Effects of the January, 2008 CDPR Field Fumigation Regulations: Ventura County Case Study

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I. Introduction

On January 25, 2008, the California Department of Pesticide Regulation (CDPR) adopted regulations regarding volatile organic compound (VOC) emissions from field fumigation that apply to five ozone nonattainment areas, including Ventura County. Two of the nonattainment areas do not require further reductions in VOC emissions from pesticides currently (Sacramento Metro and South Coast). Use of the low-emission preplant soil fumigant application methods specified in the regulations is projected to be sufficient to bring the San Joaquin Valley and Southeast Desert nonattainment areas into compliance. In Ventura County, however, CDPR had to implement an emission allowance system for the ozone peak season (May to October) in order to bring it into compliance.[1]

CDPR's initial compliance plan included a four-year phase-in period for emission allowances in Ventura County. The phase-in period was rejected initially by the court. While appealing the ruling, CDPR initiated its implementation of the emission allowance system. In August, CDPR prevailed in court. Consequently, it was able to increase emission allowances partway through the 2008 ozone season.

This report presents a multi-crop case study analysis of the potential impacts of the January, 2008 CDPR fumigant use regulations on Ventura County agriculture. After providing background information regarding Ventura County (Section II) and the recent evolution of Ventura County agriculture (Section III), the report includes profiles of the ten largest crops in Ventura County by 2006 value of production (Section IV), as well as some other crops that are or have the potential to increase production substantially in response to changes in relative profitability (Section V). Because crop-based analyses do not reflect fully the situations of individual growers, Section VI "clusters" growers based on their crop production choices, and addresses their potential responses to the regulations. Section VII discusses land use and urbanization and assesses the likelihood that the regulations will lead to a substantial change in land use. Section VIII discusses the initial implementation of emission allowances, and compares preliminary data regarding growers' actual fumigation product choices to their emission allowance requests. It evaluates the welfare implications of the permits granted under the emission allowance system, examines how growers' actual fumigation choices altered these implications, and compares the system used for 2008 to a market-based system. Section IX concludes.

[1] All calculations in this report regarding emission levels, percentage of total emissions, etc. refer to peak season emissions only, not calendar year emissions.

II. Ventura County

Ventura County is located on the California coast between Los Angeles County (to the south and southeast) and Santa Barbara County (to the northwest. Kern County is to its southeast. The total land size of the county is 1,845.3 square miles (USCB, 2002). The Los Padres National Forest covers 46% of the county. In 2006, the population reached 821,698 (CDF, 2006) with a labor force equal to 425,407 people (Fedstats, 2008). In terms of the economy, the total personal income of Ventura County was $32 billion in 2005 (Fedstats, 2008).[2] The top five sectors of the economy are biotechnology, telecommunications and advanced technologies, manufacturing, tourism, and military testing and development (COV, 2008)

Ventura County Water Resources

Background. There are five watersheds in Ventura County: Calleguas Creek, Ventura River, Santa Clara River, Malibu Creek, and Cuyama River. The first three are the major watersheds in the county, and are where most agricultural activity occurs (VCPA, 2008e). There are thirty-two groundwater basins in the county, the majority of which are in these three watersheds (VCPA, 2005).

The Calleguas Creek watershed covers an area of approximately 341 squares miles, mostly in Ventura County. It includes agricultural production areas in various valleys and the Oxnard Plain, as well as the cities of Camarillo, Moorpark, Simi Valley and Thousand Oaks (VCPA, 2008a). While Calleguas Creek and its tributaries were seasonal historically, treated wastewater flow has resulted in a year-round water system. The watershed also contains the Bard Lake water supply reservoir (CEPA, 2007a).

The Calleguas Municipal Water District is a member of the Metropolitan Water District of Southern California (MWD), which allows it to purchase water from the organization annually. The MWD gets its water from the Colorado River and Northern California (MWD, 2007). From June 2006 to July 2007, the Calleguas Municipal Water purchased 134,048.9 acre-feet of water of which 7,164.0 acre-feet were for agriculture.

The Ventura River Watershed covers approximately 223 square miles in the western part of the county with approximately half in the Los Padres National Forest. Most of the watershed is open space due to the national forest, but the rest is a mixture of urban, agricultural, and industrial uses (VCPA, 2008d). The Ventura River Watershed does not import outside water (CWN, 2006). "Groundwater basins…are highly interconnected with the surface water system and are quickly recharged or depleted, according to surface flow conditions." (CEPA, 2007c).

The Santa Clara River is the largest undeveloped river system in Southern California (VCPA, 2008c). The Santa Clara River watershed is the largest in Ventura County at

[2] Total personal income is the sum of all individual wages and salaries, supplements to wages and salaries, farm and nonfarm proprietors' income, property income, and personal current transfer receipts less contributions for government social insurance and residence adjustment (CDF, 2006).

1,634 square miles. Sixty percent of the watershed is contained in Ventura County (CWN, 2006). Most of the land within the watershed is open space, but a mixture of urban, agricultural and industrial uses are concentrated around the river (VCPA, 2008c). The Santa Clara River watershed management entity is the United Water Conservation District. The watershed contains various cities including Oxnard, San Buenaventura, and Port Hueneme. The upper end of the Oxnard Plain serves as the recharge area for the aquifers under the Oxnard Plain. There are several major reservoirs located in the watershed: Castaic Lake, Piru Reservoir, Couquet Reservoir, and Pyramid Lake (CEPA, 2007b). Users in the watershed import water from Calleguas Municipal Water District, and rely heavily on groundwater (CWN, 2006).

At the current time, groundwater is more important for direct water consumption than surface water is. Groundwater satisfies 67% of the overall water demand in Ventura County (VCPA, 2008b). The share of agricultural water demand met by groundwater is essentially the same: 68% (VCPA, 2008b). It is important to note that the surface water and groundwater systems in Ventura County are highly connected. Aquifers' ability to recharge depends on surface water use, as well as groundwater use.

Demand for water in Ventura County has almost tripled in the last quarter century and is expected to double in the next fifty years (VCPA, 2008b). In order to meet agricultural and residential demand, three pipeline systems were built by the United Water Conservation District: Oxnard-Hueneme, Pumping Trough Pipeline, and Pleasant Valley. These pipelines deliver surface water in order to prevent the overuse of groundwater in the Oxnard Plain and Pleasant Valley Basins. However, these surface waters also replenish the Oxnard Forebay, which is a major space for storage. By law, the pipelines must shut down if available water storage in the Oxnard Forebay exceeds 80,000 acre-feet. The 2007 United Water Conservation District Water Management Plan indicates that when the storage level exceeds 80,000 acre feet that many residents of the Oxnard Plain will be negatively affected (UWCD, 2008).

Current situation. Southern California is suffering from a water shortage due to drought and the court-ordered reduction of Delta water deliveries to Southern California. These shortages will in the short-run have the effect of reducing the amount of water that the MWD can supply to its members. Thus, water districts will meet their local demand through higher use of their surface and groundwater resources. In other words, surface water availability will decrease due to less imports and drought, while the groundwater table will be lowered through higher levels of pumping. If the groundwater table is lowered sufficiently, irreversible damage due to saltwater intrusion will occur; some damage has already occurred under present pumping conditions (UWCD, 2007). The California Water Plan Update 2005 lists eleven basins in California that are identified as being in a critical condition of overdraft, two of which are in Ventura County: the Ventura County Basin and the Cuyama Valley Basin.[3]

[3] "A basin is subject to critical conditions of overdraft when continuation of present water management practices would probably result in significant adverse-related environmental, social, or economics impacts" (CDWR, 2005).

Ventura County Agriculture: Background

Ventura County had 323,963 acres of agricultural land in 2006, including 45,430 acres of prime farmland, 34,231 acres of farmland of statewide importance, 28,583 acres of unique farmland, 16,717 acres of farmland of local importance, and 199,004 acres of grazing land (CDC, 2008a).[4]

There were 2,318 farms employing 26,810 individuals in Ventura County in 2002, according to the 2002 Census of Agriculture (COA, 2002). The average number of employees per Ventura County farm was approximately 12.

The total value of agriculture production in 2006 was $1.5 billion (VCAC, 2006) ranking Ventura eighth among California counties in terms of total value of agricultural production in 2006 (CDFA, 2007). In 2006, Fresno County, the top-ranked county in terms of total value of agricultural production, produced 15.4% of the total value of California agricultural production. Ventura County produced 4.8%.

Soils and Crop Choice

This subsection relates growers' choices of annual and perennial crops to soil capacity. The soil capacity data are obtained from the Soil Survey Geographic Database (SSURGO). Class 1 soils have the highest capacity. Class 2 soils have more limited crop choices and/or require the use of some soil conservation practices. Class 3 soils and Class 4 soils have increasingly severe limitations affecting crop choice and/or requiring increasingly intensive soil conservation management. Class 5 soils are not prone to erosion but are also not suitable for agricultural use. Class 6, 7 and 8 soils are not suitable for cultivation, generally (NRCS, 2008). In the SSURGO database no class 5 category soils are reported for Ventura County. As we can see from Map II-1 below, the soils with the fewest crop choice restrictions (classes 1 and 2) are in the Oxnard Plain, along the Santa Clara River, and in various valleys.[5]

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[4] The definitions of the agricultural land categories are from CDC (1996): "**PRIME FARMLAND**: Farmland with the best combination of physical and chemical features able to sustain long term production of agricultural crops. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. The land must have been used for the production of irrigated crops at some time during the two update cycles prior to the mapping date. **FARMLAND OF STATEWIDE IMPORTANCE**: Farmland similar to Prime Farmland but with minor shortcomings, such as greater slopes or with less ability to hold and store moisture. The land must have been used for the production of irrigated crops at some time during the two update cycles prior to the mapping date. **UNIQUE FARMLAND**: Farmland of lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include nonirrigated orchards or vineyards as found in some climatic zones in California. The land must have been cropped at some time during the two update cycles prior to the mapping date. **FARMLAND OF LOCAL IMPORTANCE**: Land of importance to the local agricultural economy, as determined by each county's board of supervisors and a local advisory committee. **GRAZING LAND**: Land on which the existing vegetation is suited to the grazing of livestock. The minimum mapping unit for Grazing Land is 40 acres."

[5] Note that Map 1 does not depict the entire county. Soils data are not available for the missing areas.

