timeframe
Solicitation Release	October 21, 2019
Grant Applications Due	December 16, 2019
Review Process	Winter 2019 - 20
Announce and Award Funding	Spring 2020
Project Start Date	June 15, 2020

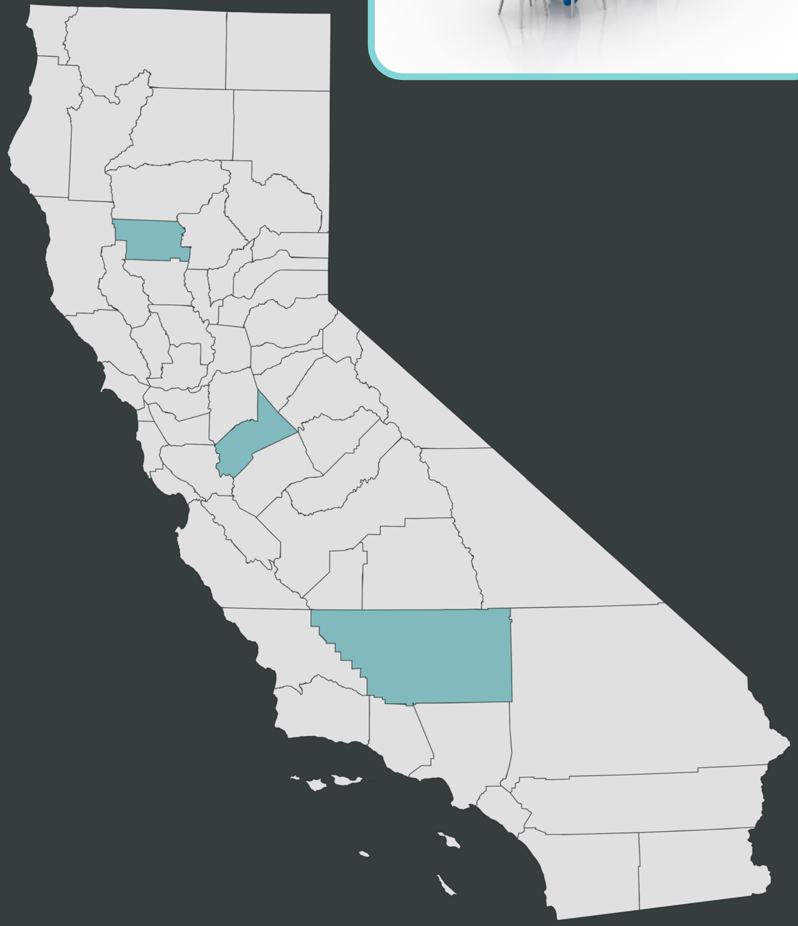
Workshops and Assistance

Workshop Dates and Locations

- Monday October 28th 2019 in Willows - Glenn County
- Tuesday October 29th 2019 in Modesto – Stanislaus
- Wednesday October 30th in Bakersfield – Kern County

Workshops will review the following:

- Request for Grant Applications
- Application process including Wizehive demo
- Calculator tools and required attachments
- Q&A



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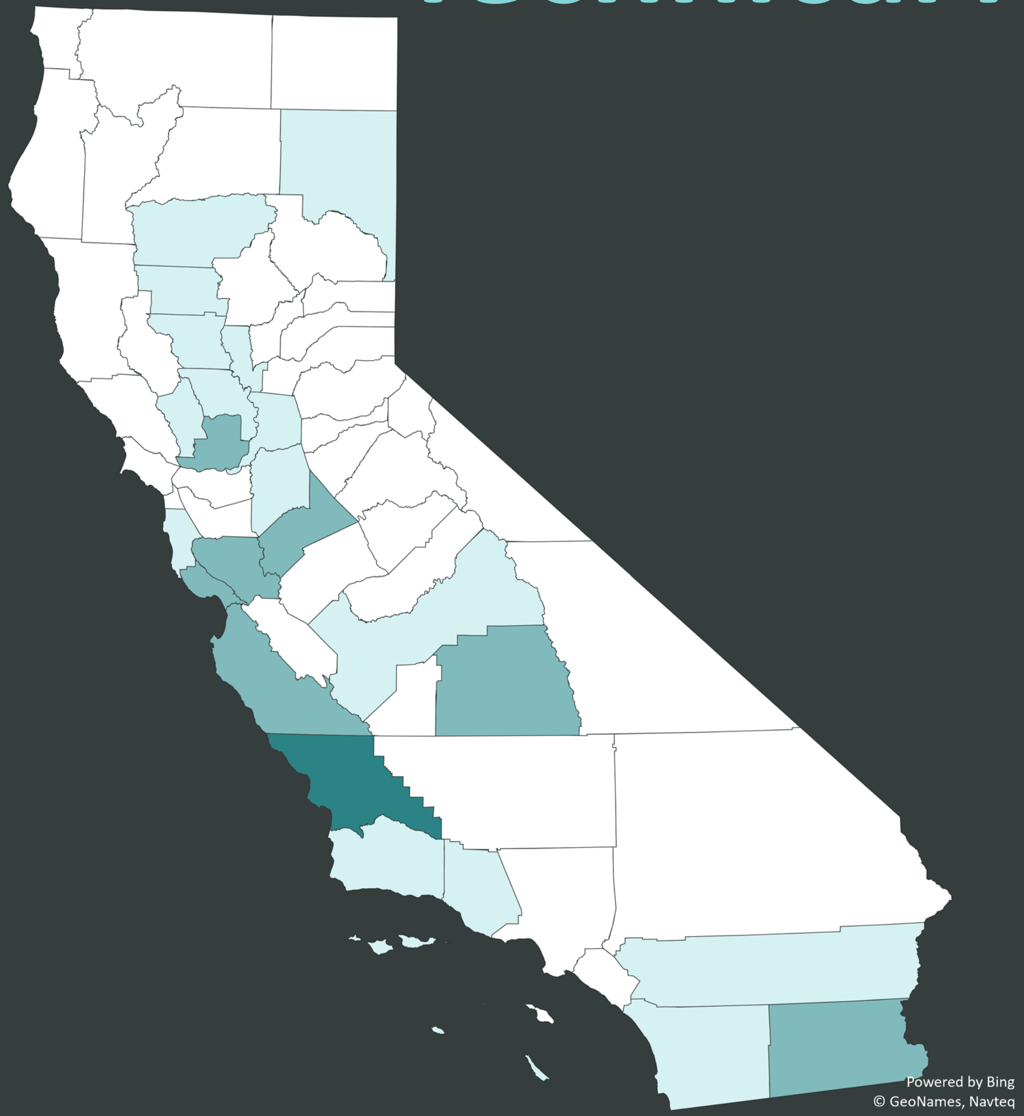
Technical Assistance Providers



- 34 Technical Assistance Providers (TAPs)
  - 20 RCDs
  - 10 Non-Profit Organizations
  - 4 Universities
- Some regions had multiple providers
- Many providers offered assistance outside of their county
- Each provided one-on-one assistance
- Some providers will hold workshops

Application Submission Portal

The portal worked successfully during the last solicitation

- Application portal will remain the same
- Application itself will be the same
- Past applicants can view their past applications

wizehive

Thank you!

CALIFORNIA DEPARTMENT OF
FOOD AND AGRICULTURE

SWEEP TEAM

CAROLYN COOK

Senior Environmental Scientist, Supervisor

SCOTT WEEKS

Environmental Scientist

STEPH JAMIS

Environmental Scientist

WESLEY FRANKS

STAFF SERVICE ANALYST

HEALTHY SOILS PROGRAM (HSP)

Public Listening Session Summary

August 25, 2019

Purpose

- Public meeting held on August 23, 2019, 9am-12pm in Sacramento to hear from stakeholders and the public about perspectives on the program and ideas for future program outreach and engagement and maximizing potential of the Healthy Soils Program.
- Meeting covered several important topics, including feedback on developing partnerships, information sharing and engagement with socially disadvantaged farmers, conservation practices and ideas and strategies for maximizing participation and potential.
- Held one month before the listening sessions about the application and RFP, so that there would be dedicated time for “bigger picture” discussion on the program.

Attendees

Webinar: 122 attendees

In-person: 21 attendees (+/- approx. 10-15 people who didn’t sign in)

- Farmers: 17
- Ag Industry Reps: 36
- University and UCCE: 16
- Non-profit groups: 34
- Resource Conservation Districts: 13
- Government (state and local):27

Discussion Topics

- HSP Data/ Metrics
- HSP Practices: New Ideas
- HSP Program Strategic Planning
- Engagement with socially disadvantaged farmers, small scale, beginning and limited resource farmers

HSP practices: New Ideas

- Reducing orchard burning by incentivizing whole orchard chipping and/or incorporation or removal. Air quality mentioned several times as a big issue facing many farmers and communities
- Supporting farms to transition to organic (CAPSOT 138)
- Align HSP better with USDA- NRCS EQIP funding- improve outreach and demonstrate synergies between programs
- Incentivize IPM methods and recognizing or incorporating environmental co-benefits for air and water quality as well as pesticide reduction
- Incentives for longer term implementation projects

HSP Data/ Metrics

- Need for more data on how HSP helps mitigate economic risks for farmers
- Data on compost effect on yields will help encourage more farmers to subscribe to program
- Discussion about data collection- who collects it and who does it belong to?
- Data gathered through demonstration projects will help quantify the agronomic and economic benefits of the incentive practices and increase interest among farmers.
- Need for thinking about an overall metric and goals for data collection with the program

HSP Program Strategic Planning

- Important to understand or define the strategic goals of the program and define program metrics- how do HSP metrics fit into the bigger strategic picture of greenhouse gas reduction in California?
- CDFA should consider developing a framework for a strategy within with HSP fits: including metrics for increasing C sequestration, GGR, as well as other co-benefits; including water quality, biodiversity, air quality
- Think through data collection; how it is collected, how does it fit and how can it be conveyed to farmers and ranchers

HSP: Engagement with SDFR, small-scale, beginning and limited resource farmers

- Simplified application, in multiple languages
- Up front payment for practices for limited resource farmers, or payment on completion of each practice rather than at end
- Alternative to site visit to verify compliance (photographs)
- Regional cost payment scale
- Grant applications difficult and time intensive for farmers trying to run their businesses

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

HEALTHY SOILS PROGRAM

Andrew Whitaker, Ph.D.

Environmental Farming Act – Science Advisory Panel Meeting

October 17, 2019

San Luis Obispo, CA

CALIFORNIA CLIMATE INVESTMENTS

Cap and Trade Dollars at Work

Outline

- 2018 HSP Updates
- 2018 HSP Awarded Projects
- 2020 HSP Funding and Program Framework

2018 HSP Updates

- 2018-19 Funding:
  - Budget Act of 2018 - $10 Million through Proposition 68 (California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018).
  - Budget Act of 2018 (SB 856) - $5 Million through the Greenhouse Gas Reduction Fund (GGRF)

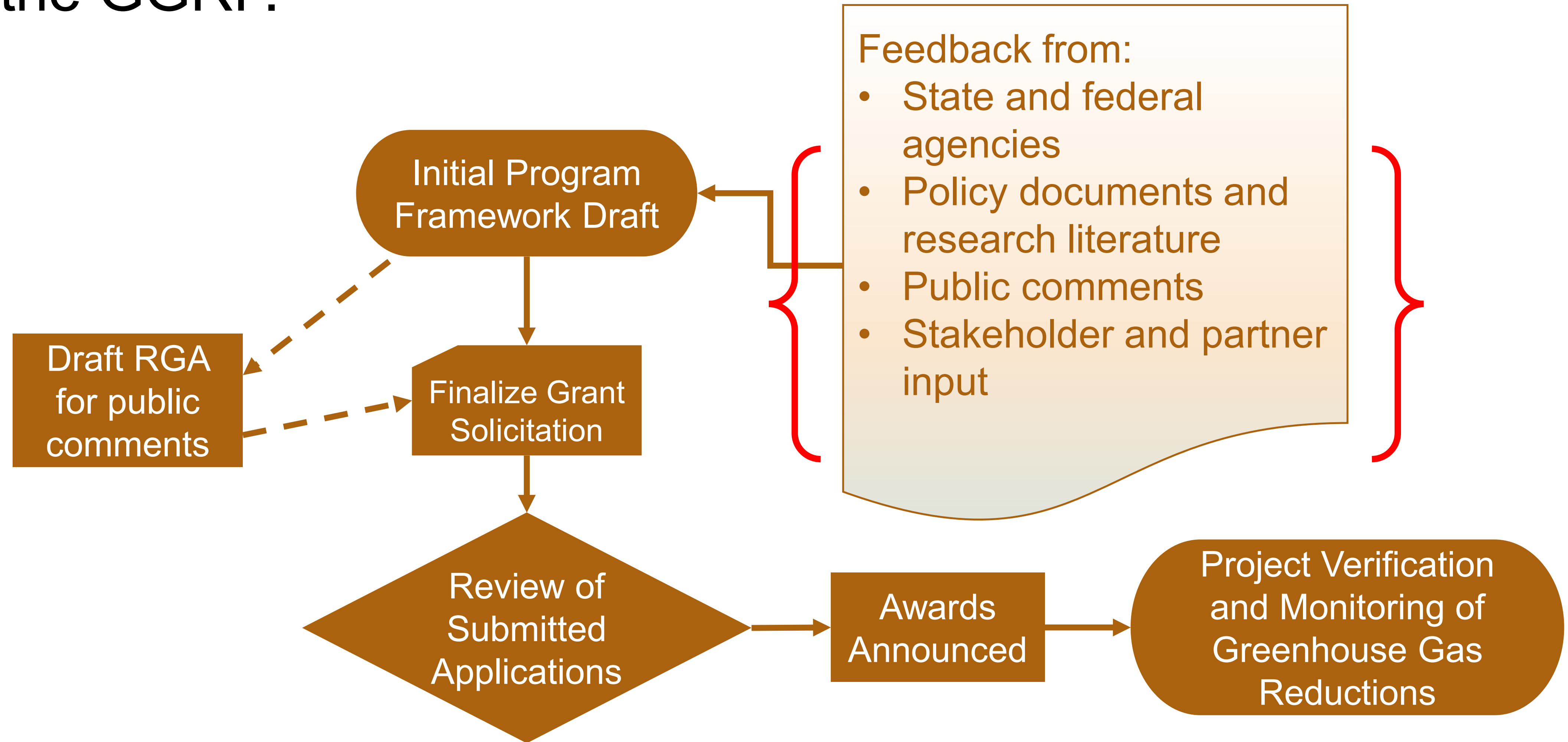
2018 HSP Awarded Projects Update

- Applications submitted:
  - HSP Incentives Program: 222 applications, $9.7 million requested.
  - HSP Demonstration Projects: 30 applications, $5 million requested.
    - 16 Type A projects, 14 Type B projects
- Projects Awarded*:
  - HSP Incentives Program: 188 projects totaling $8.7 million
    - Estimated GHG reduction 24,000 $MTCO_2e$/year across 27,700 acres
  - HSP Demonstration Projects: 21 projects totaling $3.6 million.
    - 11 Type A projects, 10 Type B projects
    - Estimated GHG reduction 980 $MTCO_2e$/year

*Subject to change pending final execution of grant agreements.

2019-20 HSP Funding and Program Process

- 2019-20 Funding: Budget Act of 2019 - $28 million through the GGRF.



Public and Stakeholder Listening Sessions

Orland

23 Sep 2019

Fresno

24 Sep 2019

Sacramento

25 Sep 2019

Major Comments Received

- Application process is cumbersome.
- Need local technical assistance providers for recipients.
- CDFA compost prices are too low due to high transport costs.
- Eligibility for previously funded APNs for same practice(s) on different fields.
- 120 attendees is too high for Demonstration Projects outreach.
- Application period is short.
- Need for Spanish language application materials.