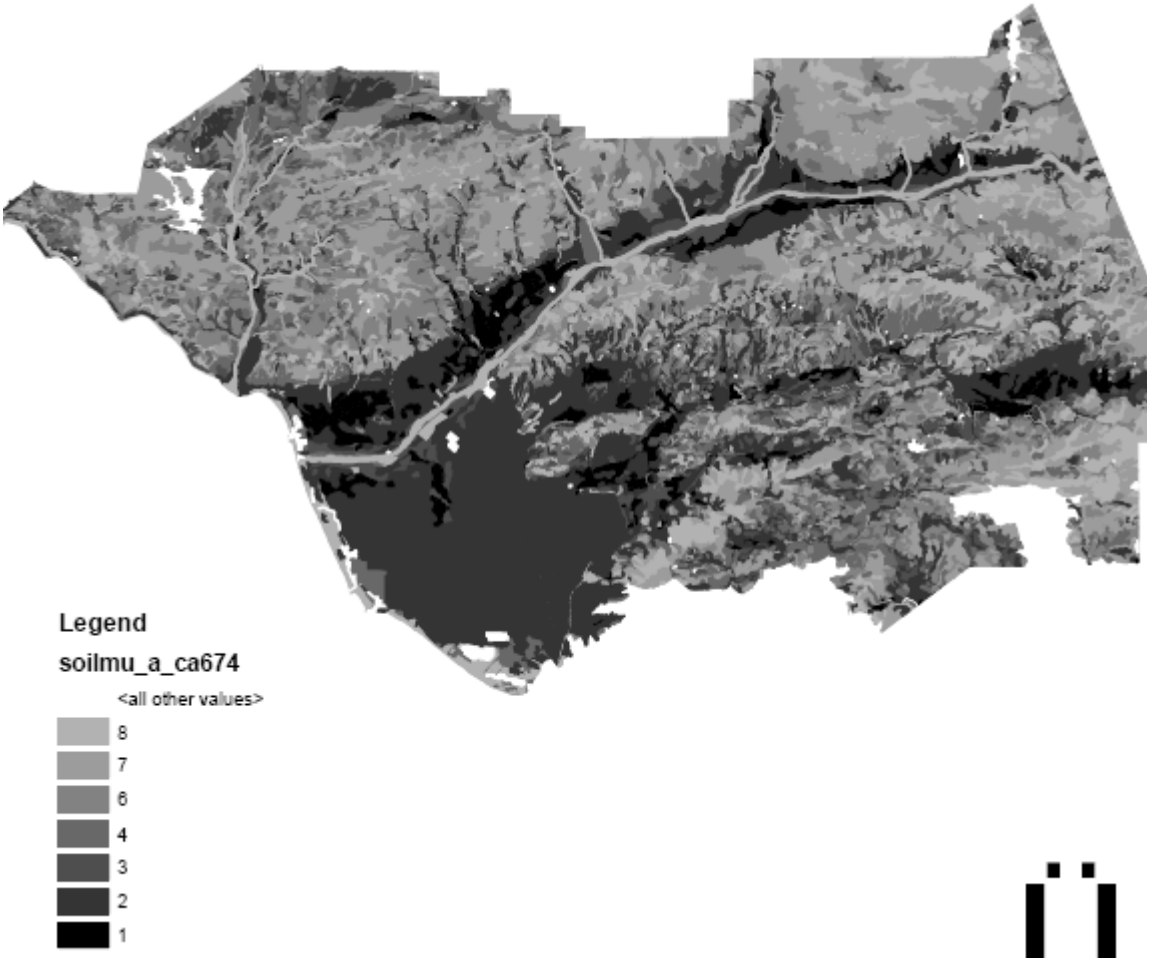
The data on crop location are from the California Department of Water Resources (CDWR) 2000 Ventura County Land Use Survey, the most recent available. The CDWR survey groups crops into the following classes: grains and hay crops, rice, field crops, pasture, "truck, nursery, and berry crops," deciduous fruits and nuts, citrus and subtropical, vineyards, idle, and "semi-agricultural and incidental to agriculture." Truck, nursery and berry crops include the following: artichokes, asparagus, green beans, cole crops, carrots, celery, lettuce, melons, squash, cucumbers, onions, garlic, peas, potatoes, sweet potatoes, spinach, tomatoes, "flowers, nursery, and Christmas trees," miscellaneous truck, bush berries, strawberries, peppers (chili and bell), broccoli, cabbage, cauliflower, and Brussels sprouts. Deciduous fruits include apples, apricots, cherries, peaches, nectarines, pears, plums, prunes, figs, miscellaneous deciduous, almonds, walnuts, and pistachios. Citrus and subtropical crops include grapefruit, lemons, oranges, dates, avocadoes, olives, miscellaneous subtropical fruits, kiwis, jojoba, and eucalyptus (CDWR, 1999).

Map II-2 summarizes grower crop choices by major category. It shows that production in the truck, nursery and berry crops category is concentrated in areas with soil in capacity class 2, while some acreage is located in areas with classes 1 and 3. Within this category, strawberries and celery are similarly concentrated in class 2 soils with sprinklings in classes 1 and 3. Carrots are cultivated on soils in classes 1-3 and flowers, nursery crops, and Christmas trees are mainly located in classes 1 and 2 with some in class 3 soils.

There are very few deciduous crops. The majority of the acres are located in soil classes 1 to 3, while some are in 4 though 6. Deciduous crops are omitted from Map II-2.

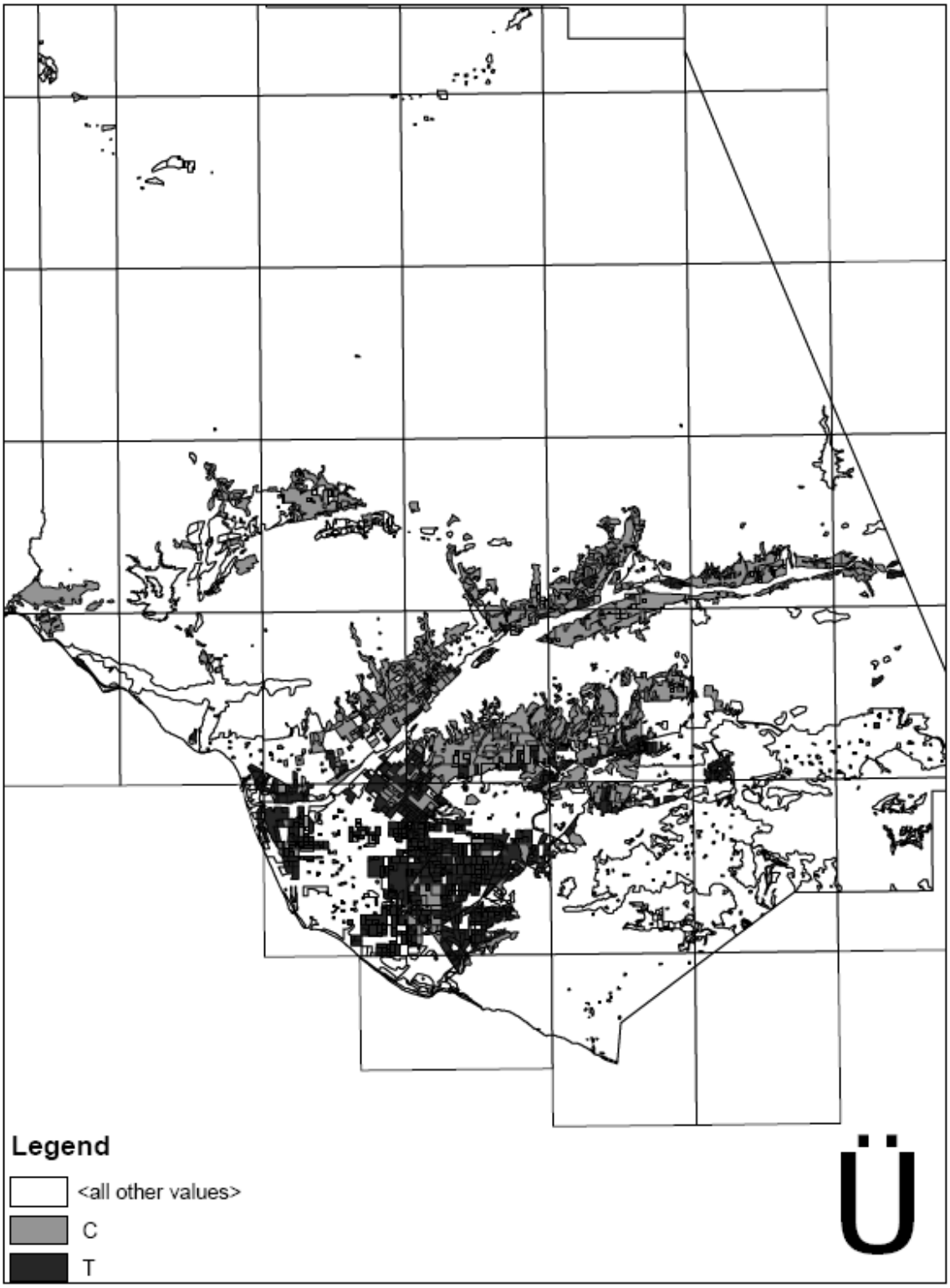
The majority of citrus and subtropical crops are located in the Oxnard Plain with soils in classes 1 and 2, as shown in Map 2. However citrus and subtropical crop acreage are also grown in the more diverse soils of the northern, central, and northeastern parts of the county. Oranges are located mainly in the northeast with soils in class 2, but some groves are located in the northwest (classes 1 and 3). There are large tracts of lemon acreage on the Oxnard Plain, primarily in soils in classes 1 and 2. There is also some lemon acreage in the central and northeastern parts of the county. Avocados are grown in diverse soil classes. Unlike the other crops a majority of them are not grown in soil classes 1 and 2.

Map II-1. Soil Capacity Classes: Ventura County



Source: SSURGO database.

Map II-2. Citrus/Subtropical and Truck Crop Production: Ventura County, 2000

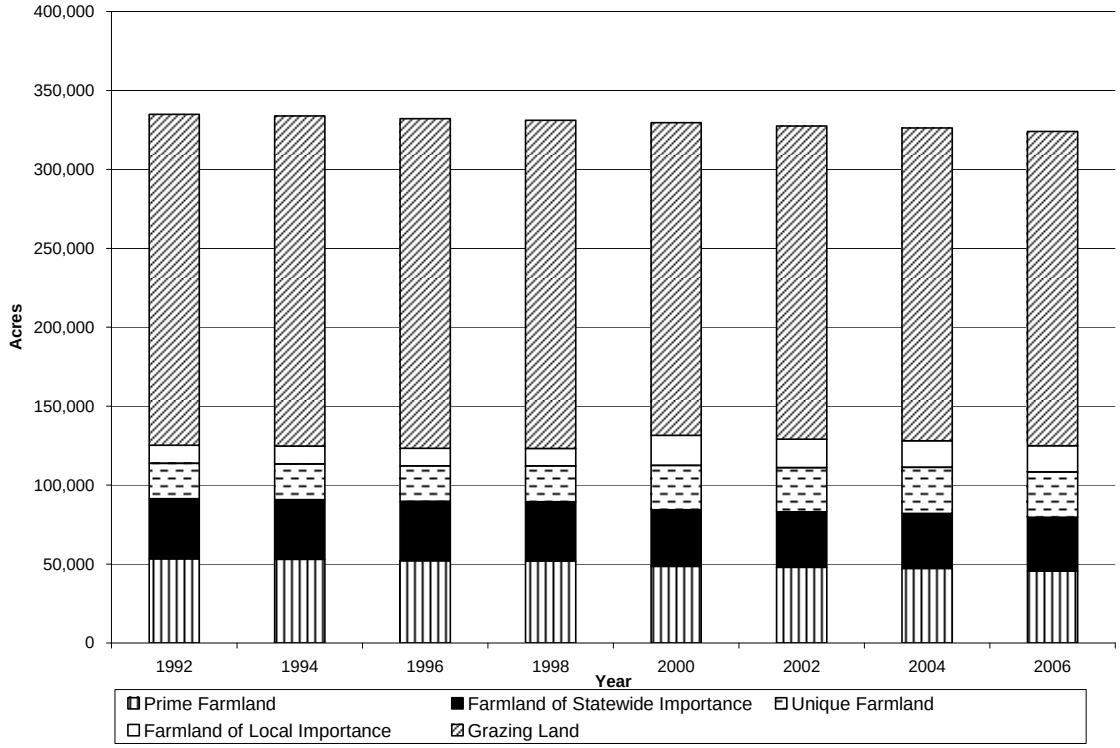


Source: CDWR Land Use Survey. Ventura County, 2000.

III. Recent Evolution of Ventura County Agriculture

Figure III-1 reports agricultural acreage by category. Since 1992, Ventura County's total agricultural land has decreased by only 3%. However, it has seen a larger percentage decrease in the area of its highest quality agricultural lands. The amount of prime farmland has decreased by nearly 15% and farmland of statewide importance has decreased by 10%. Net percentage changes for the other three individual categories of agricultural land are difficult to determine for the 1992-2006 time period. The incorporation of data from a digital soil survey in 2000 led to the reassignment of acreage from grazing land to farmland of local importance and unique farmland.

Figure III-1. Agricultural Acreage over Time: 1992-2006



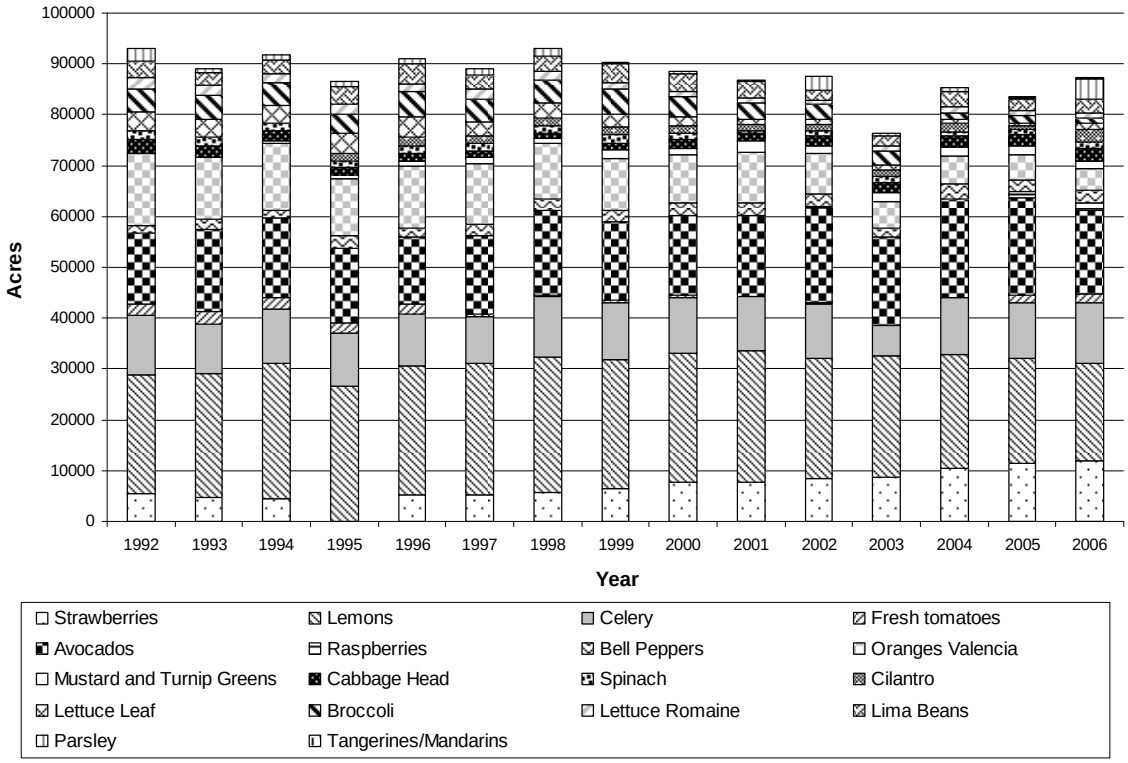
Source: http://redirect.conservation.ca.gov/dlrp/fmmp/product_page.asp

Figure III-2 depicts the acreage for several major crops from 1992 to 2006. Nursery and floriculture crops, which accounted for 21% of the value of 2006 agricultural production, are omitted from figures III-2 and III-3 due to data limitations.[6] Figures III-4 and III-5 will address those crops specifically. The total area devoted to the three most important crops among those remaining – strawberries, lemons and celery – has remained virtually constant since 1992, but within this set of crops strawberry acreage has more than

[6] Value of production, greenhouse square footage and acreage data are only available for nursery and floriculture in the *Ventura County Agricultural Commissioner: Annual Report* beginning in 1998. Due to the difficulty of separating greenhouse square footage and field acreage we exclude these crop categories from the acreage figures entirely.

doubled, while lemon acreage has declined. Additional crops that underwent a significant percentage increase in their acreage are avocados (18%) and pepper (62%). Major crops that have experienced a substantial percentage decline in their acreages include tomatoes (-20%), Valencia oranges (-69%), spinach (-29%), leaf lettuce (-69%), broccoli (-75%) and romaine lettuce (-56%). The last few years have seen the emergence of new crops including raspberries and tangerines. Declines in the acreage of the major crops are associated with an increase in the production of other, smaller-revenue crops, as well as land exiting agriculture. The former will be addressed in section V and the latter in section VII.

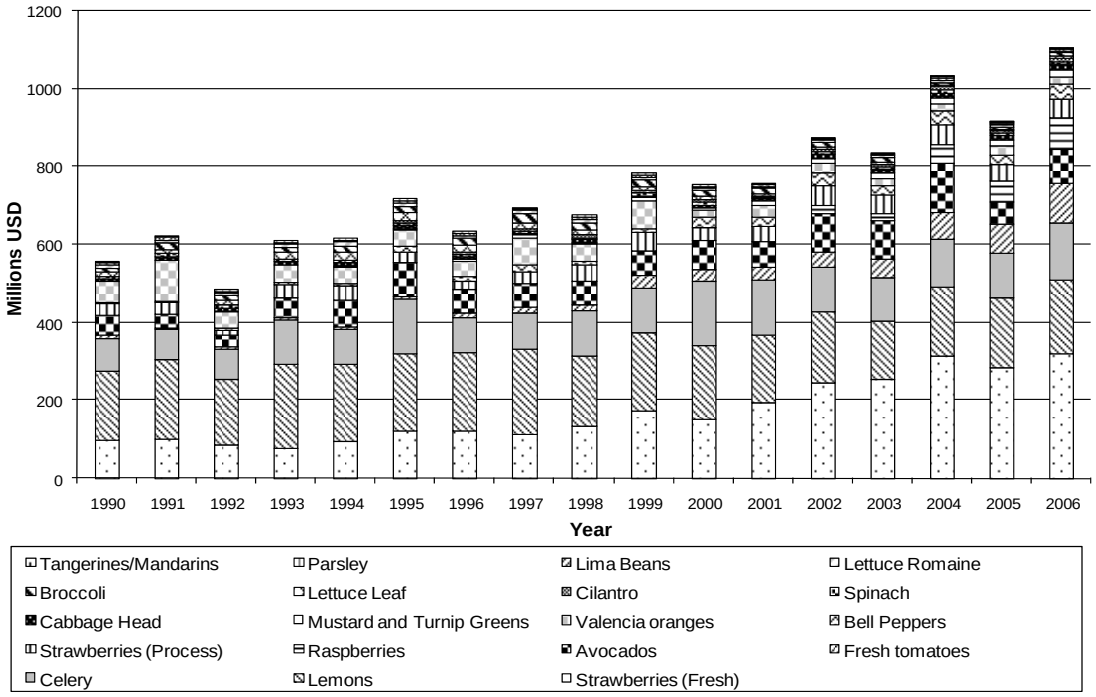
Figure III-2. Acreage for Major Crops Excluding Nursery and Floriculture: 1992-2006



Source: *http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp*

Figure III-3 displays the value of production for major Ventura County crops (excluding nursery and floriculture) over time in nominal dollars. Fresh strawberries, lemons and celery are the most important crops in Ventura County in terms of the value of production as well as in terms of acreage. Since 1990, the value of fresh strawberry production has increased by over 200%, the value of celery production has increased by 70% and the value of lemon production has grown by almost 10% in spite of its acreage decline. Raspberries are a relatively new commodity in Ventura County, but were the sixth highest value crop in 2006. The biggest declines have occurred in Valencia oranges and lettuce (both leaf and romaine) acreage.

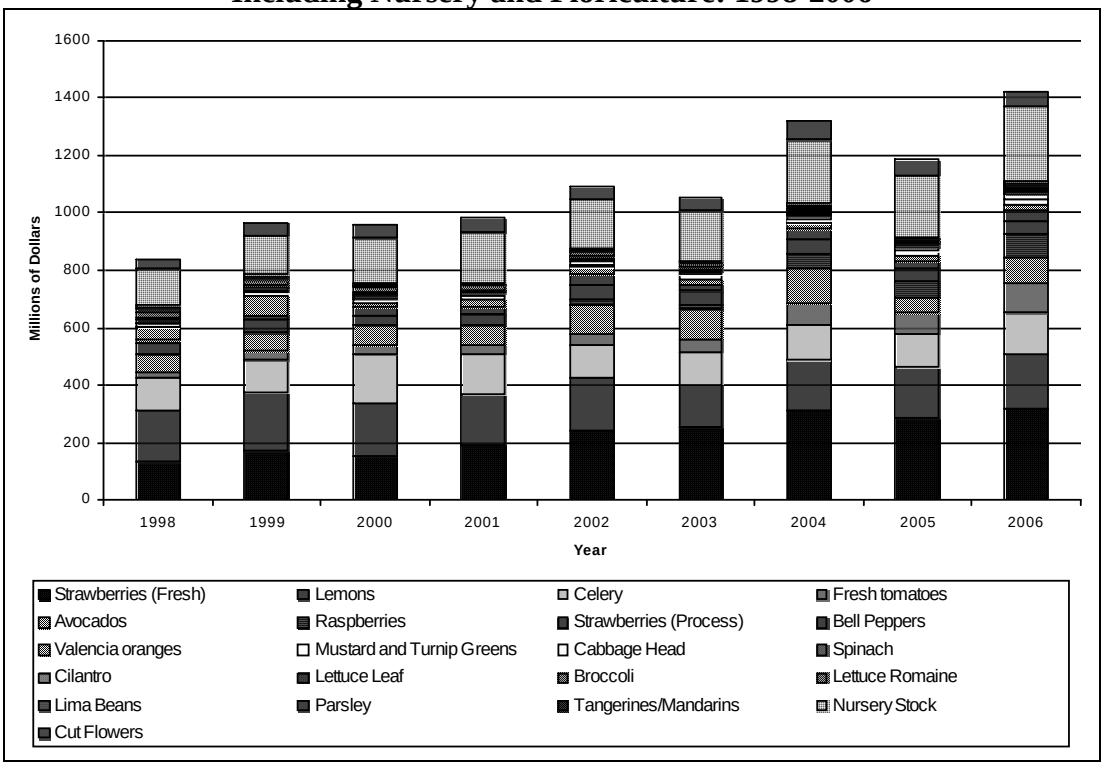
Figure III-3. Value of Production for Major Crops Excluding Nursery and Floriculture: 1990-2006



Source: http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp

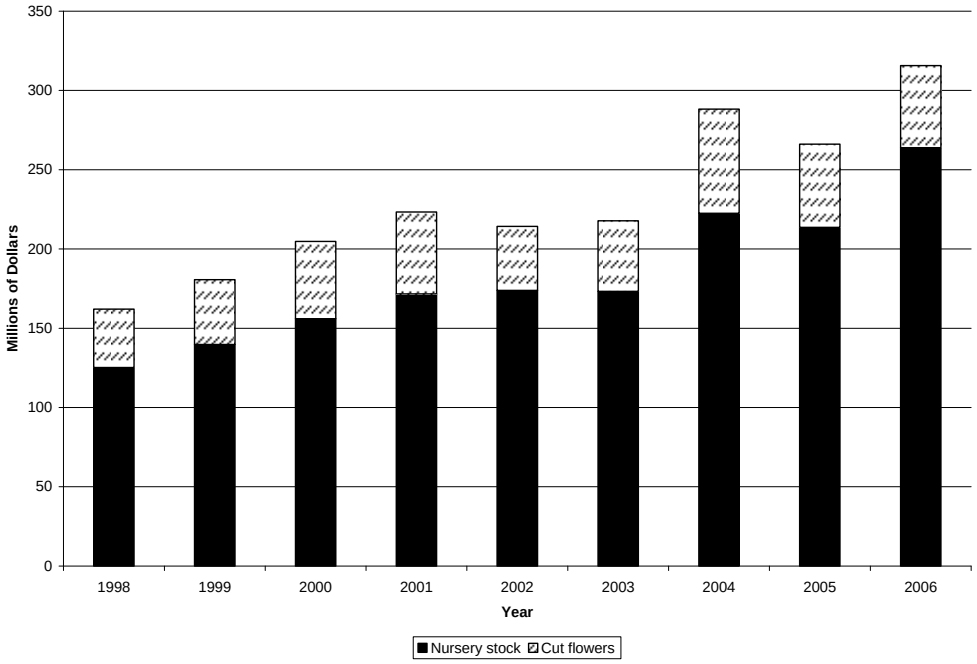
Figure III-4 depicts the value of production for major Ventura County crops including nursery and floriculture for the 1998-2006 period. The value of nursery stock crops has more than doubled since 1998 while the value of cut flowers has increased just over 40% in the same period. This increase in value over time is easier to see in Figure III-5**,** which shows the value of production for only nursery and floriculture over time**.**

Figure III-4. Value of Production for Major Crops over Time Including Nursery and Floriculture: 1998-2006



Source:
http://portal.countyofventura.org/portal/page?_pageid=826,1101429&_dad=portal&_schema=PORTAL

Figure III-5. Nursery and Floriculture Value of Production: 1998-2006



Source:
http://portal.countyofventura.org/portal/page?_pageid=826,1101429&_dad=portal&_schema=PORTAL

IV. Major Crops

In this section we provide profiles of the ten crops with the highest total value of production for Ventura County in 2006. Crops are discussed in decreasing order of total value of production in 2006. Each crop profile includes information on the competitive conditions facing the crop and, where applicable, VOC emissions from preplant soil fumigation, the importance of preplant soil fumigation, and alternatives available for reducing VOC emissions from preplant soil fumigation. We exclude the low emission methods specified by CDPR in the January, 2008 regulations.