Major Comments Received

- Suggestions for practices: mycorrhizae, vermiculture, one-time high rate of compost application, whole orchard recycling and reduction in pesticide use.
- Eligibility of urban farms.
- Block-grant process.
- Fund transition to organic farming.
- CDFA's plan for soil organic matter data from funded projects.
- Reimburse for true costs instead of standard payment rates.
- Details of various disadvantaged groups was confusing.

Public Comment Process

Public Comment Period
9/23/19 – 10/23/19

Please e-mail comments to:
cdfa.HSP_Tech@cdfa.ca.gov

2020 Program Timeline*

• Program framework public comment period	9/23/2019 – 10/23/2019
• Draft Request for Grant Applications (RGA) public comment period	Nov – Dec 2019
• Training of HSP Technical Assistance Providers	Jan 2020
• Release of RGA	Late Jan/Early Feb 2020
• Grant applications due	March 2020
• Review process	TBD, 2020
• Announce awards	TBD, 2020

* subject to change

CDFA HSP Team

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Amrith Gunasekara, Ph.D.

Science Advisor to CDFA Secretary

Manager, Office of Environmental Farming and Innovation

Amrith.Gunasekara@cdfa.ca.gov

AB2377 Climate Smart Agriculture Program Technical Assistance Grants

Update on 2019 Solicitation

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

Program Framework and Funds Available

- AB 2377 requires CDFA make available 5% of each appropriation for technical assistance, no more than $5 million
    - AMMP, along with Dairy Digester funding, received $34 million in the 2019-20 budget
    - The HSP received $28 million in the 2019-20 budget
- $120,000 maximum award
    - $60,000 maximum award per CSA program assisted
- Three year grant term
    - Assistance runs parallel with the 2019 funding appropriation to AMMP and HSP
    - Pre-award assistance (e.g., project design, application assistance)
    - Post-award assistance (e.g., implementation, invoicing, reporting)

2019 Solicitation

Activity	Tentative Dates
Application period begins	July 30, 2019
Applications due	August 30, 2019
Review of applications received	September 2019 – October 2019
Announcement of awards	November 2019*
Execution of grant agreements for awarded projects	December 2019 – January 2020*
CDFA-led training for technical assistance grant recipients	January 2020*

*Announcement of application periods for AMMP and HSP may vary and overlap through 2019-20. Exact dates are subject to change.

Application Process

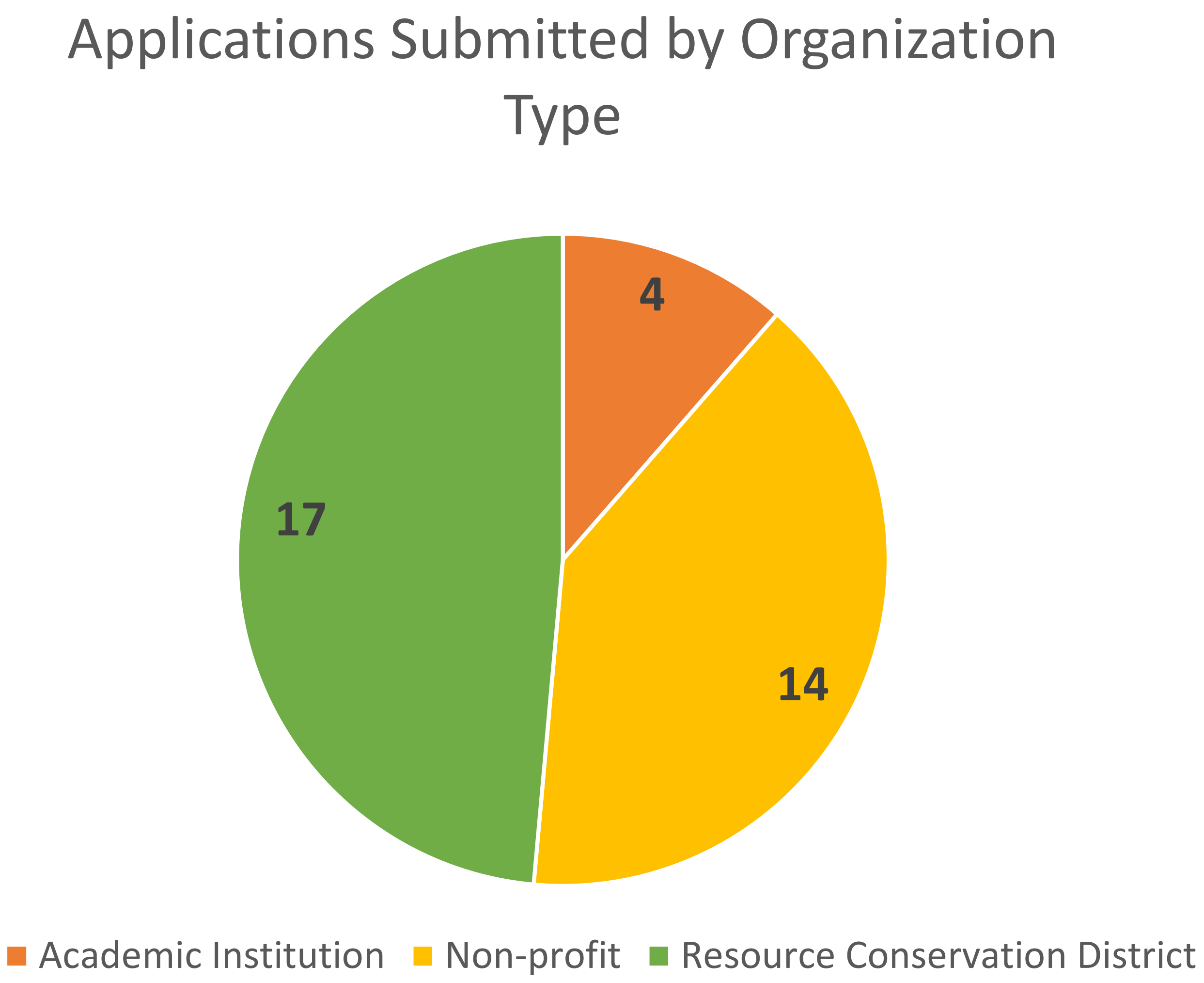
- Online submission portal
- Three application attachments
  - Workplan
  - Budget Workbook
  - Statement of Qualifications

Solicitation Response

CDFA received a total of 33 applications.

Eligible organizations are University of California Cooperative Extension, Non-profits, and Resource Conservation Districts

- 4 applicants are Academic Institutions (UC Cooperative Extension)
- 14 applicants are Non-profits
- 17 organizations are Resource Conservation Districts



Support for Climate Smart Agriculture Programs

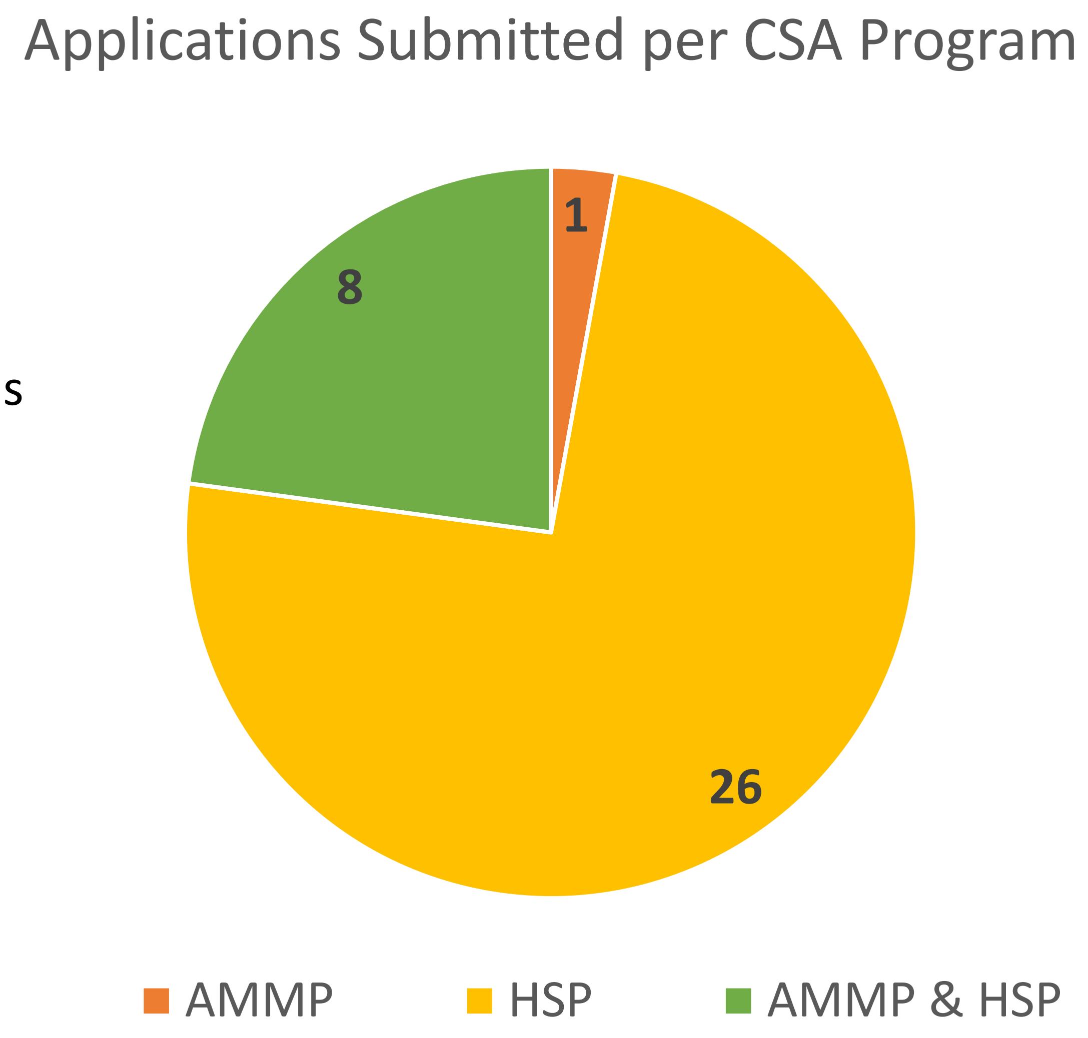
The Alternative Manure Management Program and the Healthy Soils Program received new appropriations of funding in the 2019 budget. CDFA accepted technical assistance applications to prepare for the 2019 AMMP and HSP programs.

- 1 applicant applied for funding for AMMP
- 8 applicants applied for funding for both AMMP and HSP
- 26 applicants applied for funding for HSP

<u>Funding Requested</u>

AMMP = $465,837.93

HSP = $1,877,550.46



Review Process

- Administrative review completed by OEFI staff
  - Two applications were disqualified
  - One was determined to be ineligible and requested greater than the maximum award
  - One requested greater than the maximum award
- Technical review is underway
  - Performed by staff at partner agencies
  - Projects will be scored from 1 - 100
- Funding recommendations will be based on the scores, ability to meet 25% target for Socially Disadvantaged Farmers and Ranchers and geographical coverage.
- Anticipate announcing awards early November 2019

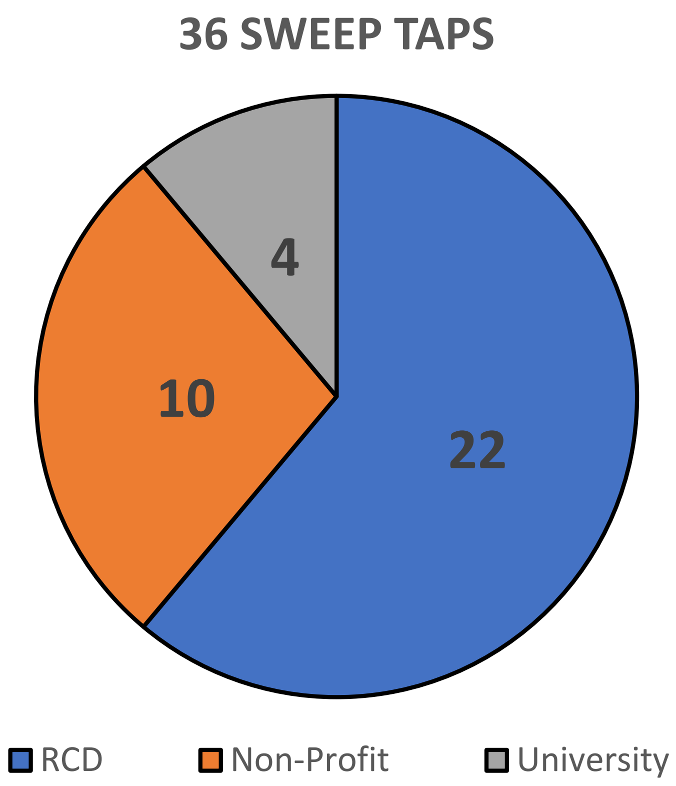
Analysis of Technical Assistance Efforts from 2018 Solicitations

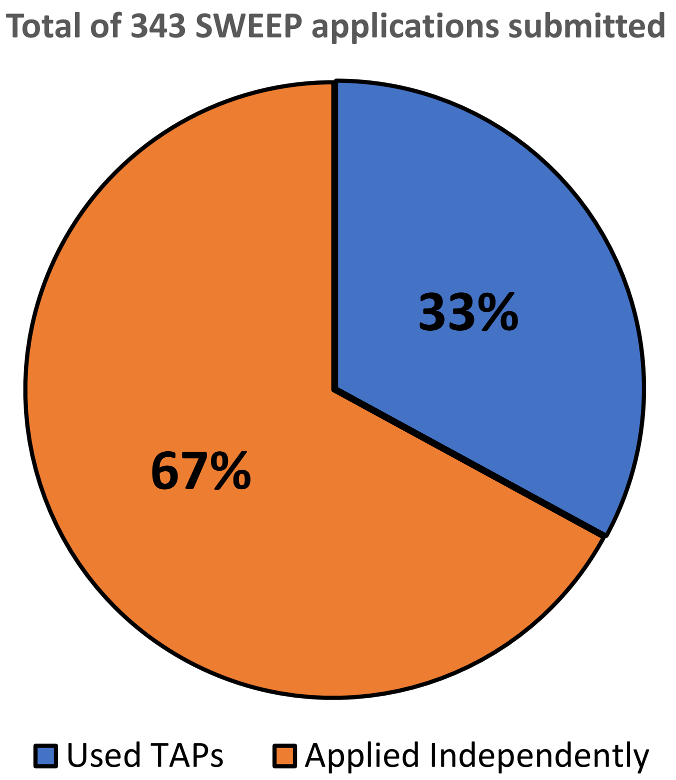
2018 Climate Smart Agriculture Technical Assistance Summary for AMMP, HSP and SWEEP

2018 Climate Smart Agriculture Technical Assistance

- Two solicitations for technical assistance applications in August and November 2018.
- Total of 55 agreements, most awardees provided assistance for more than one program
- Technical Assistance Providers Methods of Outreach:
    - Flyers
    - Workshops
    - Email/newsletter
    - Videos
    - Conference booths
    - Word-of-mouth