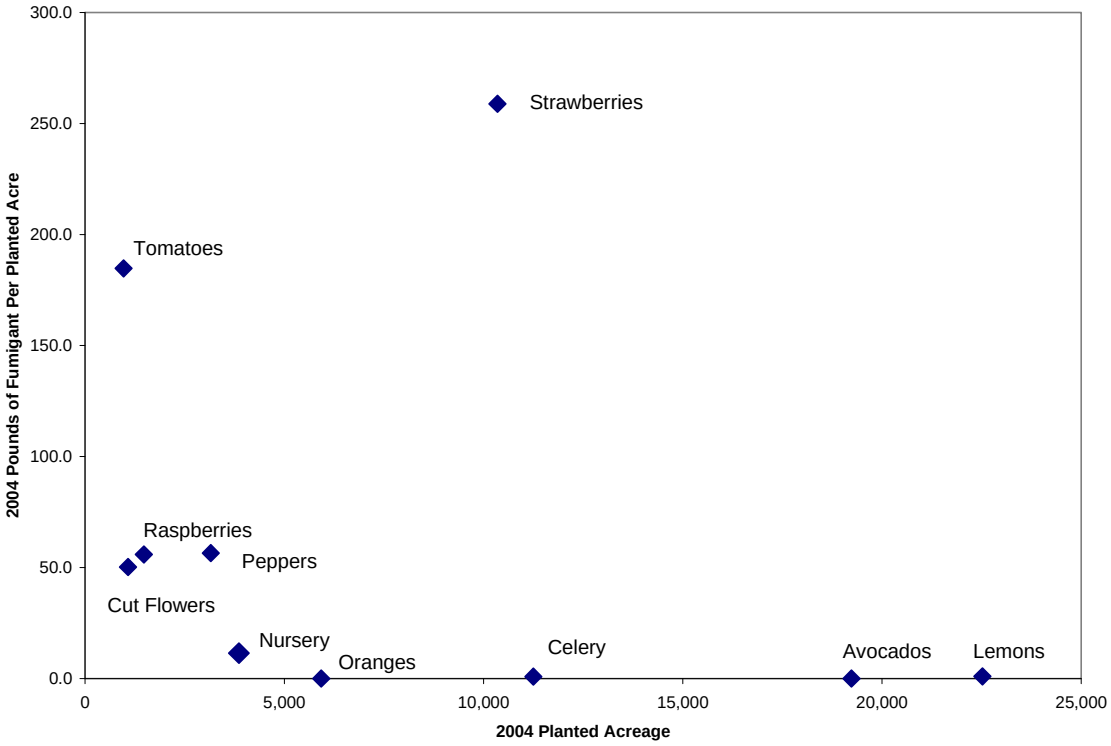
It is important to note that in the crop profiles we discuss the potential for acreage expansion. In some instances, overall demand conditions appear favorable for an expansion of production for crops that have actually realized substantial acreage declines in Ventura County in recent years. These two things are not necessarily contradictory. First, other suppliers may be better-placed to exploit these favorable demand conditions. Second, even if acreage could be expanded, growers may find it more profitable to plant alternative crops that are not among the top ten in terms of 2006 value of production. We will discuss some of these crops in section V.

Preplant Soil Fumigation: Importance of Use and Total VOC Emissions, 2004

When applicable, peak season VOC emissions from preplant soil fumigation for each crop based on CDPR calculations are reported. The crops with the largest peak season VOC emissions from preplant soil fumigation in Ventura County in 2004 were strawberries (78% of total emissions), tomatoes (5%), nursery and ornamentals (2%), raspberries, tangerines and peppers. Earlier, we provided a discussion of the evolution of acreage and value of production of major Ventura County crops. While strawberries are the largest crop both in terms of total value of production and in terms of peak season VOC emissions from fumigants, their share of total value of production is substantially smaller than their share of total VOC emissions from preplant soil fumigation during the peak ozone season. Strawberries accounted for 24% of the value of agricultural production in Ventura County in 2006 (VCAC, 2007).

Three factors drive total VOC emissions from preplant soil fumigation of a given crop: total acreage, the intensity of use of preplant soil fumigation, and the fumigant product(s) and application method(s) used. Section III discussed acreage for the crops discussed in this section. Each crop profile will present a summary measure of the intensity of use of preplant soil fumigation. Because the share of planted acreage using preplant soil fumigation varies across crops and data regarding application methods are not available, we present a summary measure of the importance of preplant soil fumigation by crop: the total pounds of fumigant applied divided by planted acreage as reported by the County Agricultural Commissioner. In order to illustrate the contributions of the intensity of use and of planted acreage to total VOC emissions from the use of preplant soil fumigation, Figure IV-1 plots the 2004 intensity of fumigant use measure against 2004 planted acreage for the top ten Ventura County crops.

Figure IV-1. Pounds of Fumigants Applied Per Planted Acre by Total Planted Acres: Major Crops, 2004



Sources: Calculations based on PUR data and California County Agricultural Comissioners' Data available at http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp.

The use of this measure is subject to at least four important caveats. First, the usefulness of the pounds of fumigant per planted acre as a summary measure is dependent on the homogeneity of the specific crop in question. Nursery production in particular is very heterogeneous. Cut flowers are also heterogeneous. Consequently, the use of a summary measure almost certainly understates the importance of preplant soil fumigation for some types of nursery production and overstates it for others.

Second, this measure does not, and is not intended to, represent preplant fumigation application *rates*. Rather, it is a measure of the economic value of a pound of a fumigant product applied prior to planting. The planted acreages reported by California's county agricultural commissioners generally do not coincide with the application acres reported in the PUR data. Obviously, most pesticides are not applied to every acre planted. Even for annual crops that use pre-plant fumigation on all or virtually all non-organic acreage the numbers do not match after subtracting organic acreage from planted acreage. Most important for our purposes, pesticides that are only applied prior to the planting of perennial crops will show relatively low pounds of fumigant per acre, consistent with the many years over which the revenues are obtained from an acre treated with preplant soil fumigation.

The third caveat is due to the fact that the second-largest source of peak season VOC emissions from fumigants in Ventura County in 2004 is not linked to a specific crop in the pesticide use report data used by regulators to calculate emissions. The site name "Soil Application, Preplant-Outdoor (Seedbeds, etc.)" accounted for 12% of VOC emissions from fumigants in 2004. The existence of this category will bias downward estimates of pounds of fumigants per planted acre for at least some crops. It is difficult to link the effect of reducing these emissions to specific crops. Section VI discusses other site names for which pesticide use is reported by grower identification numbers utilizing this site name in order to provide some guidance regarding which crops' intensity figures are likely to be affected, but does not provide any information regarding the magnitude of any effects. This caveat is likely to become less important in the future; CDPR's implementation of quotas based on grower requests for specific fumigation purposes reduced the share of fumigant applications (and emissions) reported under this category (CDPR, 2008b).

Finally, the fourth caveat regards the annual changes in pounds of preplant soil fumigant per planted acre over the 2004 to 2006 period. The four annual crops utilizing preplant soil fumigation most intensively realized significant declines in pounds of fumigant per planted acre over this period: strawberries, tomatoes, peppers and cut flowers. There are a number of factors that may have contributed to this decline. Changes in application methods, changes in fumigant products used, and/or the use of the "Soil Application, Preplant-Outdoor (Seedbeds, etc.)" category for PUR reporting purposes may all have had an effect. Changes in the patterns of application methods and fumigant products used are discussed in CDPR (2008b). It is possible that growers chose to fumigate a smaller share of their acreage for these crops, or to reduce application rates. Another factor may be that when fumigants are applied to soil beds through drip lines only the beds are treated; consequently, only a portion of every planted acre is fumigated. An increase in the share of planted acreage treated with bed fumigation between 2004 and 2006 would have reduced the average pounds of fumigant applied per planted acre.

Strawberries

In 2006, strawberries were the largest crop in terms of the total value of production, and generated $30,690 per acre. This was the fifth highest value of production per acre for the top ten Ventura County crops.

According to PUR data, strawberries were the largest single source of peak season VOC emissions from preplant soil fumigation in Ventura County in 2004, accounting for just over three-fourths of all such emissions. VOC emissions from strawberry fumigation were over six times as large as those from the next largest single fumigant source (unspecified pre-plant soil fumigation) and over sixteen times as large as those from the next largest crop-specific preplant soil fumigation source: tomatoes. Strawberries are relatively dependent on the use of preplant soil fumigation. In 2004, 259 pounds of fumigants were applied per planted acre, substantially more than tomatoes, the second most intensive user at 185 pounds per acre.

Using only the low emission application methods specified in the January, 2008 regulations reduced estimated VOC emissions from preplant soil fumigation for strawberries by

approximately 20%. Strawberries' share of estimated VOC emissions from preplant soil fumigation increased very slightly relative to the baseline scenario.

Alternatives for reducing VOC emissions from fumigation. The California strawberry industry has qualified for a critical use exemption for continuing use of methyl bromide as a preplant soil fumigant due to a lack of technically and economically feasible alternatives for some growers. The industry does not rely exclusively on methyl bromide, however. Some producers have transitioned to alternative fumigants. In Ventura County, methyl bromide was applied to 2,651 acres in 2006, while 11,936 acres were harvested. Current alternatives to preplant soil fumigation with methyl bromide are based on fumigation with other compounds. Because the primary alternatives to methyl bromide are fumigants, they also create VOC emissions.

Given that their economically preferred option is to continue to fumigate prior to planting, growers have an economic incentive to maximize the value of their fixed VOC emission quota. Current avenues for further reducing VOC emissions from preplant soil fumigation for strawberries include additional low emission application methods, such as the use of virtually impermeable film (VIF).[1] VIF has been shown to reduce emissions from fumigants, including methyl bromide and 1,3-D (Yates et al., 2002; Martin, 2003; Papiernak et al., 2004; Gao and Trout, 2006). However, the emission reduction is highly dependent upon the success of the application. In the past there have been difficulties with the application of VIF under field conditions (Martin, 2003). Stretching can cause a break in the impermeable layer. Reported difficulties with gluing VIF sheets together in the field may affect emissions (Yates et al. 2002). Newer VIF products and increased experience with the product may partially mitigate these difficulties. VIF is also more expensive than standard polyethylene.

Even if VIF is not assigned a regulatory value that reduces VOC emissions for a given application method and fumigant it may increase fumigant efficacy. This will enable growers to reduce application rates and VOC emissions from preplant soil fumigation while maintaining efficacy and economic viability through lowering costs more than any reduction in revenues (Gullino et al. 2003; Papiernik et al., 2004; Goodhue et al. 2006).

Crop rotation can aid with the management of some pests. Approximately one-third of California's strawberry acreage is rotated with another crop (UC IPM, 1999). Because land is very expensive in Ventura County's strawberry-producing areas, strawberries must be rotated with other cash crops, rather than cover crops or fallowing.