SWEEP Technical Assistance Summary

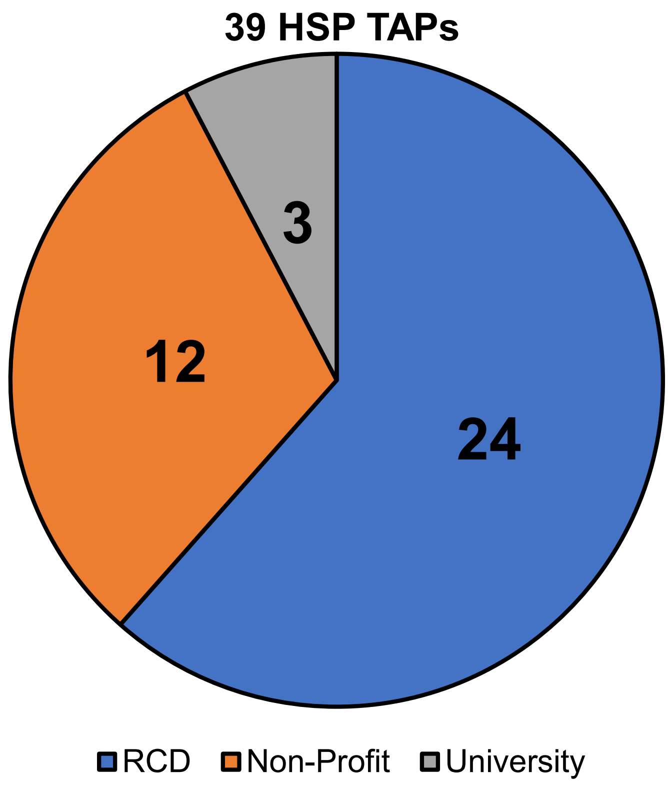


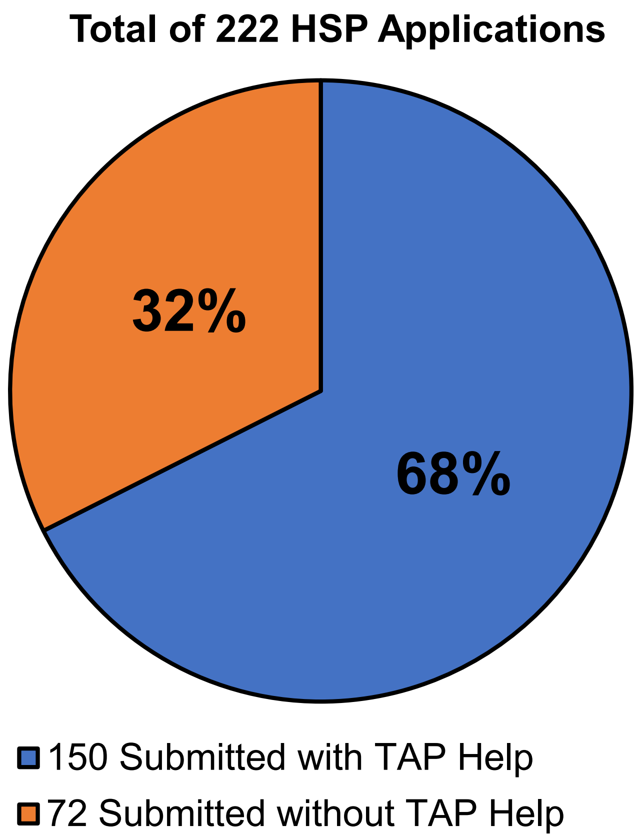


- ~$240,000 spent on TA
- 34 Workshops reported

- Total 389 individuals assisted
- 113 of the 343 applicants were assisted by TAPs
- 49 of the 114 assisted applicants were funded (43%)

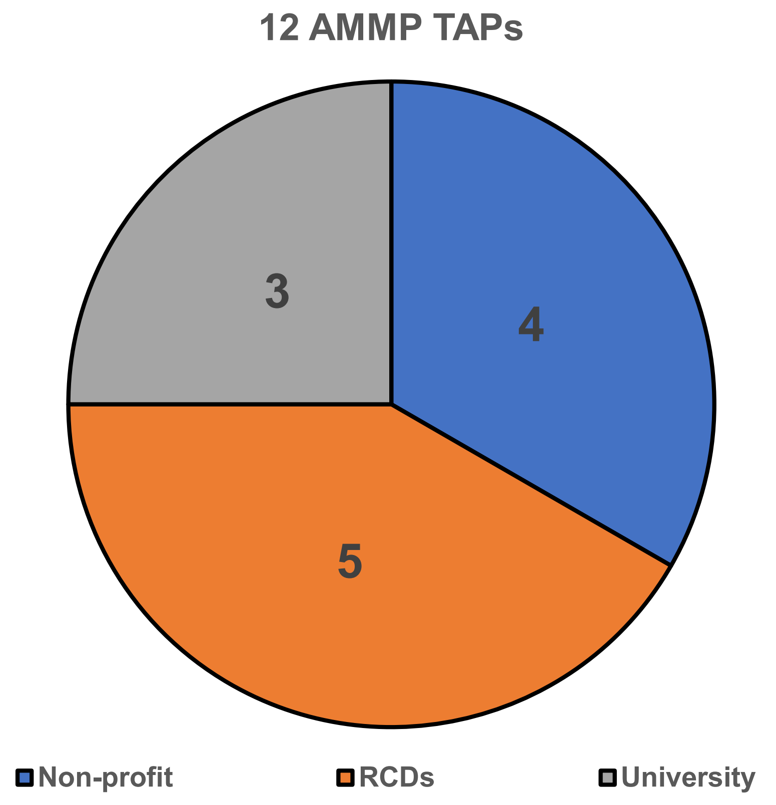
HSP Technical Assistance Summary

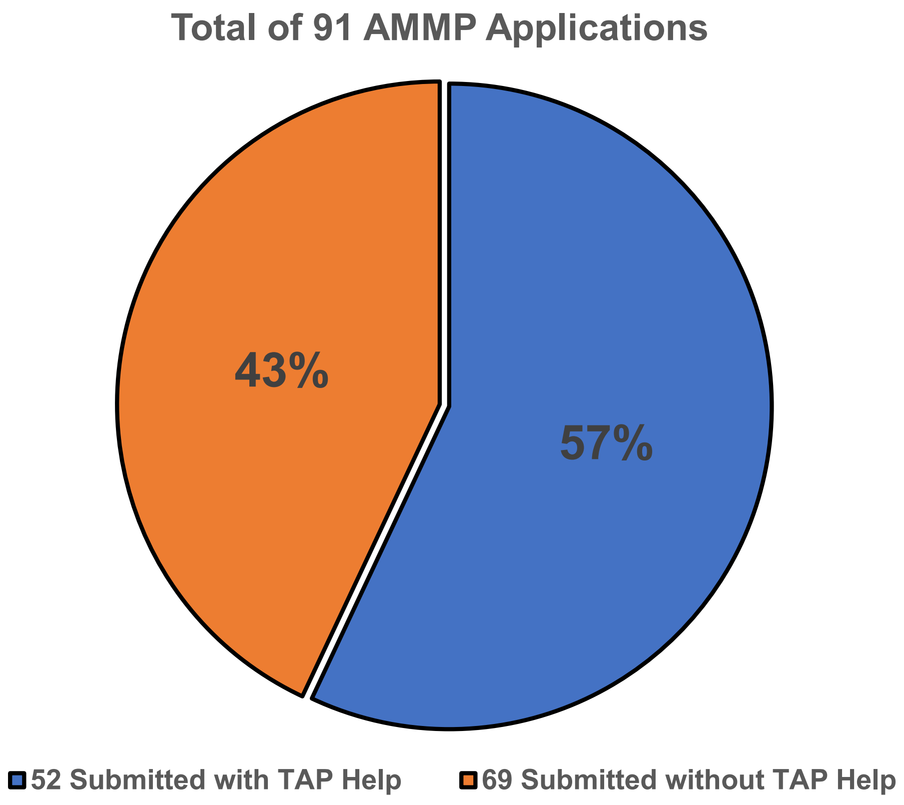




- ~$275,000 spent on TA
- 39 workshops with 643 attendees
- 136 of the 150 applicants assisted were funded (91%)

AMMP Technical Assistance Summary





- ~$104,000 spent on TA
- 14 workshops with 168 attendees

- 21 of the 52 applicants assisted were funded (40.4%)

Questions and Panel Discussion

Thank you!

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Whole Orchard Recycling (WOR): Inclusion of Practice in the CDFA Healthy Soils Incentive Program

Michael Wolff, Ph.D., CDFA
Benjamin Nicholson, P.E., M.B.A., CARB

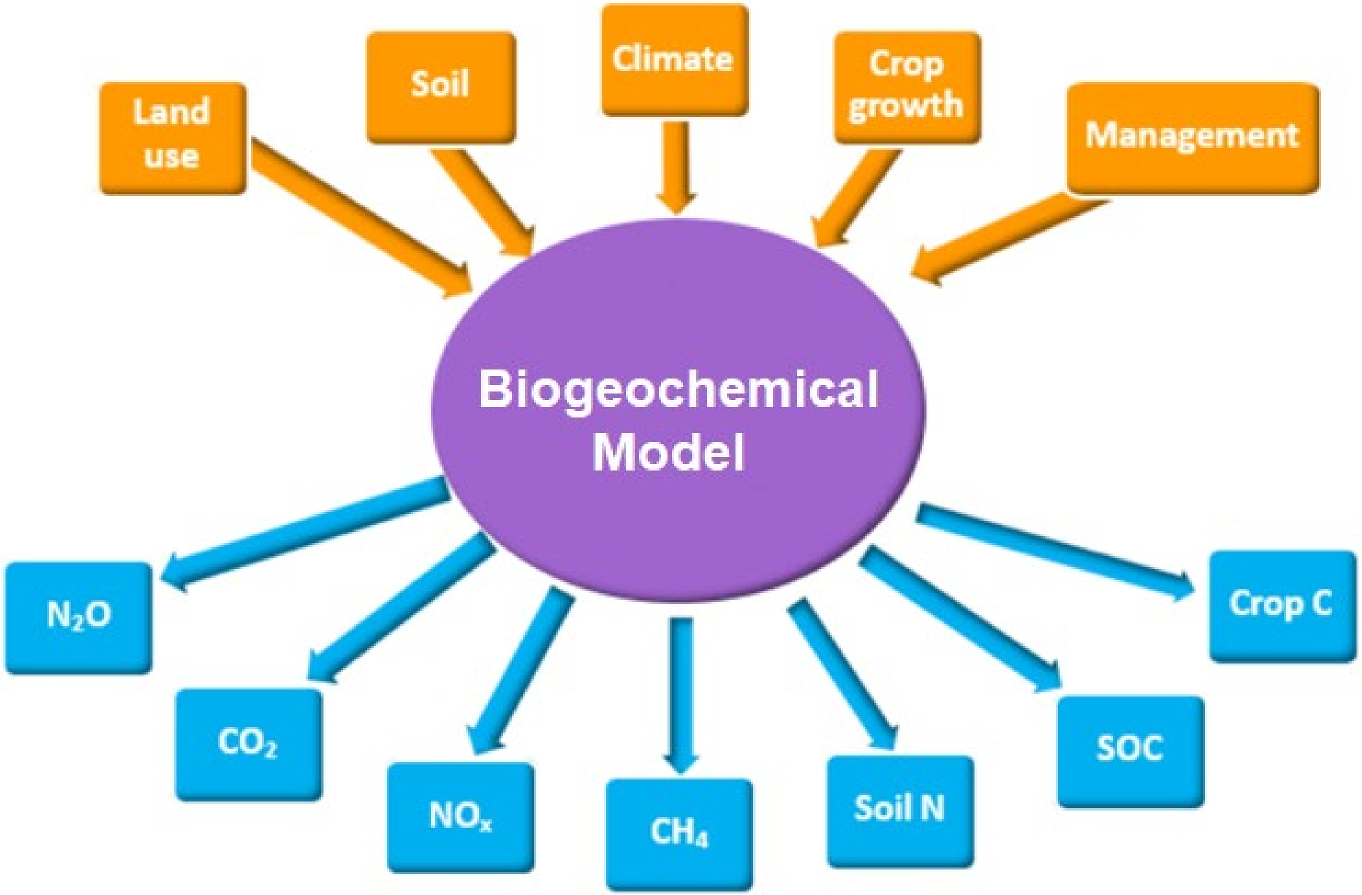
Environmental Farming Act Science Advisory Panel Meeting
October 17, 2019
San Luis Obispo, CA

Cap and Trade Dollars at Work

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Healthy Soils Quantification

- All Healthy Soils Practices have been quantified using biogeochemical models.



Healthy Soils Quantification

- All Healthy Soils Practices have been quantified using biogeochemical models.

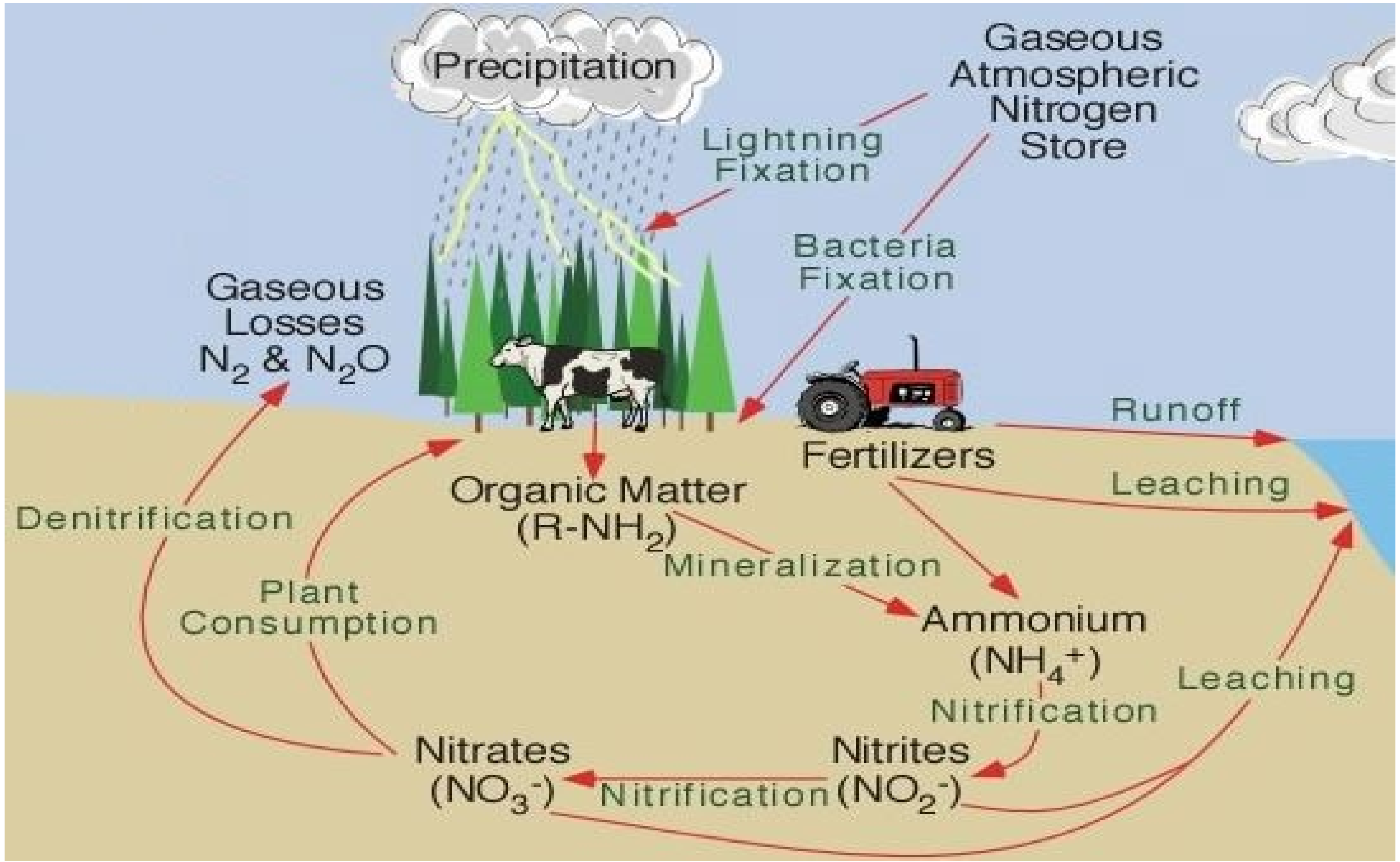
NRCS Conservation Practices are modeled in DayCent, and the results are available in *COMET-Planner*.

COMET Planner | USDA United States Department of Agriculture Natural Resources Conservation Service | Colorado State University | CALIFORNIA AIR RESOURCES BOARD | cdfa | Carbon and greenhouse gas evaluation for NRCS conservation practice planning

Recommended use of COMET-Planner CDFA HSP: This evaluation tool is designed to provide estimates of the net greenhouse gas reductions of specific conservation practices included in the CDFA Healthy Soils Program
Please note that a comprehensive assessment of site specific conditions may not be accounted with this tool.

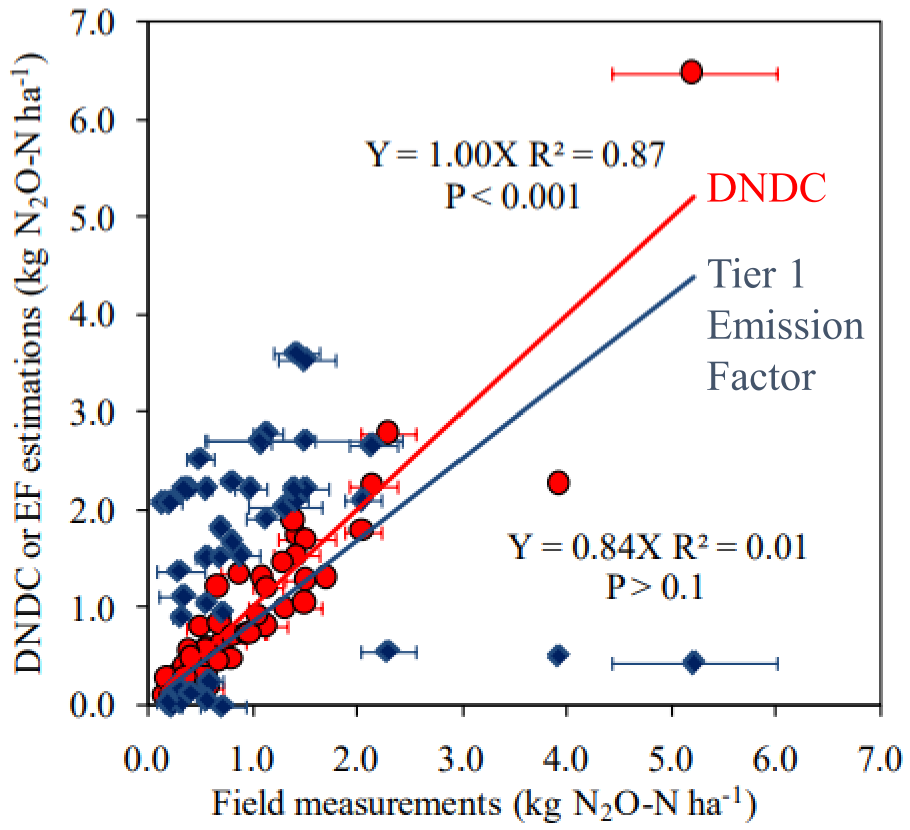
DNDC - Biogeochemical Modelling

De**N**itrification-
De**C**omposition Model calculates daily emissions of carbon- and nitrogen-based gases from changes in organic and mineral carbon and nitrogen.



CARB DNDC Research

- CARB has been evaluating DNDC since 2008.
- Focus on NO_x, N_2O
- Quantification tool in Rice Protocol
- Used to determine small agricultural contribution to NO_x in SJ Valley



Whole Orchard Recycling (WOR)

- Entire orchard is chipped to 2” chips, normally
- Chips are incorporated into soil to at least 6”.
- Pioneered in California, thanks to UC Cooperative Extension.
- Machinery and services have evolved greatly in recent years.

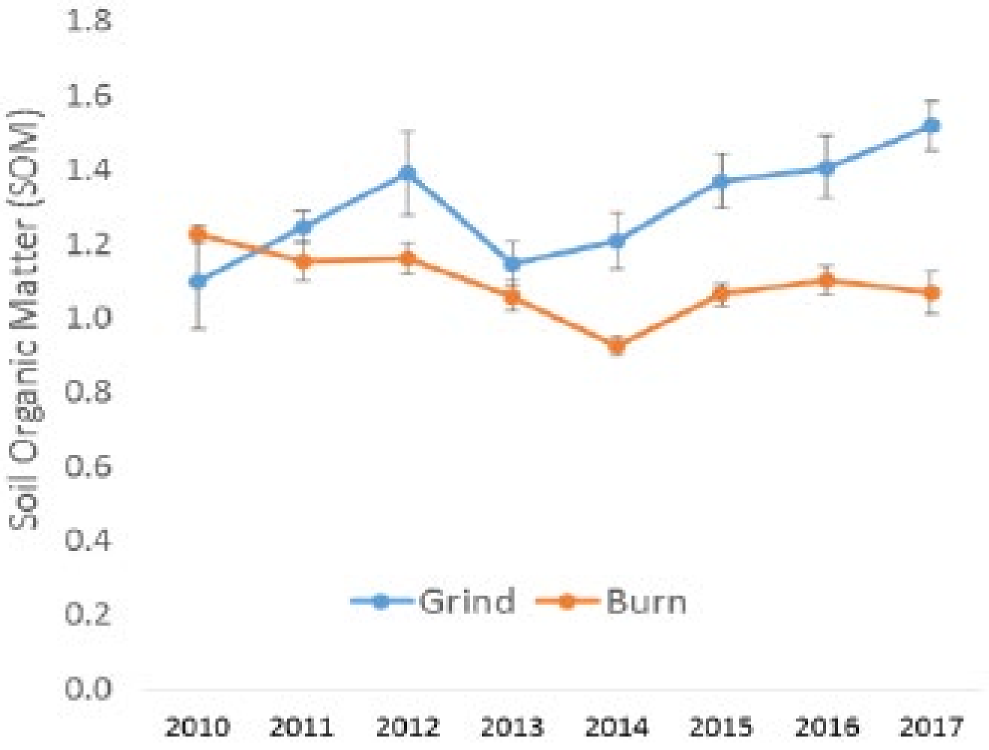
Photo Credits: Brent Holtz, UCCE
WOR area statistic: Holtz, 2018

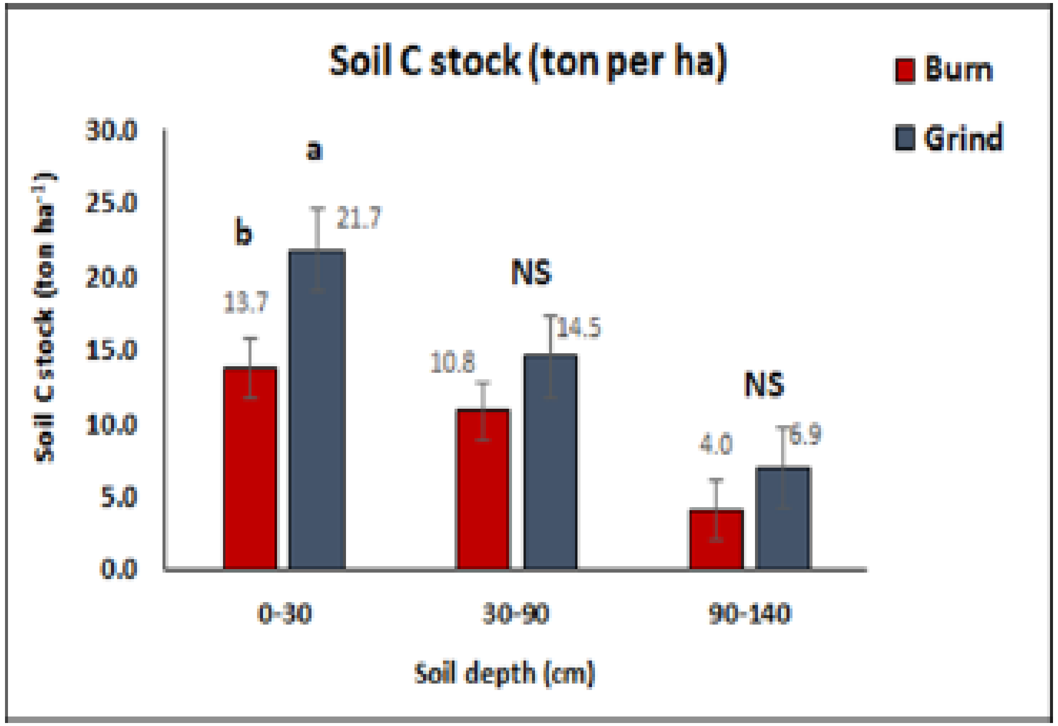
Soil Organic Carbon (SOC) increases with Whole Orchard Recycling (WOR)

Gradual breakdown of wood chips supplies organic matter to fungal and then bacterial populations.

- Improved tree root exploration leaves more dead roots and exudates, through improved structure, fungal networks, water retention and aeration.
- Both mulching and WOR affect deep soil profiles; so *dissolved* organic carbon (DOC) is an important product.
- Likely lowered leaching, together with retention of former orchard's micronutrients means improved fertility.

SOC Results from Kearney ARE Center





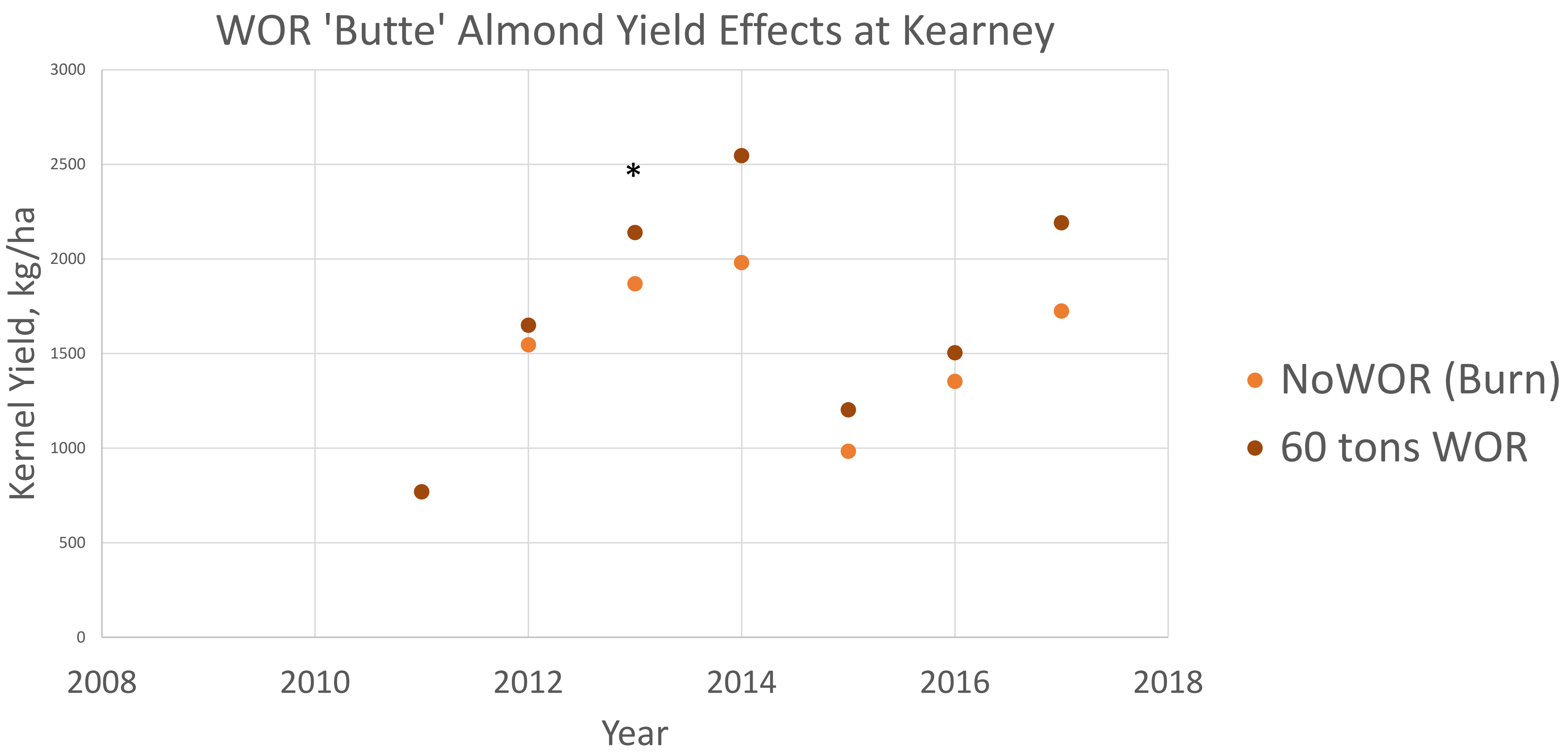
Sampling in upper 6 inches of the soil over Years 3-10

- Annual SOC was affected by root growth and climate
- But tendencies of annual results were confirmed during Year 10, *to right*
- By that time, WOR had apparently affected most of the root zone, down to at least 4 ½ feet.
- Results were significant in the upper foot of soil, where wood chips had been incorporated.
- Suggested over 4 tons of SOC sequestration per acre