Organic strawberry growers rely heavily on crop rotation to substitute for preplant soil fumigation. The use of appropriate cultivars and clean planting material are also important tools (Martin and Bull, 2002). In the standard organic rotation strawberries are grown once every four or more years on a given field (Bolda et al., 2006). Consequently, organic strawberry production is highly dependent on access to substantial quantities of certified organic land. Given this requirement, additional organic production is highly unlikely to emerge as a widespread means of reducing emissions from fumigation.

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[1] The use of VIF with methyl bromide is currently prohibited in California. In contrast, the use of VIF was made mandatory for methyl bromide fumigation in the EU in 2000 (Gullino et al., 2003).

Solarization is another alternative that may reduce the need for preplant soil fumigation, and hence reduce VOC emissions, although there are issues with its control spectrum and predictability of control. While solarization alone has been used successfully in California's cool coastal regions, its success at controlling pests is less predictable than in the Central Valley. Alone, it does not control some pests reliably, including yellow and purple nutsedge (Elmore et al., 1997). Another possibility is to combine solarization with reduced fumigation rates. Solarization may allow reduced rates of metam sodium and dazomet (Elmore et al., 1997; Gullino et al., 2003).

Steam is a potential replacement for preplant soil fumigation in the long term. Steam has a very broad control spectrum (Gullino et al., 2003). Using heat to kill soil pests has been done in ornamental nurseries for over a century (Baker, 1962), and steam is used in greenhouses. However, the use of steam alone for preplant soil treatments is subject to at least two important objections: it is extremely energy-intensive, and it is very slow.

Competitive situation. Strawberry production in California and in Ventura County has grown substantially over the past decade, indicating that strawberries have been a relatively profitable crop. As recently as 2000, total strawberry acreage in Ventura County's Oxnard District was only 7,591 acres, compared to 12,048 acres in 2007 (CSC, 2004; CSC, 2008).

Table IV-1. Value of Annual Production, Imports and Exports: All Strawberries, 2004-2006.

Strawberries, Total
1,000s of $

	2004	2005	2006
Value of Production			
Ventura County	363,646	328,567	366,310
Other California	677,254	794,267	828,069
Other US	254,564	272,890	320,619
Imports	128,635	159,558	220,235
Exports	207,958	238,316	281,095

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Table IV-1 summarizes the value of annual production, imports and exports for all strawberries. However, these totals are based on combining revenues from fresh sales and processed (frozen) sales. Competitive conditions are very different in these two markets.

Table IV-2 provides summary information regarding the competitive situation of Ventura County processed strawberries. Processed strawberries are storable, so there is a single worldwide market. Ventura County produced about one-third of the total value of U.S. production of processed strawberries over the 2004-2006 time period. Ventura County growers compete with growers elsewhere in California and in other states, most notably Oregon and

Washington. Internationally, the biggest supplier of U.S. imports is Mexico. Chile, Argentina and China were the next largest suppliers. Canada, Japan and Mexico were the largest importers of U.S. processed strawberries. Because processed strawberries are storable and there are many competing producers, it is unlikely that the farmgate price of processed strawberries will increase if Ventura County production declines.

Table IV-2. Value of Annual Production, Imports and Exports: Processed Strawberries, 2004-2006

Strawberries (Processed)
1,000s of $

	2004	2005	2006
Value of Production			
Ventura County	50,623	43,936	48,009
Other California	67,851	88,253	74,448
Other US	17,908	15,753	17,379
Total	136,382	147,942	139,836
Imports	56,973	67,573	89,850
Exports	15,247	14,453	20,120

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Ventura County faces very different competitive conditions in the market for fresh strawberries (Table IV-3). U.S. strawberry imports were valued at less than 10% of total U.S. production in the 2004-2006 time period. Mexico, China and Canada were the largest foreign suppliers of fresh strawberries to the U.S. Exports were even smaller, valued at 5% of total U.S. production. Canada, Mexico and Japan were the largest importers of U.S. fresh strawberries.

Table IV-3. Value of Annual Production, Imports and Exports: Fresh Strawberries, 2004-2006.

Strawberries (Fresh)
1,000s of $

	2004	2005	2006
Value of Production			
Ventura County	313,023	284,631	318,301
Other California	609,403	706,014	753,621
Other US	236,656	257,137	303,240
Total	1,159,082	1,247,782	1,375,162
Imports	71,662	91,985	130,385
Exports	192,711	223,863	260,975

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

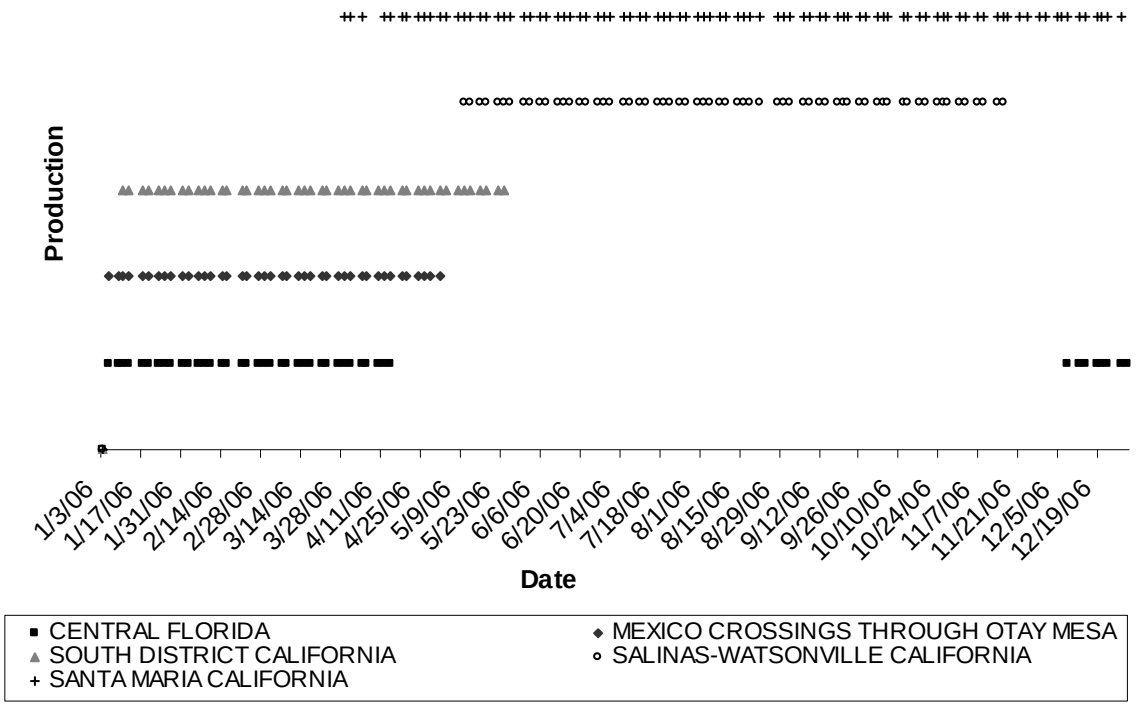
On an annual basis, Ventura County accounted for roughly a quarter of the value of U.S. production. However, this statistic underestimates the importance of Ventura County production to the strawberry industry because it ignores seasonality considerations. Figure IV-2 plots the seasonal pattern of U.S. strawberry production by major production region, along with imports from Mexico through Otay Mesa.

Per capita consumption of fresh strawberries was 5.82 pounds per person in 2005, compared to 4.86 pounds per person in 2000: a 20% increase (ERS, 2007c). Given that the average real retail price per pound of fresh strawberries has increased slightly, this increase suggests that the demand for fresh strawberries has shifted out, increasing the quantity of strawberries demanded at any given price. Frozen strawberry production per capita increased from 4.86 pounds per person to 5.82 pounds per person: also a 20% increase (ERS, 2007c).

Estimates of the own-price elasticity of demand for strawberries vary. Within a demand system for major fruits, Henneberry, Piewthongngam, and Qiang (1999) actually estimate a positive value, which implies that the quantity of strawberries demanded increases with the price of strawberries. This counter-intuitive finding may be due in part to their use of annual data and their choice of products to include in the demand system. Price and Mittelhammer (1979) estimate an own-price farmgate elasticity of demand of -1.96. You, Epperson and Huang (1996) estimate a retail own-price elasticity of -0.28.[2] Incorporating seasonality considerations, Carter et al. (2005) provide "stage" estimates that generate a volume-weighted own-price elasticity of demand for Ventura strawberries at the farmgate level of -1.57.

Figure IV-2. Seasonal Pattern of Fresh Strawberry Production: U.S. and Mexico

[2] Retail data do not take food service sales into account.



Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

If Ventura County growers decrease strawberry production in response to the January, 2008 regulations, there may be a corresponding increase in prices that may at least partially offset the reduction in the quantity produced and any cost increases. Accordingly, while there is some scope for increased production by competing regions any substantial decline in Ventura County strawberry production will almost certainly induce a price increase. This increase will mitigate revenue losses due to increased production. Based on the more aggregate estimates of inelastic demand, the increase in price will offset the decrease in quantity. However, based on the seasonality-adjusted own-price elasticity of demand from Carter et Al. (2005) the increase in price will not offset the decrease in quantity entirely, and revenues will decline.

If growers anticipated a decrease in profits per acre, economic theory predicts that they would take strawberry acreage out of production in favor of other crops, or reduce total production acreage if they do not grow any other crops. The 2008 California Strawberry Commission acreage survey provided a snapshot of growers' planting intentions when the emission allowance system was expected to be in effect without the phase-in period. It reported an estimated overall acreage decline for 2008 strawberry plantings in Ventura County of 3.7%, or 448 acres. It reported a 27 acre decline (0.32%) decline in fall-planted acreage, and an estimated 421 acre decline (11.9%) in 2008 summer-planted acreage. The latter decline may be due to the 2008 preplant soil fumigation use regulations, anticipated market conditions, or some combination of the two.

Information available prior to August 2008 regarding growers' emission allowance acreage requests combined with their 2008 summer planting intentions suggested that there may not have been a decline in fall-planted strawberry acreage, even if the initial quotas had remained in place. Growers requested emission allowances for 13,681 acres of pre-plant fumigation for strawberries (CDPR, 2008b). Assuming that preplant fumigation for all summer-planted strawberries occurred no earlier than May 1, these requests should include the estimated 3,124 acres of 2008 summer-planted strawberries (CSC, 2008), plus the strawberries intended to be planted in fall 2008 for the 2009 market, which are not reported in the 2008 survey. The difference between reported summer planting intentions and the acreage included in the emission allowance requests equals 10,557 acres in growers' projected fall-planted strawberry acreage in Ventura County, which is an increase of 2,082 acres (24.6%) over the reported 2007 fall plantings in the 2008 survey. In contrast, actual fall 2008 plantings for the 2009 season were 8,713 acres, slightly over the 8,564 acres planted in fall 2007 (CSC, 2009). Actual summer 2008 plantings were 3,157 acres, only slightly higher than intended plantings (CSC, 2009).

There are at least two reasons why the implied increase in fall-planted strawberry acreage was so much larger than actual plantings. First, growers may have been conservative in their emission allowance requests and requested the maximum possible acreage they projected that they might plant. Second, they may have anticipated market conditions that will be sufficiently favorable to make a large acreage expansion profitable, but updated their expectations between the acreage survey and the actual planting time. Both reasons may have played a role. In any event, growers' announced acreage allocation decisions suggested that they did not anticipate large negative effects of the 2008 regulations on the profitability of fall-planted strawberries in 2008.