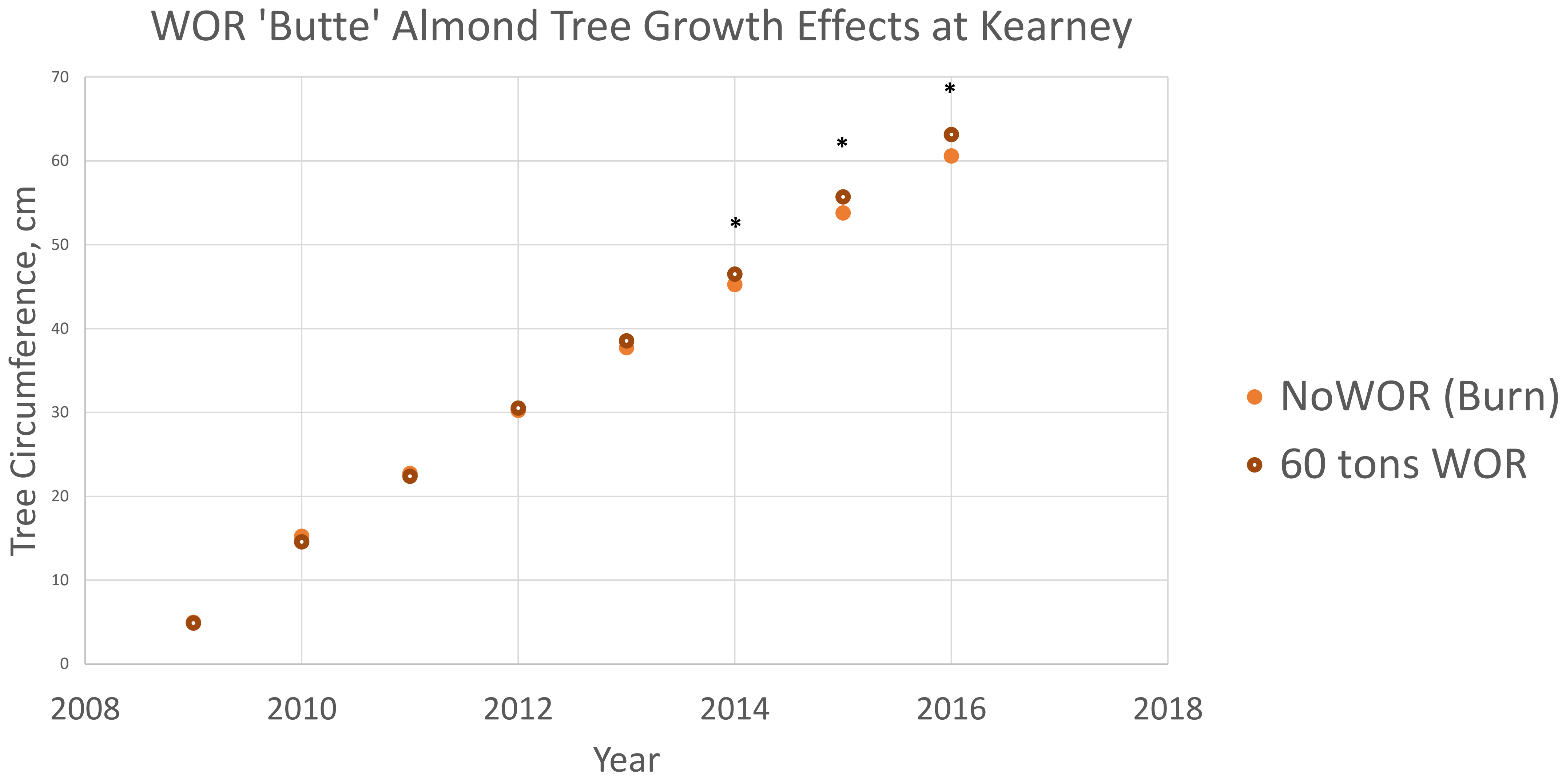
Holtz et al., 2018

Jahanzad, 2019

Yield and Growth Results, Kearney ARE



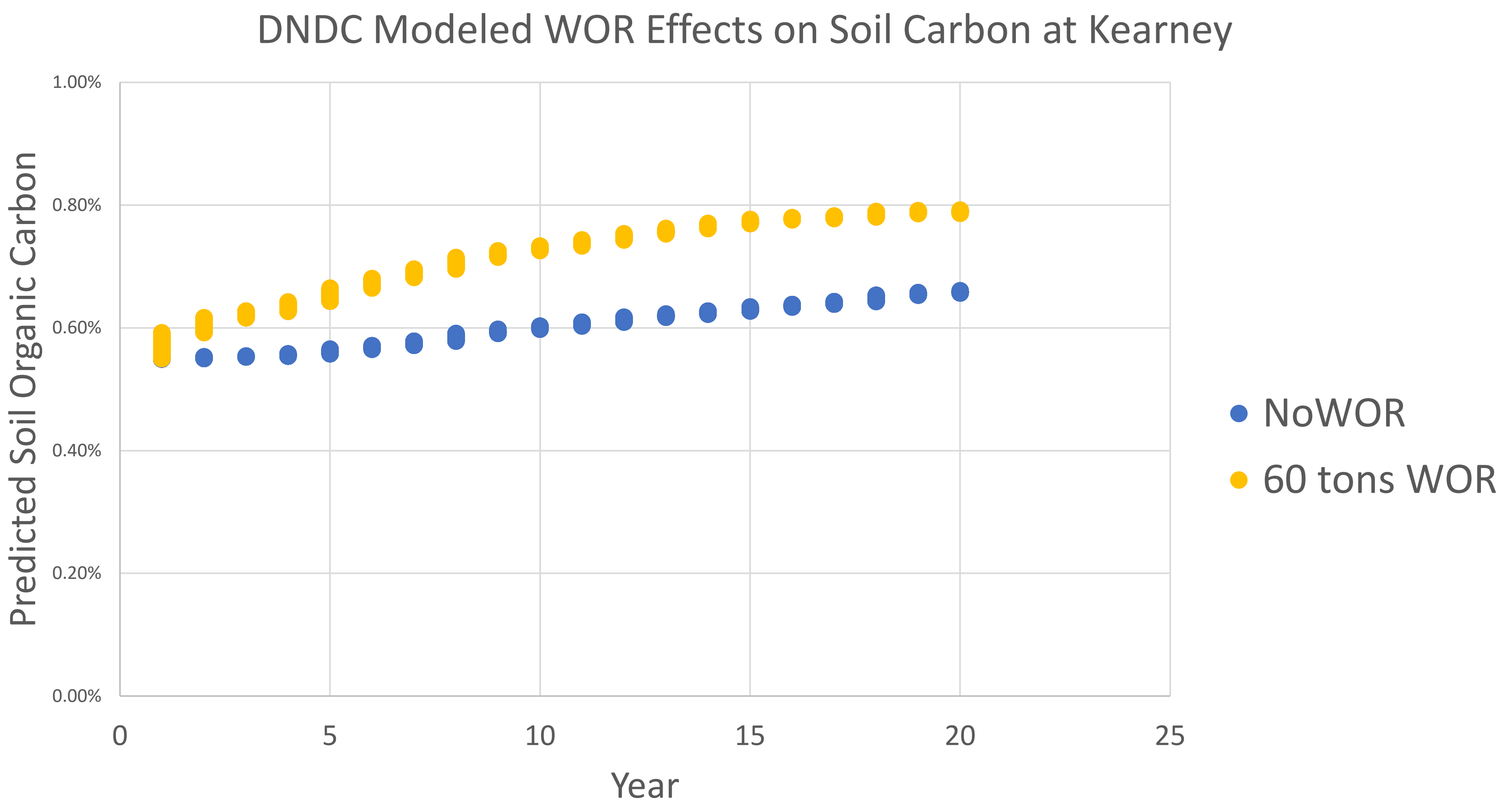
Yield and Growth Results, Kearney ARE



DNDC preparation for Validation and Projections

1. “Site” mode for DNDC, as tested in Kearney, was chosen to allow precise simulations of particular crops (here, almond).
2. Crop parameters: Average California almond growth parameters from literature; other *Prunus* and nut species should respond similarly. (All parameters and sources are tabulated in white paper.)
3. Irrigation parameters: supply UCCE-defined crop water demand using 1-inch applications, following nearest CIMIS station reports for last 10 years, repeated to reflect the next 10 years.
4. Soil parameters: from Jahanzad *et al.* (MS submitted 2019) and Holtz *et al.* (2018) for Kearney, and from ARB for Counties.

Validation of DNDC with Kearney ARE data



Validation of DNDC with Kearney ARE data

1) Yields modeled very close to ‘Butte’ cultivar’s average (1917 vs. 1930), although the real field suffered water stress in certain years; so model was *conservative*.

2) % SOC increase modeled was also *conservative* for Year 10:
   -> model: 0.13% (0.79%-0.66%) to 50 cm.
   -> field: 0.18% (0.79%-0.55%) to 15 cm (Jahanzad et al., 2019)
   -> field: 0.30% (approx. 0.82%-0.52%) to 30 cm (Jahanzad, 2019)

3) Total SOC gains modeled also *conservative* because DNDC models the upper 50 cm of soil, not the entire tree root depth:
   -> model: 4.98 metric tons per ha down to 50 cm
   -> field: 8+ tons per ha down to 140 cm (Jahanzad, 2019)

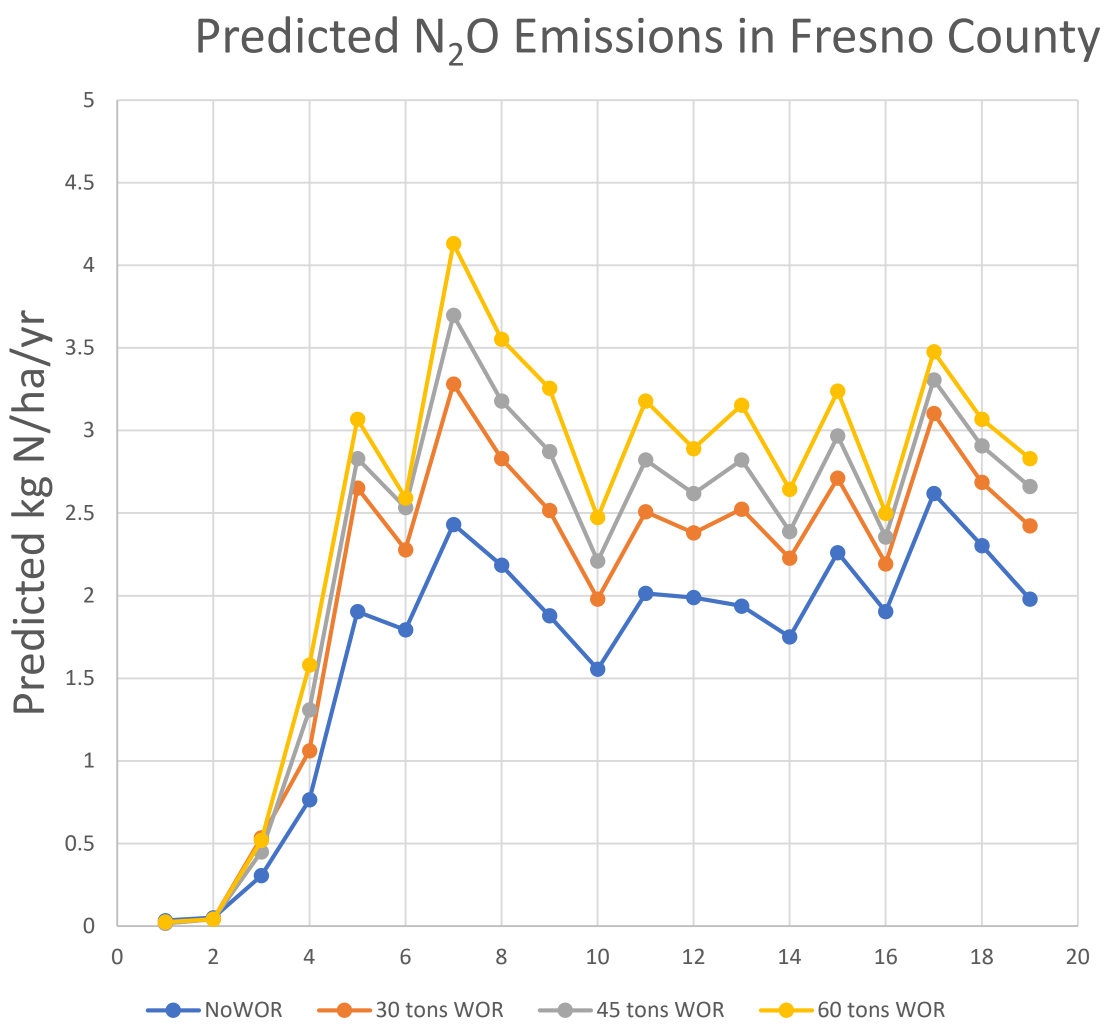
GHG Totals and Emission Factors

- Methane (CH_4) is negligible in the model and in field studies.
- Therefore soil GHG balance was tabulated as CO_2 and N_2O.
- Even if N_2O increases by the highest margin, seen in DNDC's Butte County simulations, the cumulative emissions increase would ultimately be less than the predicted CO_2 sequestration.
- Since DNDC's SOC appears to be conservative and N_2O appears to be overestimated, there is very little chance that N_2O could outweigh sequestered CO_2.

County /WOR (mt-C/ha)	humads-C & humus-C (mt/ha)	WOR benefit as C (mt/ha)	C-seq factor	benefit as CO_2 (mt/ha)	N_2O emissions (mt CO_2-eq/ha)
Butte 0	64.31				
Butte 30	66.63	2.32	7.70%	8.51	5.09
Butte 45	67.78	3.47	7.70%	12.72	7.74
Butte 60	68.89	4.58	7.60%	16.81	11.36
Fresno 0	27.35				
Fresno 30	30.36	3.01	10.00%	11.03	4.81
Fresno 45	31.83	4.48	10.00%	16.42	7.16
Fresno 60	33.19	5.84	9.70%	21.41	9.59
Kern 0	21.79				
Kern 30	24.45	2.65	8.80%	9.73	1.20
Kern 45	25.77	3.97	8.80%	14.56	1.75
Kern 60	27.09	5.30	8.80%	19.44	2.36

Nitrous Oxide (N_2O)

- *Measured* N_2O emissions, from many studies, are lower than those *predicted* for middle and northern Central Valley soils by DNDC.
- N_2O emissions in DNDC, and in reality, are highly sensitive to depth of applied N in the soil; we defined a 15-cm depth based on studied fertigation distributions.
- DNDC predicts higher N_2O emissions with higher WOR because of higher C in the soil: *but* increased uptake by more active microbial biome might negate that effect.
- Two N_2O studies of WOR are currently under way, one as a Healthy Soils Demonstration Project.



Co-Benefits

- In Kearney, almond trees were planted directly in old peach rows, and showed no Prunus Replant Disease.
- *Ganoderma* (fungal) transmission was not aggravated.
- Reduces *Phytophthora,* probably through release of cellulase.
- Promotes free-living nematodes, not parasitic populations.
- Increases water retention.
- Increases micronutrients available in soil over long term.
- Counters acidification (vs. concentrated, poorly distributed burns).
- Alleviation of salinity has been seen with similar practices.

Proposed Practice Requirements

Based on analyzed data, modeling parameters and current field practices:

1. WOR is only to be implemented with new (replanting) tree crops.
2. Mature orchards should be chipped in place without exporting chips off-site or to new fields (for verification and DNDC modelled conditions).
3. WOR practice shall not be implemented in soils with Soil Organic Matter greater than 20% (DNDC modelled conditions).
4. WOR can be repeated no more than once every ten years for an APN or field (DNDC modelled conditions).
5. Chips must be evenly distributed throughout the orchard. When a service provider is contracted, their commitment to distribute the wood chips must be in the contract/invoice for verification purposes .
6. Chips must be incorporated into the soil to at least 6 inches depth (DNDC modelled conditions).

Next Steps: Updates to Healthy Soils Program and CARB Quantification Methodology (QM)

I. CARB: The CARB California Climate Investments Quantification Methodology for the Healthy Soils Program will be updated to include Whole Orchard Recycling and will be made available for public comment. https://www.cdfa.ca.gov/oefi/efasap/meetings_presentations.html

II. CDFA: Accepting public comments on presented information and report until 11/8/2019 (three week public comment period). Email comments to cdfa.oefi@cdfa.ca.gov

Whole Orchard Recycling (WOR)

Inclusion in the CDFA Healthy Soils Incentive Program

Michael Wolff, PhD
California Department of Food and Agriculture
Lei Guo, PhD
California Air Resources Board

Prepared in coordination with Amrith (Ami) Gunasekara, PhD
Liaison to the Environmental Farming Act Science Advisory Panel
California Department of Food and Agriculture, Sacramento

A report for the Environmental Farming Act Science Advisory Panel
Draft (Version 1.0 – 10/7/2019)

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CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade Dollars at Work

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Executive Summary

Whole Orchard Recycling (WOR) is an emerging practice by which orchards are chipped and incorporated back into the soil. As an alternative to burning, it builds soil organic carbon and microbial biomass, which improves soil health, nutrient levels, structure, and water retention. It has also been shown to boost tree growth and almond yields over the long term. Despite some initial fears among growers, WOR has not been shown to transmit Prunus Replant disease, *Ganoderma* fungi or parasitic nematodes from one orchard to the next. The Denitrification-Decomposition Model (DNDC) has been validated for the yield and surface-layer soil carbon records kept over 9 years at a WOR trial at the Kearney Station of the UC Cooperative Extension (UCCE). The model gives conservative predictions extending up to 5.84 tons of soil carbon sequestration per hectare, while sequestration in Kearney was estimated at 8 tons by field data, assessing deeper soil profiles than DNDC can model. WOR's effects on nitrous oxide effects are uncertain but are being studied by a Healthy Soils Demonstration Project, and in any case are very unlikely to outweigh the carbon sequestration benefits of the practice.

Introduction

This report provides information on an agronomic management practice not currently included in the Healthy Soils Incentives Program. The report defines the management practice, provides a literature review of the scientific information currently available on the management practice, models the practice for greenhouse gas reductions and makes a case for the inclusion of the management practice into the Healthy Soils Incentive Program. All current Healthy Soils Incentive Program management practices have been modeled for greenhouse gas reductions. As new scientific field study information becomes available, either through the scientific community, through results obtained in the Healthy Soils Demonstration Program and federally funded initiatives (USDA NRCS), that new information will be used to further calibrate the models used, to more accurately quantify the greenhouse gas and carbon sequestration benefits of the Healthy Soils Incentive Program management practices. Vineyard and orchard chipping is currently covered in California by the USDA NRCS Standard Practices for Woody Residue Management, but these do not include economic costs of incorporation of the wood chips into the soil and do not have a greenhouse gas emission factor under Comet-Planner.

Definition

Whole Orchard Recycling (WOR) is an emerging practice which consists of the chipping of woody perennial crops (only fruit and nut trees are considered in this report) at the end of their agronomic life cycle. The chips are then incorporated into the soil of the fields that were removed from, which continues agronomic production under minimum-tilled perennial crops.

Problem Statement

The closure of about half of the Central Valley's former biomass co-generation plants, along with increased acreage of woody perennial crops and the arrival of more wood chips from forest thinning efforts, has led more growers to either pile burn removed orchards in the field, or simply stack them for unknown types of disposal. Burning in the field is subject to certain county restrictions and has direct adverse effects on human health, particulate matter, atmospheric black carbon and emits some greenhouse gases.

Burning also releases nitrogen, sulfur, and phosphorus from woody biomass to the air instead of returning them to the local soil. The remaining, largely alkaline nutrients in the ashes (Ca, K, Mg) usually remain undistributed back to the field from which they came, promoting acidification of the original soil as well as lost fertility.

Furthermore, carbon is emitted in burning which could otherwise serve to boost organic matter in soils. Increasing organic matter would improve fertility, nutrient retention, soil structure, water retention, microbial biomass, and soil health in general, as well as likely bringing about long-term carbon sequestration in many Central Valley soils. These undesirable outcomes from the loss of woody material on farms can be addressed with WOR.

WOR is expected to reduce nitrate leaching from subsequent fertility management. There are also preliminary indications that WOR, instead of transmitting pathogens and vectors, ameliorates prunus replant disease and other root diseases, by causing a deep shift in the soil microbiome, and particularly in nematode populations (i.e., free-living vs. parasitic). It may also act as an alternative to fumigation for suppression of certain dieses.

Existing Field Data

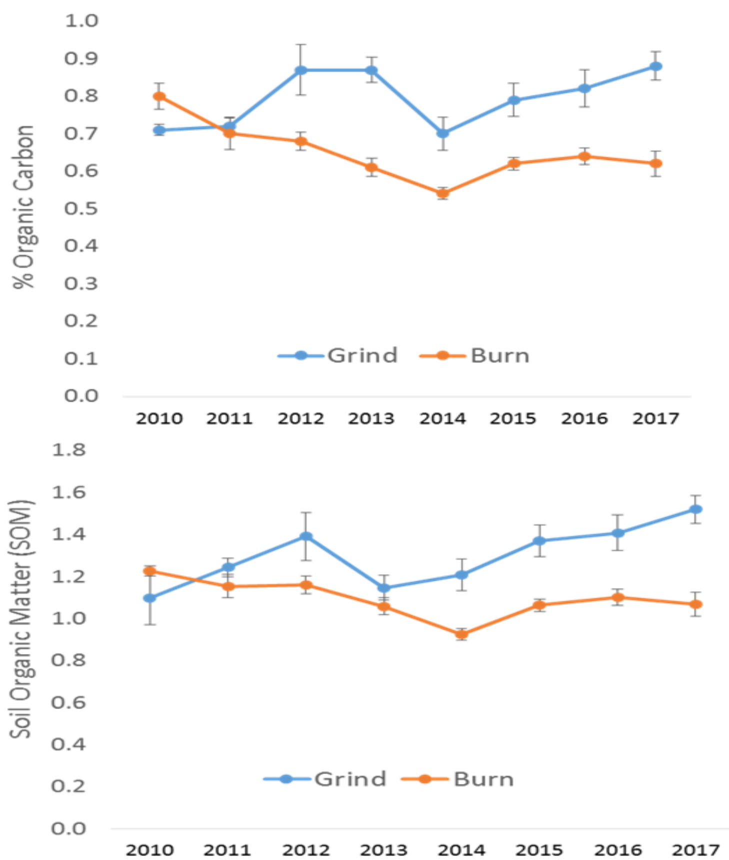
Whole Orchard Recycling as a treatment for entire orchards has been researched primarily by Brent Holtz of the UC Cooperative Extension Services, with various colleagues over the last 20 years (first publication in 2004). Their investigations have found that WOR improved soil health (microbial biomass and various enzyme activities increased, staying proportional with SOC levels), hydraulic properties (water infiltration and soil water retention), soil structure (wet aggregate stability and bulk density) (Jahanzad et al., 2019)(submitted MS), and availability of micronutrients (Holtz et al., 2017). In one study's fourth year, WOR soils contained more nitrate, calcium, manganese, iron, magnesium and boron than non-WOR soils, and even three years later, trees on plots treated with WOR still had higher leaf N content than non-WOR plots.

Additionally, eight other WOR experiments, including one Healthy Soils Demonstration Project, have recently been installed at various locations in the Central Valley. However, given the long-term nature of WOR effects, data on soil carbon, soil health, and yield will not be available for many years to come. The Healthy Soils Demonstration Project will quantify nitrous oxide emissions under WOR, an important knowledge gap which can be described over a two-year timeframe.

Currently available field trial scientific data for WOR includes a 9-year study at the Kearney UC Cooperative Extension station in Parlier. The climate, soil, cropping system, wood characteristics, and management of the experiment were typical of almond orchards in the southern Central Valley, where their production is most concentrated, and extensive data on the effects is published (esp. in Holtz el al., 2017). In this research trial 30 tons of dry wood chips were applied per acre, incorporated into a sandy loam, before establishment of a new almond orchard. Since the chips were only applied to half of the surface (planting rows), where soil tests were subsequently carried out, the trial served as an effective test for 60-ton applications, which is the likely minimum weight of chips from a mature almond orchard. In the control treatment the same quantity of wood chips was burned and redistributed following the same spatial pattern. Despite being planted in the same rows as the former orchard, there was no prunus replant disease or significant pathogenic issues in either treatment.

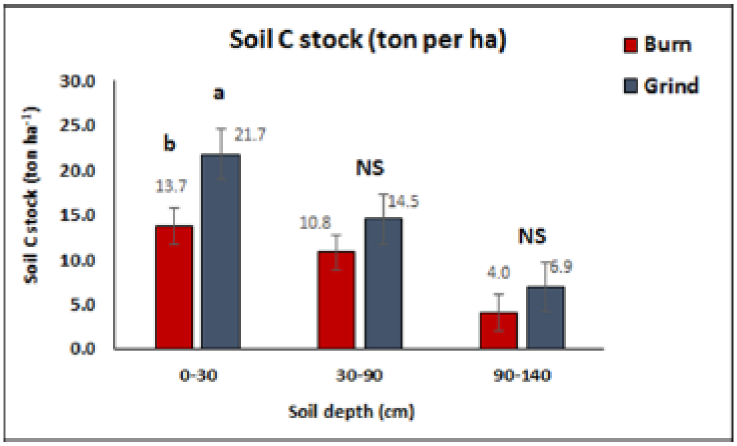
Growth was somewhat slower under WOR in the first 2-3 years, but then rebounded such that the WOR trees consistently grew and yielded more than in the Burn treatment. Soil organic carbon (SOC) was measured annually in the surface soil to about 6 inches, after sieving for any wood chips. The SOC fluctuated significantly, generally with wet years and dry years. The overall trends, however, show an increase of SOC in WOR. The graphic below was published by Holtz et al. (2017):

Figure 1: % Organic Carbon and % Soil Organic Matter over time under WOR (Grind) and Burn.



A more comprehensive analysis was carried out in summer of 2017, after 9 years of WOR (Jahanzad et al., 2019). The soils were analyzed for soil carbon at three layers (0-30, 30-90 and 90-140 cm). The results showed increases in SOC in the WOR treatment, at a point in time when virtually all of the mass in the original wood chips would have decomposed. Furthermore, the gains were significant down to 30 cm, and similar proportional differences in SOC were strongly suggested by data from the lower layers. The surface layer results ratified the overall tendency and recent values in the annual 6-inch soil sampling. It was estimated that the WOR treatment soils contain about 8 tons/ha of SOC more than Burn treatment soils. Public presentation has been made of the following data (Jahanzad et al., 2019):

Figure 2. Soil Carbon Stock of "Burn" and "Grind," nine years after WOR.



WOR does not bring about carbon sequestration by simply depositing woody material that remains intact in the soil. Instead, WOR promotes the gradual migration of wood chip organic matter into an increased microbial biomass, from there creating more resistant soil organic matter; it likely also increases tree root exploration and organic exudates; and it apparently increases microbial biomass connected with fungal populations, soil structure, and improved water retention (Jahanzad et al., 2019).

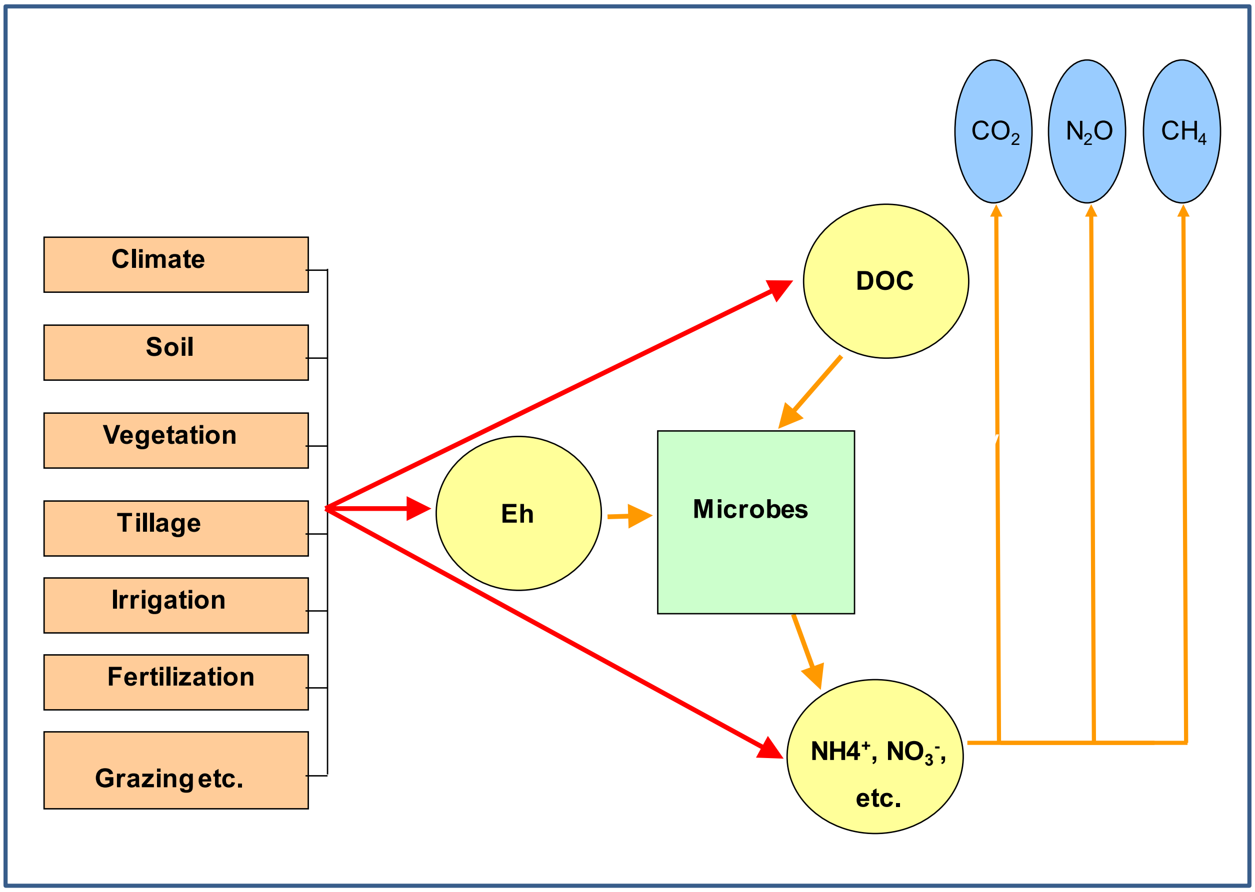
Model Validation

The CDFA's Office of Environmental Farming and Innovation, working in tandem with the California Air Resources Board (CARB), have validated the performance of the DNDC soil nutrient cycling model using the results from the Kearney WOR trial.

The Denitrification-Decomposition model (Li et al., 1992; Li, 2000) is a process-based computer simulation model of carbon (C) and nitrogen (N) biogeochemistry and was developed for quantifying carbon sequestration and emissions of greenhouse gases in agroecosystems. The core of DNDC modeling consists of microbe-mediated biochemical processes commonly occurring in terrestrial soils. The processes simulated include decomposition, nitrification, denitrification, fermentation, and methanogenesis. A full description of the DNDC scientific basis and processes, including all equations involved, is available at http://www.dndc.sr.unh.edu/. DNDC simulates rates of the processes by tracking activities of different groups of microbes which are activated under various environmental conditions in response to temperature, moisture, pH, redox potential (E_h) and substrate concentration gradient in soil. Nitrification-induced N_2O production is modeled as first order of soil ammonium (NH_4^+) concentration under aerobic conditions. Denitrification induced N_2O production is initiated once soil is saturated, which is assumed to lead to anaerobic conditions. Soil E_h is calculated with the Nernst equation at a daily time step following soil saturation and used to determine anaerobic microbial group activities under the given soil conditions. The anaerobic microbial group activity is then modeled using standard Michaelis-Menten-type kinetics.

The hypotheses backing the DNDC simulations of soil GHG emissions include: a) CO_2, N_2O and CH_4 are products of oxidation-reduction reactions through electron exchange between electron donors and acceptors that is mediated by microbes; b) the occurrence of the electron exchange is determined by the soil E_h that is described by the Nernst Equation, a thermodynamic equation calculating E_h based on the concentrations of paired oxidative and reductive forms of dominant oxidants in the soil; c) when the suitable E_h is established, the functional groups of bacteria will grow to their full capacity within a short timeframe (hours or days) due to rapid regeneration; and d) when the microbial capacity is established, the reaction rate will be primarily controlled by the concentrations of the relevant substrates based on the Michaelis-Menten Equation. DNDC currently tracks microbial activities primarily based on three drivers, i.e., E_h, dissolved organic carbon (DOC) as electron donor and oxidants as electron acceptors. Nitrification-induced N_2O production is integrated into DNDC with ammonium (NH_4^+) and ammonia (NH_3) levels under aerobic conditions as a major driver. Figure 3 provides a functional overview of DNDC and how climate, soil, vegetation and management practices influence E_h, DOC, substrate concentrations and GHG emissions.

Figure 3. DNDC functional overview



In DNDC, soil organic carbon (SOC) resides in four major pools: plant residue (i.e., litter), microbial biomass, humads (i.e., active humus), and passive humus. Each pool consists of two or three sub-pools with specific decomposition rates. Daily decomposition rate for each sub-pool is regulated by the pool size, the specific decomposition rate, soil clay content, N availability, soil temperature, and soil moisture. When SOC in a pool decomposes, the decomposed carbon is partially lost as CO_2 with the rest allocated into other SOC pools. DOC is produced as an intermediate during decomposition and can be immediately consumed by soil microbes. During the processes of SOC decomposition, the decomposed organic nitrogen partially transfers to the next organic matter pool and is partially mineralized to NH_4^+. The free NH_4^+ concentration is in equilibrium with both the clay-adsorbed NH_4^+ and the dissolved NH_3. Volatilization of NH_3 to the atmosphere is controlled by NH_3 concentration in the soil's liquid phase and subject to soil environmental factors (e.g., temperature, moisture, and pH). When rainfall or irrigation occurs, NO_3^- leaches into deeper layers with the soil drainage flow. A simple kinetic scheme known as the "anaerobic balloon" predicts the soil aeration status by calculating oxygen or other oxidants' content in the soil profile. Based on the predicted redox potential, the soil, discretized into 2-cm layers, is divided into aerobic and anaerobic pockets where nitrification and denitrification occur, respectively. The nitric oxide (NO) and N_2O gases produced in either nitrification or denitrification are subject to further transformation during their diffusion through the soil matrix.