Nursery and ornamentals

Nursery stock was the second largest crop in Ventura County in 2006 in terms of total revenues from production. Calculating its revenues per acre is challenging, primarily because it is difficult, if not impossible, to assign revenues to open field acreage versus covered (greenhouse) acreage for nursery production on an aggregate basis. Consequently we offer three approaches to estimating revenues per *open field* acre. Nursery production produced $55,721 per acre in revenues if field acres and greenhouse acres are assumed to have the same average value of production for all products. Another way to address the value of open land in nursery production is to focus on nursery categories with negligible greenhouse production area (less than 1% of total production area). Three nursery categories meet this criterion: fruit and nut trees ($92,500 per acre); woody ornamentals ($69,130 per acre); and bedding plants, ground cover and turf ($30,748 per acre). These three categories produced an average of $50,525 in value of production per acre. Weighting the three categories' value of production per acre by their share of the sum of their total value of production yielded an average value of production per acre of $58,635. Overall, based on these various calculations we rank the nursery stock sector as one of the top four crops in terms of value of production per acre in open fields, along with cut flowers, tomatoes, and raspberries.[3]

[3] While cut flowers have the highest value of production per acre, as with nursery production it is difficult to calculate the precise value of production per open field acre due to the difficulty of separating greenhouse and field production. The same problem applies to fresh tomatoes. See the tomato crop profile for additional information.

According to CDPR estimates using PUR data, under the 2004 baseline scenario, ornamental turf accounted for roughly 1% of total peak season VOC emissions from preplant soil fumigation in Ventura County. No other category of nursery production accounted for more than 0.05% of total emissions. Overall, nursery production has a very low intensity of preplant soil fumigation use. For the sector as a whole, 11.5 pounds per acre planted were applied in 2004.[4] In addition to the caveats discussed at the beginning of this section, the downward trend in pounds of fumigant per acre may also be affected by shifts in product mix within the nursery sector.

Using only the low emission application methods specified in the January, 2008 regulations reduced estimated VOC emissions from preplant soil fumigation of ornamental turf by approximately 25%. The share of estimated VOC emissions from preplant soil fumigation was very close to constant.

Alternatives for reducing VOC emissions from fumigation. Regulations governing plant certification and plant movement are an important concern for the nursery industry. Turf and sod was the only nursery crop for which VOC emission allowances were requested for 2008 (CDPR, 2008b). Preplant soil fumigation is an important tool that aids in enabling nursery crops to be certified to be nematode-free, as required by state law. For nematode management, UC IPM guidelines for commercial turfgrass (UC IPM, 2003b) recommend preplant soil fumigation with methyl bromide, chloropicrin or metam sodium. Turfgrass producers also use preplant soil fumigation to prevent contamination of a new variety or species with volunteer plants from the previously planted crop.

The use of VIF in the nursery and ornamental industry could reduce VOC emissions from preplant soil fumigation. Steam, which has been proven effective in greenhouse settings, is a potential substitute for field fumigation. See the discussion of these methods for reducing emissions from fumigation in the strawberry crop profile for additional information.

Competitive situation. In 2006, $263.9 million in nursery stock was produced in Ventura County. Of this, $68.7 million was in the bedding plants, ground cover and turf category, which includes turf and sod production. The bedding plants, ground cover and turf category accounted for 17 acres of greenhouse production, and 2,218 acres of open field production in 2006 (VCAC, 2007).

The complexity of the nursery and ornamental industry is evidenced in any assessment of its competitive situation. Carman and Rodriguez (2004) provide an assessment of the economic role of the California nursery industry utilizing data from 1982-1997, but do not evaluate factors affecting its competitiveness relative to other states and countries. They report that in 1997 California accounted for only 7.36% of all U.S. farms producing nursery and floriculture crops, 16.86% of U.S. square feet under glass or other protection, and 7.33% of open field acres. Using these inputs, California accounted for 20.20% of the total value of U.S. nursery and floriculture sales. The higher per acre values generated in California indicate a potential competitive advantage, although it depends also on the intensity of the use of other inputs per

[4] For this calculation the nursery sector was defined to include the following five PUR site names: N-Grnhs Plants In Containers, N-Grnhs Transplants, N- Outdr Plants In Containers, N-Outdr Transplants, and Turf/Sod.

acre, their prices, and the cost of land. An off-setting consideration is that the nursery and ornamental industry is distributed throughout the southern U.S. and near other major population centers in part because growers who are located near their customers are able to provide fresher products (Strickland, 2007).

Lemons

Lemons were Ventura County's third-largest crop in terms of total value of production in 2006. On a per-acre basis, lemons generated $10,029 in revenues, the eighth highest value of production per acre.

In Ventura County, preplant soil fumigation is used when citrus groves are planted on land that was previously planted to citrus. Due to the long productive life of a citrus grove, annualized VOC emissions from preplant soil fumigation of a given grove are limited. However, in terms of regulatory compliance the emissions are "lumpy." They all occur in the year the grove is replanted. Thus, their contribution to total emissions depends on replant and acreage expansion decisions rather than total acreage at any given point in time. Their intensity of use of preplant soil fumigation depends on all of these factors. Lemons used one pound of fumigant per planted acre in 2004.

Alternatives for reducing VOC emissions from fumigation. UC pest management guidelines identify preplant soil fumigation as a means of controlling citrus nematode when a citrus orchard is replanted, even when planting a resistant rootstock (UC IPM, 2003a). A 1997 UC cost study for Ventura County lemon production does not include preplant soil fumigation; the cited reason is that, commonly, fumigation with methyl bromide is not done due to its expense (Takele, Sakovich and Walton, 1997). However, a 2005 UC cost study for Ventura County mandarin production does include preplant soil fumigation with Endzone (Takele, Faber and Nigatu, 2005).

Other tools are also recommended for use in managing damage due to citrus nematodes. Rotating into annual crops for one to three years before replanting a citrus orchard helps decrease citrus nematode populations, and the use of a resistant rootstock is always recommended regardless of whether or not citrus nematodes are present prior to planting (UC IPM, 2003a; CCQC, 2003).

Competitive situation. There are two primary products in the lemon market: fresh lemons and lemon juice. For California as a whole, about two-thirds of the lemon crop is sold in the fresh market, and the remainder is sold as juice (ERS, 2007a). Traditionally, the juice market has been considered a residual market, rather than a primary market. This discussion focuses on the fresh lemon market. Table IV-4 reports fresh lemon imports, exports, and value of production for Ventura County, the rest of California and all other states for 2004-2006. 2005 was an unusual year for U.S. citrus, due to two consecutive harvests affected by hurricanes in Florida that raised prices. California ships fresh lemons year round; harvest begins in the late summer in the desert, then moves to the coast and San Joaquin Valley (ERS, 2007a).

Ventura County is the most important lemon-producing county in the U.S., accounting for 47% of U.S. production according to value in 2006. However, its share has declined precipitously; as

recently as 2004, Ventura County produced 64% of U.S. production. The change in Ventura County's share of California's production has been comparable, declining from 72% in 2004 to 49% in 2006. One driver of this shift was a 15% decrease in Ventura County's lemon acreage between 2004 and 2006. The other was that over the same time period acreage increased in other parts of the state, as did California's total volume produced.

The U.S. is the world's second largest lemon producer, following Argentina. Imports are relatively small compared to exports and to production, and peak in the summer when domestic supplies are smallest and demand is greatest. Chile, Mexico and Spain were the biggest suppliers of U.S. imports in 2006. Exports were valued at slightly under 20% of U.S. production in 2006. Japan, Canada and Hong Kong were the biggest buyers of U.S. exports, followed by South Korea and Australia. Japan accounts for about half of total fresh lemon exports.

Table IV-4. Value of Annual Production, Imports and Exports: Lemons, 2004-2006.

Lemons
1,000s of $

	2004	2005	2006
Value of Production			
Ventura County	176,361	179,228	191,552
Other California	68,921	101,630	198,376
Other US	30,338	28,443	35,601
Total	275,620	309,301	425,529
Imports	19,240	16,320	20,294
Exports	66,963	75,992	83,159

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Per capita annual fresh lemon consumption has risen slightly over the past two decades, and is now slightly over three pounds (USITC, 2006). Demand for fresh lemons tends to be strongest in the summer (ERS, 2007a). Overall, the demand for fresh lemons is relatively inelastic. Estimates in the literature of the farmgate price elasticity of demand for fresh lemons include -0.34, (Green, 1999) and -0.21 (Nuckton, 1978). You, Epperson and Huang (1996) estimate a retail own-price elasticity of -0.20.

Consumption of lemons is relatively unresponsive to a change in price; consequently, a substantial increase in lemon production in Ventura County would lead to a relatively large decline in the price of lemons, other things equal. If only domestic demand was relevant, this would tend to limit the economic incentive for growers to replace crops that use fumigants relatively intensively with lemons and other perennial crops, which are fumigated only prior to planting, if at all. The international market for fresh lemons is very competitive; the ability of growers to expand production for export purposes profitably is uncertain. U.S. growers,

including Ventura County growers, face high input costs compared to those faced by producers in some exporting countries, such as Argentina. While U.S. lemons have had an international reputation for high quality, other countries are now able to compete on the quality dimension as well (USITC 2006).

Celery

Celery was Ventura County's fourth largest crop in terms of total value of production in 2006. On a per-acre basis celery generated $12,110 in revenues, ranking it seventh.

While metam sodium is applied to celery, the crop accounted for less than 0.05% of peak season VOC emissions from preplant soil fumigation in CDPR's 2004 baseline scenario. Celery's intensity of use of soil fumigants is relatively low for an annual crop: 0.9 pounds per acre in 2004.

Although it is not highly dependent on preplant soil fumigation directly, to the extent it is rotated with fumigated crops its benefit from the use of preplant soil fumigation is understated. Because celery is a weak competitor with weeds, it is often rotated with cool or warm season vegetable crops that have effective weed management systems, like broccoli, lettuce, and strawberries. Rotating celery with strawberries is particularly beneficial, because preplant soil fumigation is effective at eliminating weeds (UC IPM, 2005).

Competitive situation. Ventura County produced 46% of the value of California's celery crop in 2006 (Table IV-5). California accounted for 94% of the value of U.S. production that year, so Ventura County accounted for 43% of national production. Although celery is produced in many states, California and Florida account for the majority of the crop.

Table IV-5. Value of Annual Production, Imports and Exports: Celery, 2004-2006

Celery
1,000s of $

	2004	2005	2006
Value of Production			
Ventura County	122,832	114,759	144,313
Other California	150,744	134,057	167,884
Other US	15,215	10,493	19,920
Total	288,791	259,309	332,117
Imports	9,044	10,258	11,326
Exports	53,782	55,104	58,435

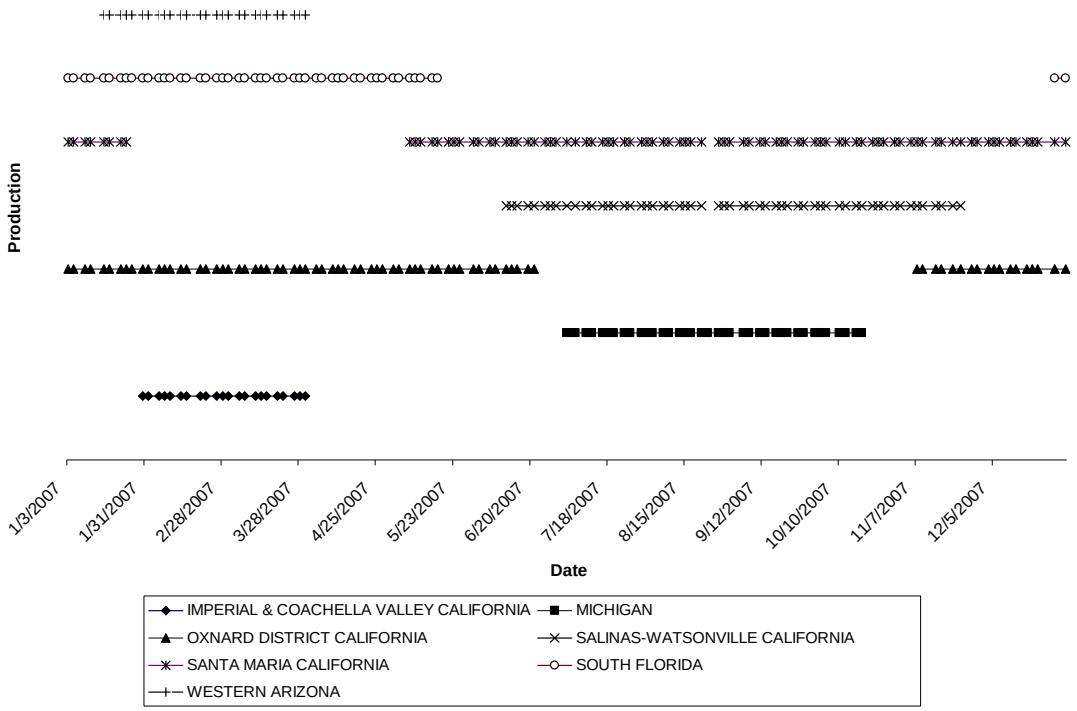
Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Total U.S. consumption of celery was steady from 1960 to 2000 (ERS, 2005). However, domestic celery consumption per capita has declined slightly over the past two decades: about 2% per year (ERS, 2005). Demand for celery is fairly constant throughout the year, but peaks during the holiday season. Though there is some demand for processed celery, the majority of celery production is for the fresh market (ERS, 2000). Estimates of the demand for celery suggest that it is own-price inelastic. Huang (1986) estimates an own-price elasticity of demand for celery of -0.25 at the farmgate. Taylor and Kilmer (1988) estimate an own-price elasticity of demand for celery of -0.42 at the farmgate. You, Epperson and Huang (1996) estimate an own-price elasticity of demand for celery of -0.05 at retail.

Figure IV-3 displays the seasonal location of celery production in 2007. Only domestic production locations are displayed in the figure because celery imports are insignificant, as shown in the above table. Ventura County produces celery from the beginning of November until late June. It competes with at least one other producing region throughout its season.

The highly inelastic demand for celery and its slightly declining per capita consumption suggest that a substantial increase in supply by Ventura County producers would result in a correspondingly substantial decrease in the price, especially because Ventura County accounts for a fairly large share of national production.

Figure IV-3. Seasonal Pattern of Celery Production, 2007



Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

Tomatoes

Tomatoes were Ventura County's fifth largest crop in terms of value of production in 2006. Tomatoes generated $58,832 in revenues per acre, ranking it among the top four crops along with cut flowers, nursery production, and raspberries. This revenue per acre figure overstates revenues per acre for field tomatoes to an unknown extent. It includes hydroponic tomatoes as well as field-grown tomatoes (VCAC, 2007). Data are unavailable for dividing Ventura County tomato production into these categories.[5] Knowing that greenhouse tomatoes constitute some share of the whole, revenues per acre for field-grown tomatoes are almost certainly lower than revenues per acre for nursery stock. However, by the same token, available information regarding the extent of greenhouse tomato production in Ventura County suggests that it is rather unlikely that the value per open field acre is lower than that of strawberries, the crop with the fifth highest value of production per acre of $30,690.

[5] Houweling Nurseries, a Canadian firm, owns the only substantial tomato-producing greenhouse in California. The 34 hectare greenhouse (84 acres) is located on 65 hectares of land near Oxnard. The location allows for winter production of on the vine and beefsteak tomatoes, as well as cucumbers. The company's greenhouses in British Columbia and Oxnard make it one of only two greenhouse tomato firms that produce year-round in North America. However, the Oxnard facility is in direct competition with Mexican producers and major US greenhouses in Arizona (Eurofresh), Colorado (SunBlast), and Texas (Village Farms).

According to CDPR estimates using PUR data, tomatoes accounted for just under 5% of total peak season VOC emissions from preplant soil fumigation in Ventura County in 2004. Of these emissions, 49% were due to methyl bromide use, 44% to chloropicrin, and the remainder to 1,3-dichloropropene. As noted above, VOC emissions from preplant soil fumigation of tomatoes were considerably smaller than those from preplant soil fumigation of strawberries. VOC emissions from preplant soil fumigation of tomatoes were over three times as large as those from the next crop: nursery-grown cut flowers or greens. Compared to other crops, tomatoes utilize preplant soil fumigation relatively intensively. In 2004, 185 pounds of fumigant per planted acre were applied.

Using only the low emission application methods specified in the January, 2008 regulations reduced estimated VOC emissions from preplant soil fumigation of tomatoes by approximately 20%. Tomatoes' share of estimated VOC emissions remained constant.

Alternatives for reducing VOC emissions from fumigation. California producers were not included in the tomato request for a critical use exemption for methyl bromide for 2010, although methyl bromide accounted for approximately half of 2004 VOC emissions from preplant soil fumigation of tomatoes in Ventura County. Field-grown tomatoes are used in crop rotations in order to increase revenues per acre as well as for pest control benefits. Preplant soil fumigation of tomatoes can benefit the cool-weather crops that follow, such as lettuce and cabbage.

Cultural practices can aid in tomato pest management. Crop rotation can help in managing tomato pests (UC IPM, 2008). The UC IPM Guidelines for tomatoes (2008) indicate that the use of nematode-resistant varieties and rotation with non-host crops is as effective as preplant soil fumigation for nematode management. For Fusarium wilt and Verticillium wilt, the use of resistant varieties is recommended, to the extent that these varieties are available. Because it is long-lived, using crop rotation as a control for Fusarium wilt requires rotation out of tomatoes for several years in order to reduce inoculum. For Verticillium wilt, crop rotation with non-susceptible crops can reduce inoculum (UC IPM, 2008). The UC IPM Guidelines for tomatoes address processed and fresh tomato production. The economic viability of rotating fresh tomatoes with small grains and corn in Ventura County is much less than the economic viability of rotating processed tomatoes with small grains and corn in the Central Valley, due to higher land costs.

In greenhouse tomato production, Giannakou, Sidiropoulos and Prophetou-Athanasiadou (2002) evaluated the ability to control rootknot nematodes of three non-fumigant nematicides (oxamyl, fenamiphos and cadusafos) and four fumigants (dazomet, metam sodium, methyl bromide-chloropicrin and 1,3-D). They found that the non-fumigant nematicides provided less effective control of root-knot nematodes than the four fumigants did.[6] The applicability of these greenhouse trial results to field tomato production is unclear.

Competitive situation. Ventura County produced 20% of the value of California's fresh tomato crop in 2006 (Table IV-6). California accounted for 32% of the value of U.S. production that year, so Ventura County accounted for 6% of national production. Although fresh tomatoes are

[6] The specific products used for each active ingredient were Vydate (oxamyl), Nemacur (fenamiphos), Rugby (cadusafos) Basamid (dazomet), Vapam (metam sodium), methyl bromide-chloropicrin (98-2) and Condor (1,3-D).

produced in many states, Florida accounts for the largest share of U.S. fresh tomato production, followed by California. Among the remaining states, Ohio, Virginia, Georgia and Tennessee were the next-largest producers in 2006.

Table IV-6. Value of Annual Production, Imports and Exports: Fresh Tomatoes, 2004-2006

Fresh Tomatoes
1,000s of $

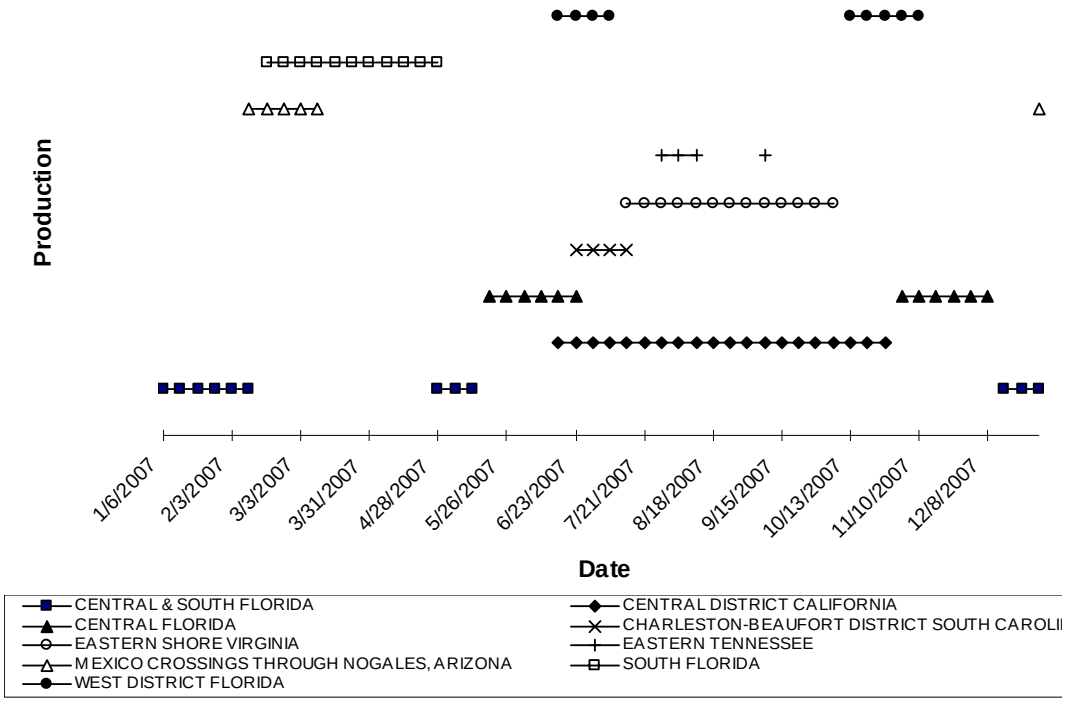
	2004	2005	2006
Value of Production			
Ventura County	71,735	74,988	102,426
Other California	438,649	272,212	402,694
Other US	919,293	1,251,628	1,091,156
Total	1,429,677	1,598,828	1,596,276
Imports	1,053,538	1,074,836	1,233,608
Exports	174,787	166,279	172,502

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Mexico and Canada account for the vast majority of fresh tomato imports. Tomatoes are imported from Mexico year round, although the production region varies seasonally. Tomatoes imported from Canada are mostly grown in greenhouses and shipped throughout most of the year, except for mid-winter (Cook and Calvin, 2005). Fresh tomato exports are limited, compared to U.S. production and imports. Canada was the top importer of U.S. tomatoes, followed by Mexico.

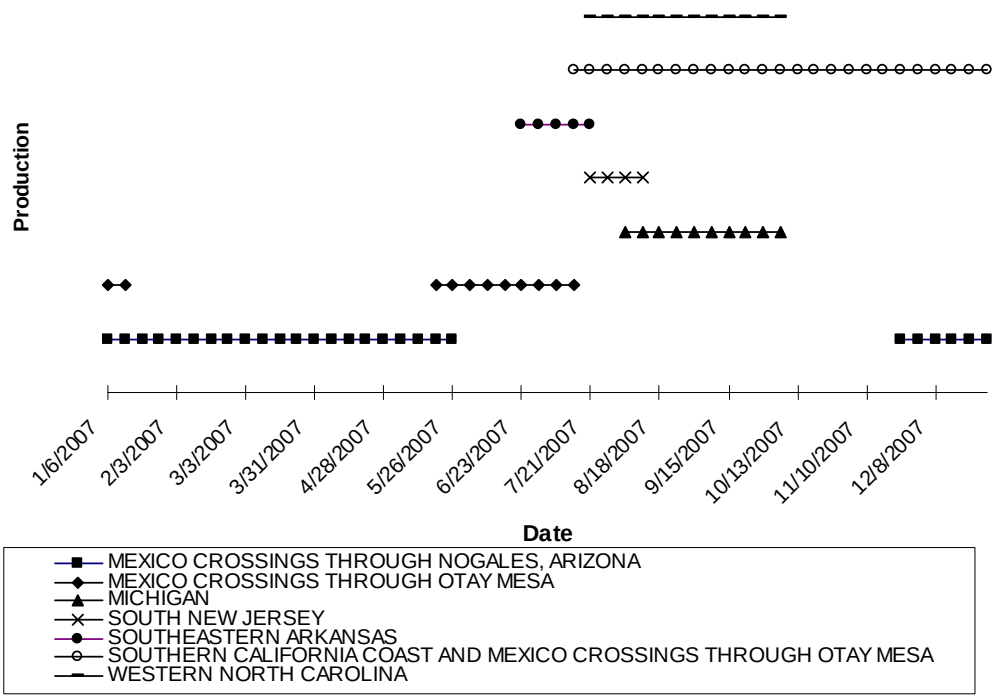
Figures IV-4 through IV-7 depict the seasonal pattern of production in the U.S. and imports from Mexico for four tomato categories: mature green tomatoes, vine-ripe tomatoes, grape tomatoes, and cherry tomatoes. Notably, over the majority of its season for producing mature green tomatoes California's Central District competes only with producers in Virginia and elsewhere on the Eastern seaboard (Figure IV-4). Competition from Florida occurs only at the beginning and end of the season. In Figures IV-5 to IV-7 imports from Mexico and California shipments are included in a single category.