For validation, the DNDC model tested the soil and climate conditions used in the Kearney experiments (Holtz, 2018), together with the parameters listed below. Following validation, the same parameters were applied to local climate and soil data for three counties in the Central Valley. All simulations tested sprinkler-distributed water applications using the UCCE crop coefficient values for almond (Kc) and a corresponding nitrogen application regime to supply potential crop demand. The fertilizer regime reflects widespread use of urea ammonium nitrate (UAN-32). Other parameters used are listed with their sources; all values were set at the most realistic levels, representing averages across almond cultivars used in California, rather than being manipulated to "fit" the model:

Table 2. Fertilizer Regime used in DNDC

Date	Fertilizer	Year 1	Year 2	Year 3	Year 4	Year 5 and after
1-Mar	Urea-N	8	8	14	20	30
	Ammonium-N	4	4	7	10	15
	Nitrate-N	4	4	7	10	15
	Phosphate-P	1.5	3	4	4	5
15-Apr	Urea	9	9	14	24	34
	Ammonium	5	5	7	12	18
	Nitrate	5	5	7	12	18
	Phosphate	1.5	3	4	5	5
1-Jul	Urea	8	8	12	20	30
	Ammonium	4	4	6	10	15
	Nitrate	4	4	6	10	15
	Phosphate	1.5	3	4	5	5
1-Oct	Urea	4	4	6	10	15
	Ammonium	2	2	3	5	7.5
	Nitrate	2	2	3	5	7.5
	Phosphate	1	2	3	4	5
	Annual N	*59*	*59*	*92*	*148*	*220*
	Annual P	*5.5*	*11*	*15*	*18*	*20*

Table 3: Parameters Modified in DNDC, and their sources

Parameter	Value	Source
Initial CO_2	385 ppm	Mauna Loa Observatory
CO_2 increase/yr	2 ppm	Mauna Loa Observatory
Simulation Years	20 years	Expected profitable lifespan for almond orchards, as main example
Soil parameters	Table 3	California Air Resources Board, by County
SOC Soil A depth	15 cm	Holtz et al., 2018; and WOR will go down to at least 15 cm, making it uniform
SOC Soil Decrease with Depth	2.5/m	Estimated from Jahanzad et al., 2019; SOC is dimensionless
Crop Maturity	10 years	Conservative estimate, since Year 7 can be full production (Kendall et al., 2015)
Kernel Biomass, kg/ha	2500	USDA NASS defines this average yield level for 2018
Shell Biomass	2242	Kendall et al., 2015
Hull Biomass	4483	Kendall et al., 2015
Kernel % C	33%	Wikipedia almond kernel constituents
Shell % C	72%	(Li et al., 2018)
Hull % C Biomass	50%	Construed from characterization as 85% fiber, cellulose and lignin (Feedipedia.org)
Leaf % C	48%	(Ma et al., 2018)
Shoot % C	48%	Ma et al., 2018
Root % C	47%	Ma et al., 2018
Grain Biomass Fraction	0.41	*Adjusted to agree with other fractions*
Leaf Biomass Fraction	0.1	(Muhammad et al., 2015) recorded 2,000 kg/ha/year as a normal/high dry mass of leaves at harvest, probably reduced from peak by remobilization
Shoot Biomass Fraction	0.27	Conservatively calculated, assuming typical orchard adds 3,000 kg/yr to attain C content of 60 metric tons/ha after 20 years (Holtz and Culumber, 2019)
Root Biomass Fraction	0.22	Little data; (Heilmeier et al., 1997) suggests 1.25 shoot:root ratio, close to DNDC default for almond
Grain Biomass as C, kg/ha	4681	*Calculated with numbers above*
Leaf Biomass as C	1142	*Calculated by DNDC with numbers above*
Shoot Biomass as C	3082	*Calculated by DNDC with numbers above*
Root Biomass as C	2512	*Calculated by DNDC with numbers above*
Grain Biomass C/N ratio	21	Calculated with numbers above, verified by Muhammad et al. (2015) fruit N content of 2.3%
Leaf Biomass C/N ratio	32	Calculated with numbers above, verified by Muhammad et al. (2015) final leaf N content of 35 kg/ha
Shoot Biomass C/N ratio	140	Calculated with numbers above and Muhammad et al. (2015) perennial organ annual N increase of 40 kg/ha, including roots
Root Biomass C/N ratio	140	*Same as above*
Grain Dry Matter, kg/ha	*9059*	*Inferred from above for Water Demand calculation*

Leaf Dry Matter	*2378*	*Inferred from above for Water Demand calculation*
Shoot Dry Matter	*6442*	*Inferred from above for Water Demand calculation*
Root Dry Matter	*5344*	*Inferred from above for Water Demand calculation*
Water Demand, g H_2O/g DM	400	Optimal high-yield water consumption of 1200 mm/biomasses implied above; assuming 25% water loss to leaching and soil evaporation; lower than reported by Lopez-Lopez et al., 2018
Planting Date	1-Jan	Compensates for the actual use of nursery transplants planted in spring; in DNDC the trees grow quickly.
Harvest Date	31-Dec	Does not actually affect "perennial" crops in DNDC.
Harvest Year	1	Some anomalies have been seen with "20," so "1" is preferred
Residue left in field	0	Despite the "perennial" crop setting, with this parameter at "0," the model cycles leaf C and N, as well as some from stems, back into the soil's reserves
Tillage Application	1, moldboard (20 cm)	Orchard establishment usually involves deep tillage, such as ripping
Tillage Date	4/15, Year 1	Likely date of orchard planting
Manure Incorporation	15 cm	This is a minimum depth observed in the field, and will be the required minimum depth for the WOR practice.
Manure Type	straw	suggested because of its low nutrient content and high C:N
Manure C/N	160	Holtz and Culumber, 2019, describing lab results for WOR chips
Manure amount	60000 kg C/ha	60 U.S. tons per acre of dry wood chips carry very close to 60 metric tons of C per ha, and is a low-to-typical mass for a 20-year-old almond orchard
Fertilization composition	Table 1	Reflects best practice with 4 applications of UAN at 220 kg N/ha; low for some, but N addition from leaves compensates
Fertilizer Injection Depth	15 cm	A middle depth of urea and nitrate in drip-fertigated systems (Gärdenäs et al., 2005, p.; Wolff et al., 2017)
Irrigation Applications	2.5 cm each	An irrigation schedule was created to supply nearest CIMIS Eto adjusted for UCCE monthly Almond Kc values (Doll and Shackel, 2015); seeing the model's performance and field practice, August and September Kcs can be reduced and water reallocated to May. Adjust for 30% canopy in Year 1 advancing to "full" 85% in Year 6.
Irrigation Type	Sprinkler or Drip	Drip is more common, but the WOR trial used microsprinklers and results in growth, N2O and SOC are almost identical.
Cut Application	15-Sep	This is the harvest. Cut "grain" at a high fraction; we used 0.99

Soil data were collected from USDA's Soil Survey Geographic Database (SSURGO) database (USDA, 2016c). Key soil data, including soil organic carbon content, clay content, pH and bulk density, were compiled. The SSURGO map units were overlaid with the regions of agricultural land use developed by the Land Use Surveys of the California Department of Water Resources (CDWR, 2014) and the area-weighted means of the four soil properties were calculated for each county and used as "representative" soil values for DNDC simulation (Table 3).

Table 4: Major soil property values used in the DNDC modeling

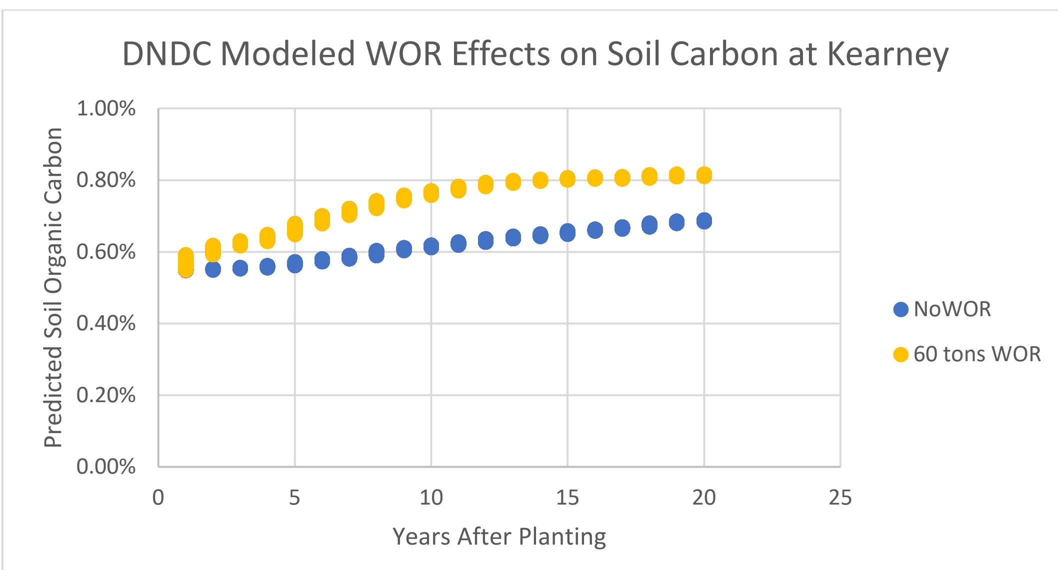
County	avg. SOC kg C / kg	avg. Clay %	avg pH	avg Density g/cm3
Alameda	0.010	0.28	6.45	1.38
Alpine	0.019	0.14	6.47	1.34
Amador	0.010	0.15	6.12	1.53
Butte	0.016	0.37	5.28	1.35
Calaveras	0.005	0.13	6.37	1.47
Colusa	0.011	0.30	6.60	1.44
Contra Costa	0.008	0.33	7.06	1.46
Del Norte	0.069	0.24	5.12	1.08
El Dorado	0.012	0.17	6.05	1.38
Fresno	0.006	0.24	7.15	1.48
Glenn	0.009	0.30	6.27	1.45
Humboldt	0.023	0.23	6.13	1.46
Imperial	0.003	0.32	8.09	1.50
Inyo	0.009	0.12	6.76	1.47
Kern	0.003	0.19	7.33	1.52
Kings	0.006	0.18	7.57	1.52
Lake	0.011	0.22	6.42	1.49
Lassen	0.013	0.24	7.00	1.37
Los Angeles	0.006	0.14	6.54	1.50
Madera	0.005	0.13	6.61	1.55
Marin	0.015	0.20	6.03	1.49
Mariposa	0.015	0.19	6.00	1.45
Mendocino	0.017	0.24	6.20	1.43
Merced	0.006	0.20	6.82	1.52
Modoc	0.012	0.22	6.89	1.40
Mono	0.020	0.13	6.71	1.32
Monterey	0.013	0.21	6.61	1.43
Napa	0.012	0.24	6.06	1.41
Nevada	0.021	0.17	6.10	1.25
Orange	0.010	0.22	6.90	1.50
Placer	0.007	0.15	6.04	1.53
Plumas	0.013	0.15	6.45	1.52
Riverside	0.005	0.17	7.09	1.54
Sacramento	0.006	0.22	6.18	1.53
San Benito	0.015	0.29	7.07	1.48
San Bernardino	0.007	0.11	6.74	1.45
San Diego	0.006	0.14	6.19	1.54
San Francisco	0.017	0.26	6.75	1.40
San Joaquin	0.010	0.24	6.74	1.51
San Luis Obispo	0.012	0.26	6.81	1.48
San Mateo	0.013	0.23	5.91	1.45

Santa Barbara	0.012	0.17	6.24	1.51
Santa Clara	0.013	0.34	6.84	1.41
Santa Cruz	0.013	0.17	6.48	1.50
Shasta	0.014	0.22	6.11	1.41
Sierra	0.014	0.19	6.45	1.40
Siskiyou	0.010	0.18	6.52	1.39
Solano	0.009	0.35	6.53	1.46
Sonoma	0.012	0.23	5.74	1.44
Stanislaus	0.006	0.19	6.70	1.53
Sutter	0.009	0.33	6.76	1.44
Tehama	0.009	0.20	6.33	1.48
Trinity	0.011	0.21	6.42	1.42
Tulare	0.007	0.20	7.21	1.50
Tuolumne	0.017	0.19	5.86	1.26
Ventura	0.012	0.22	6.90	1.47
Yolo	0.010	0.32	6.71	1.46
Yuba	0.008	0.22	6.30	1.48

DNDC predicted overall SOC for 2017 as 0.73% for WOR, compared to 0.60% for a non-WOR simulation. This can be compared to the 2017 field results of 0.79% over 0.55% obtained in 2017 (Jahanzad et al., 2019) for the upper 15 cm, or approximately .82% over .52% for the 0-30 cm depth (Jahanzad, 2019). The model predicts further increase of SOC through to the end of the orchard's assumed 20-year life span, as seen below, but at a decreased rate compared to 0-10 years.

Accompanying that, DNDC modeled kernel yields of about 1,930 average for the Kearney site, very close to the annual average of 1,917 seen on Butte rows in Kearney (Holtz et al., 2018). The model's yields have much lower annual variance than the field loads.

Figure 4. Simulated Carbon Stock of "Burn" and "Grind" soils over 20 years.



The model performance is conservative and consistent with field trial research data. And it generally predicts increases in SOC in non-WOR simulations, although Kearney results suggested a slight decrease in SOC for non-WOR sites. It is also marked by a tendency to predict higher WOR SOC increases when a previous tree crop (as opposed to a field crop) has already been established and included in the simulation.

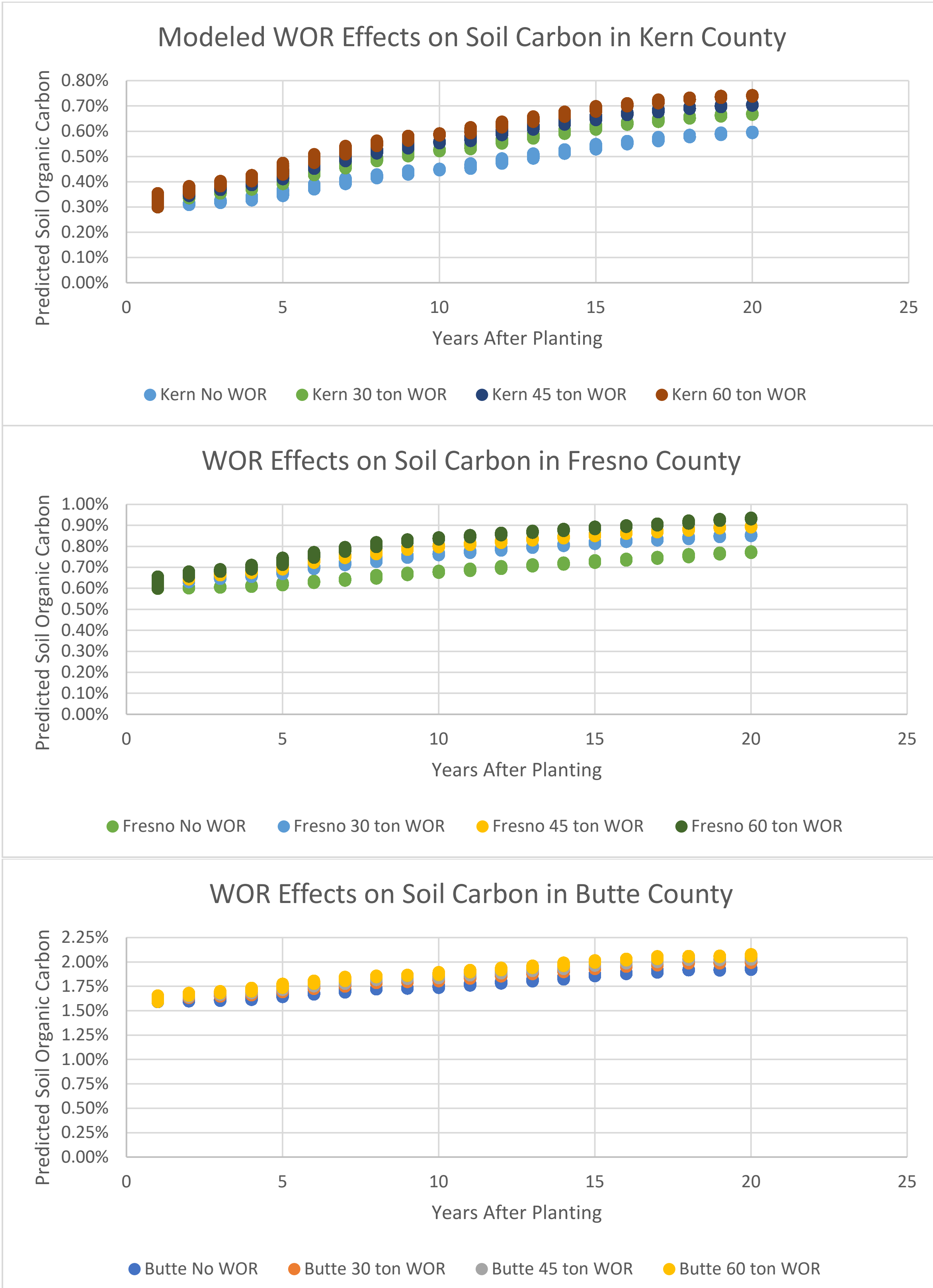
With the evidence discussed above, and available in similar studies, it appears unlikely that the WOR practice will cause losses in tree growth and production when considered over the entire lifetime of a nut or fruit orchard. Thanks in part to improved tree (root) growth, WOR's impacts on SOC should be positive, leading to net carbon sequestration. DNDC's predictions are conservative in large part because it is restricted to the upper 50 cm of soil, while tree crops will generally have significant root systems below that depth. The 9-year analysis in Kearney showed accumulation of SOC under WOR down to 140 cm depth and suggested that the effect goes even deeper.

DNDC's application to three important almond-producing counties, with their typical soils and real weather data, can be seen below, in tabled and graphic form. The WOR rates listed for clarity as "metric tons of C per hectare" are very close to the corresponding quantity of "tons of wood chips per acre" (i.e., 60 U.S. tons of dry wood chips per acre contain 60 metric tons of carbon per hectare).

Table 5. WOR application rates and carbon sequestration factors for three counties.

County /WOR (mt-C/ha)	humads-C and humus-C (mt/ha)	WOR benefit as C (mt/ha)	benefit as CO_2 (mt/ha)	C-seq factor
Butte 0	64.31			
Butte 30	66.63	2.32	8.51	7.7%
Butte 45	67.78	3.47	12.72	7.7%
Butte 60	68.89	4.58	16.81	7.6%
Fresno 0	27.35			
Fresno 30	30.36	3.01	11.03	10.0%
Fresno 45	31.83	4.48	16.42	10.0%
Fresno 60	33.19	5.84	21.41	9.7%
Kern 0	21.79			
Kern 30	24.45	2.65	9.73	8.8%
Kern 45	25.77	3.97	14.56	8.8%
Kern 60	27.09	5.30	19.44	8.8%

Figure 5. Whole Orchard Recycling predicted effects on Soil Organic Carbon in three counties.

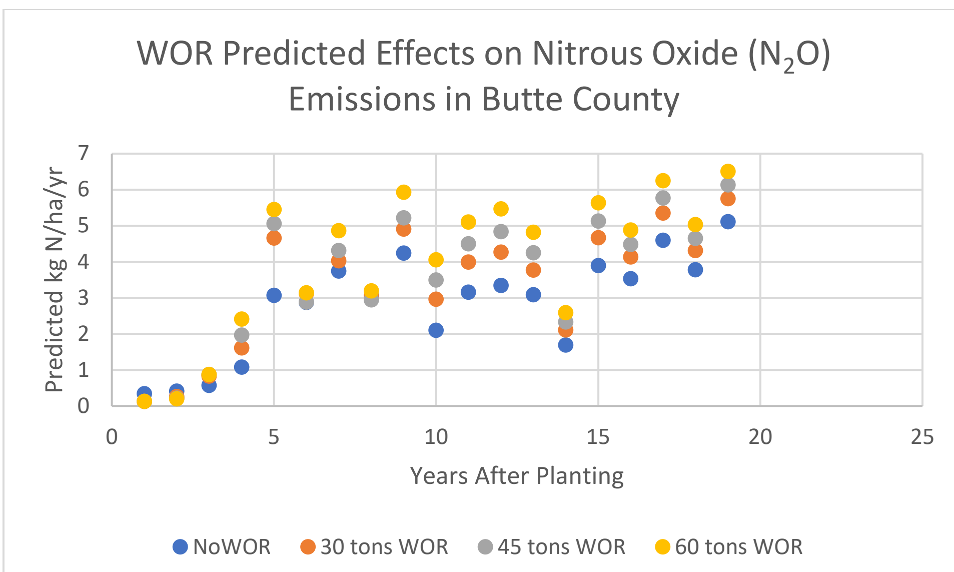


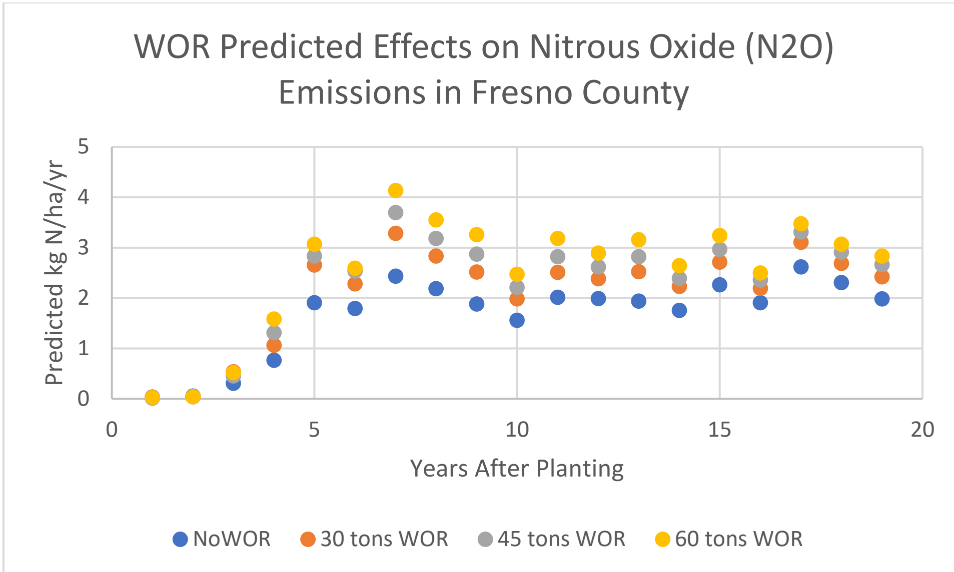
DNDC simulations predict quite linear returns in carbon sequestration according to WOR rate. A single, linear emission factor (EF) should therefore be feasible on a per-County basis, until more field data become available. For example, in Table 1 it can be seen that DNDC predicts a consistent soil organic carbon increase equal to 8.8% of the carbon incorporated into the soil as wood chips in Kern County, which is to say that "C sequestration (metric tons) = 8.8% x rate of dry wood chips (U.S. tons per acre, which is roughly equal to metric tons C per hectare) x number of hectares."

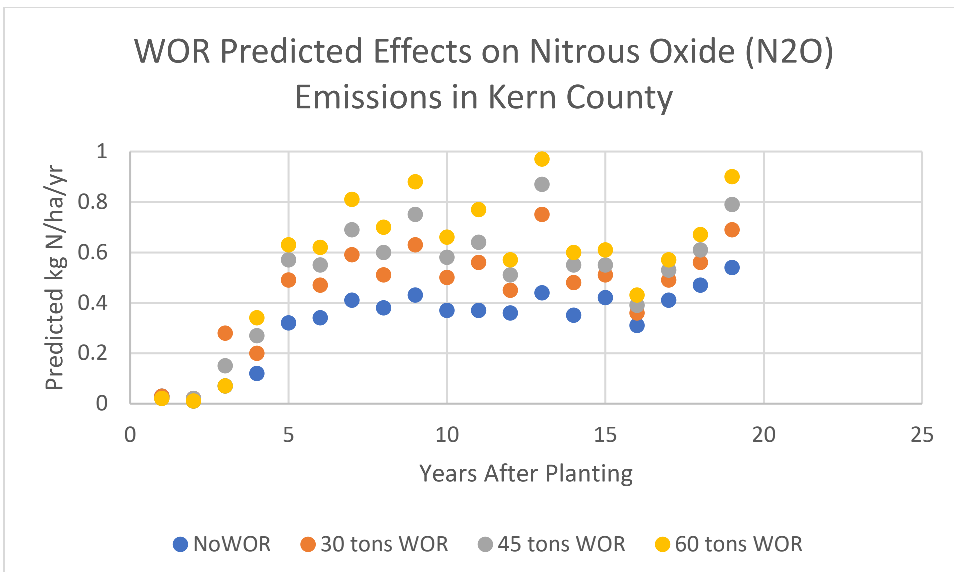
Other GHG Impacts

For an accurate GHG accounting of the WOR's impacts, emission factors for nitrous oxide (N_2O) emissions must be considered as well. DNDC models should reflect the reflect the scale seen in published reports of N_2O emissions, of which there are several under sprinklers in Californian almond orchards. In Belridge, Kern County, for example, emission factors averaged around 0.23-0.35% of applied N (Schellenberg et al., 2012), and in Arbuckle, Colusa County, on a finer soil, they were 0.26% (Alsina et al., 2013). In Deng et al.'s (2018) study for the CARB and the California Greenhouse Gas Inventory, almond under drip irrigation, which includes microsprinkler and fanjet, has a calculated emission factor of 0.42%. There is good agreement between those numbers and the DNDC predictions below for Kern County. At the same time, DNDC predicts emission factors of about 1.1% for Fresno County, farther north and with higher clay content. And in Butte County, one of the coldest and highest-clay regions for almond cultivation, DNDC's emission factors would be around 1.8%.

Figure 6. Whole Orchard Recycling predicted effects on N_2O emissions in three counties.







It is possible that N_2O emissions might increase with WOR, as DNDC predicts, although the similar case of wood chip mulch gave a contrary result in two paired field trials (Fentabil et al., 2016b, 2016a). Considering the GHG balance of WOR, it is worth noting that even if N_2O emission increases by the high margin seen in DNDC's Butte County simulations (an averaged 1.3 kg N_2O-N/ha/yr), the cumulative emissions increase would ultimately be 11.4 metric tons of CO_2 equivalent, which is less than the 19 tons CO_2-eq predicted by DNDC to be sequestered by WOR in that county.

Table 6: DNDC predictions of WOR-derived N_2O over orchard lifetime

County /WOR (mt-C/ha)	N2O-N emitted (kg)	CO2-eq emitted (mt/ha)
Butte 30	10.87	5.09
Butte 45	16.53	7.74
Butte 60	24.26	11.36
Fresno 30	10.27	4.81
Fresno 45	15.30	7.16
Fresno 60	20.48	9.59
Kern 30	2.57	1.20
Kern 45	3.74	1.75
Kern 60	5.04	2.36

WOR's effects on the third agricultural GHG, methane, appear to be negligible in DNDC simulations. There have not been measurements in the field.

Co-Benefits

As with other Healthy Soils practices, the calculation of project impacts is bounded by the soil and its retention or emission of greenhouse gases. GHG calculations take location, rate of amendment application, and area affected as the main inputs. Practices should also have positive or neutral impacts on yield, as WOR has been shown to have. Although practices such as WOR may show other benefits such as reduced disease transmission or water savings, they are not quantified as impacts.

Most research related to WOR has focused on mulching, which is already an eligible practice under the Healthy Soils Incentive Program, and one with which WOR can compete. Among WOR's advantages over wood chip mulching, it could give greater soil health and carbon benefits, because less of the wood chip carbon would probably be lost "directly" to the atmosphere, as opposed to being assimilated into soil biota, and more of the tree crop's root zone would likely be affected. Mulching has apparently boosted soil organic matter wherever it has been measured. In British Columbia an apple orchard soil had elevated C, water-holding capacity, and aggregation 7 years after shredded-paper mulch (Neilsen et al., 2003), as was also seen in Washington State (TerAvest et al., 2011). As a corollary, soil health has also been seen to improve under wood chip mulching: TerAvest *et al.* found increased earthworm counts, and root density has been found to be even higher than under living mulches, with sugar maples (Green and Watson, 1989). Indeed, increased fungal growth with wood chips, above or below the soil, may compensate for apparently decreased N availability in the soil. Tree root growth is also likely to increase with WOR. Working with pecans in New Mexico, Tahboub *et al.* (2008) tested intermediate rates of pruning-chip incorporation and found that the practice "significantly increased soil organic matter content and aggregate stability, particularly at the higher application rates and with repeated amendments." In Turkey, under a Mediterranean climate, Yilmaz et al. (2017) found various soil health and structural benefits with vineyard pruning chip incorporation into a sandy soil.

Among likely co-benefits of WOR, we note the positive effects of mulches on Prunus Replant Disease (PRD) and parasitic nematodes, both vital concerns for orchard production in California. PRD's causes have not been completely unraveled, but "it has been associated with a complex of soilborne fungi, oomycetes, and bacteria left from the preceding crop… [while] root damage caused by the ring nematode in sandy soils predisposes almond and other stone fruit trees to bacterial canker disease" (Doll, 2009). Watson *et al.* (2017) remind us of the promise of mulching for fighting PRD: "composts and BM [bark chip mulch] show potential as alternatives to fumigation for suppression of RD on sweet cherry, with promotion of beneficial rhizosphere microorganisms a possible contributing mechanism..." Working in avocados in California, Downer et al. (2002) studied short- and long-term effects of mulching on *Phytophthora* root rot and found that "Long-term effects include increases of: soil mineral nutrients, soil aggregation and drainage; microbial activity; and cellulase enzyme activities. Biological control of Phytophthora in mulched soil is partially regulated by cellulase enzyme activities." In all, a healthier soil is deemed less subject to outbreaks of opportunistic pathogens.

In saline soils, organic mulches have improved tree health (Ansari et al., 2001; Sun et al., 1994), being superior to plastic mulches. Buried straw, which is also analogous to WOR, has done the same in annual crops (Zhao et al., 2016). Salinity is an increasingly relevant concern in Central Valley and coastal soils.

Practice Requirements

A list of practice requirements have been proposed below by CDFA to support the modelling results and scientific information required to ensure carbon sequestration benefits and greenhouse gas reductions are achieved by WOR.

- WOR is only to be implemented with new (replanting) tree crops.
- Mature orchards should be chipped in place without exporting chips off-site or to new fields (for verification and DNDC modelled conditions).
- WOR practice shall not be implemented in soils with Soil Organic Matter greater than 20% (DNDC modelled conditions).
- WOR can be repeated no more than once every ten years for an APN or field (DNDC modelled conditions).
- Chips must be evenly distributed throughout the orchard. When a service provider is contracted, their commitment to distribute the wood chips must be in the contract/invoice for verification purposes.
- Chips must be incorporated into the soil to at least 6 inches depth (DNDC modelled conditions).

Future Considerations

Research focused on the following topics would be beneficial to the WOR practice:

1. WOR mixing with other organic amendments, such as manure or compost.
2. Development of a WOR Agricultural Offset Protocol.
3. Combination of WOR with anaerobic soil disinfestation (ASD). This typically requires a ready carbon source such as rice husks or almond hulls, which is flooded, and often covered with plastic. Wood chips are not likely to provide the right substrate for ASD's aims, but interactions of WOR with ASD are being explored by Greg Browne of UCCE.
4. WOR's effects on land that is converted back to annual crops, or otherwise tilled.
5. Applicability of practice to non-tree crops such as vineyards.

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Photo credits: Brent Holtz, UCCE

The UCCE Whole Orchard Recycling website is under improvement, but has some useful materials, focused on outreach: https://orchardrecycling.sf.ucdavis.edu/

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