Figure IV-4. Seasonal Pattern of Production: Mature Green Tomatoes, 2007



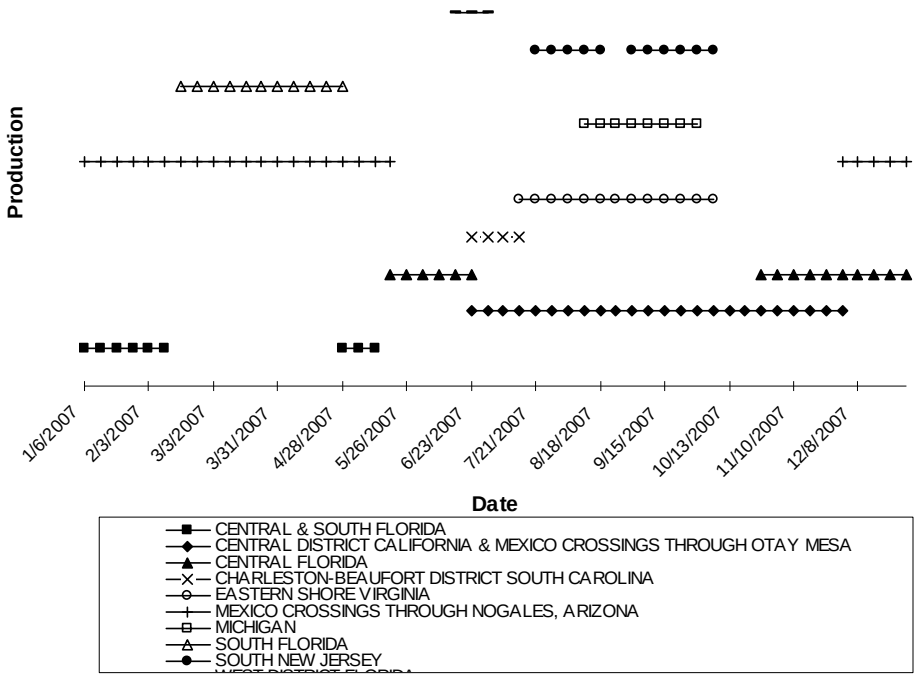
Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

Figure IV-5. Seasonal Pattern of Production: Vine-Ripe Tomatoes, 2007



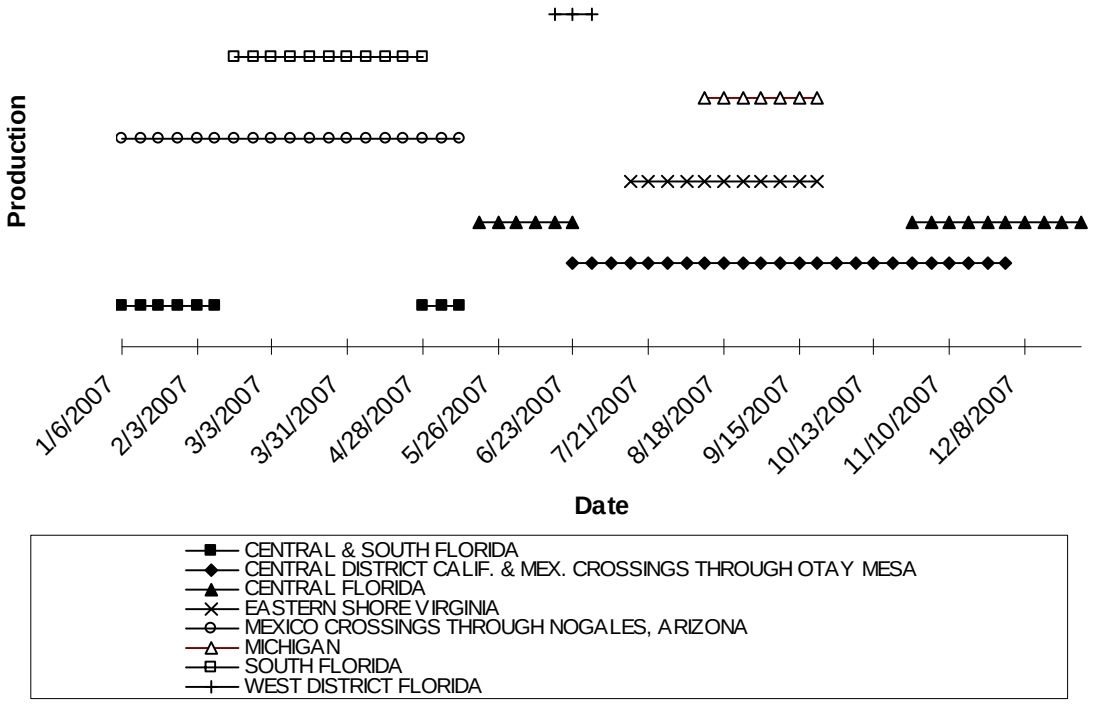
Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

Figure IV-6. Seasonal Pattern of Production: Grape Tomatoes, 2007



Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

Figure IV-7. Seasonal Pattern of Production: Cherry Tomatoes, 2007



Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

As noted earlier, data are not available that separate greenhouse and field tomato production in Ventura County. Cook and Calvin (2005) provide a national breakdown of greenhouse and field fresh tomato production and trade for the U.S., Canada and Mexico.[7] Over the past 15 years, greenhouse tomato sales in the U.S. have gone from virtually negligible levels to 37% of the fresh tomatoes sold at retail and 17% of fresh tomatoes consumed (Cook and Calvin, 2005).

A wide variety of tomato categories are available to U.S. consumers. Some of these categories are primarily produced in greenhouses, and some are primarily produced in the field. Greenhouse production tends to emphasize tomato-on-vine sales, including cherry tomato-on-vine and Campari tomatoes. Beefsteak tomatoes are another major category, although their share has declined in favor of tomato-on-vine (Cook and Calvin, 2005). Traditionally, field production focused on the mature green tomato. In part in response to increased competition from greenhouse production, field producers have reduced their production of mature green tomatoes and increased production of vine-ripe tomatoes, cherry tomatoes, plum tomatoes, roma tomatoes, and heirloom tomatoes (Cook and Calvin, 2005).

Tomatoes have the fourth highest per capita consumption among fresh vegetables in the U.S., following potatoes, lettuce and onions (ERS, 2008).[8] In 2003, per capita consumption of fresh tomatoes was 19.4 pounds, an increase of 30% since 1985 (Cook and Calvin, 2005). The increase in per capita consumption has been linked to an increase in the number of immigrants who eat more vegetables than most Americans (ERS, 2008), increased consumer awareness of the links among diet, nutrition and health (ERS, 2008), and increased use of tomatoes and other produce by fast-food companies, including McDonald's (Cook and Calvin, 2005).

Studies estimating the price elasticity of demand for fresh tomatoes vary in terms of how they define the product and the level of the marketing chain they analyze; the resulting estimates vary in the manner predicted by economic theory. The demand for more differentiated products, by national origin or product category, is estimated to be more elastic than the demand for the aggregate fresh tomato category. Green, Howitt and Russo (2006) estimate an own-price elasticity of domestic demand for fresh tomatoes of -0.25, which is relatively inelastic. They do not allow for any product differentiation within the fresh tomato market. Jung, Van Sickle, and Seale (2005) estimate a system of demand in the U.S. for fresh tomatoes produced in the U.S., Canada and Mexico. Depending on the econometric specification, they find uncompensated own-price demand elasticities for U.S.-produced tomatoes ranging from -0.61 (double-log model) to -1.20 (restricted FD/AIDS with homogeneity and symmetry). The restricted Rotterdam specification results in an own-price demand elasticity of -0.85. The only product differentiation they consider is the source of the fresh tomatoes. They do not account explicitly for seasonality. Grant and Foster (2005) estimate U.S. fresh tomato demand at the retail level for tomatoes produced in the U.S., Canada and Mexico. Their estimate of the own-price flexibility

[7] It is important to note that California's definition of greenhouse tomato requires production in a non-soil medium in order for the greenhouse label to be used; other states, Canada, and Mexico do not have this regulatory requirement.

[8] The summer 2008 *Salmonella Saintpaul* outbreak reported initially to be associated with raw red Roma tomatoes, raw red plum tomatoes and raw red round tomatoes will have a negative effect on 2008 per capita tomato consumption. Whether or not it will affect consumers' decisions in the longer term remains to be seen. The federal government cleared California as a source of the outbreak on June 10, 2008.

of U.S.-produced fresh tomatoes implies an own-price demand elasticity of -1.64. They use seasonal dummies to represent when each country supplies fresh tomatoes. Thompson (2003) uses retail scanner data to look at domestic demand for fresh tomatoes for five tomato categories in six metropolitan markets. Because he accounts for product differentiation and examines multiple markets, his findings cannot be summarized with a few numbers. While the absolute value of elasticities varies across markets, overall mature green tomatoes and greenhouse-grown tomatoes (excluding on-the-vine tomatoes) tend to have the most elastic demands. Tomatoes sold on-the-vine tend to have less elastic demands than those two categories, although demand was still elastic in two markets and not too inelastic in three additional markets. Only one market displayed an own-price elasticity with a magnitude less than 0.5, and the estimate was not significantly different from zero. No pattern was apparent across metropolitan areas regarding the elasticity of prices for roma and cherry tomatoes relative to the other three categories. Overall, there was very little evidence that consumers substituted across tomato categories based on relative prices.

Although tomato acreage has registered a substantial decline recently, demand conditions suggest that Ventura County growers could expand tomato production without having a substantial adverse effect on price, provided they are responsive to market forces. The steady increase in per capita consumption in spite of increasing real prices for fresh tomatoes, and the demographic changes linked to increased per capita consumption suggest that the demand for fresh tomatoes may be shifting outward, increasing the quantity of tomatoes demanded at a given price. The relative lack of price-based substitution by consumers across tomato categories combined with the relatively high own-price elasticities of demand for mature green tomatoes and on-the-vine tomatoes found by Thompson (2003) suggest that Ventura County growers may be able to expand production in specific categories, such as vine-ripe tomatoes, without having substantial negative effects on price. Ventura County accounts for a small share of U.S. production and an even smaller share of domestic consumption, suggesting that even a large percentage increase in Ventura County's production will have only a small effect on tomato prices, especially given the relatively elastic demand. On the other hand, other regions may be better-placed than Ventura County to respond to aggregate demand conditions, which could have induced the observed reduction in tomato acreage; or other crops could have resulted in higher profits per acre, which also could have induced a reduction in tomato acreage.

Avocados

Avocados were Ventura County's sixth largest crop in terms of total value of production in 2006. On a per-acre basis avocados generated $5,323 in revenues, ranking it the ninth highest among Ventura County's top ten crops.

Table IV-7. Value of Annual Production, Imports and Exports: Avocados, 2004-2006.

Avocados
1,000s of $

	2004	2005	2006
Value of Production			
Ventura County	124,662	54,803	87,391
Other California	255,498	221,527	263,609
Other US	14,207	14,914	11,808
Total	394,367	291,244	362,808
Imports	156,971	337,508	245,975
Exports	2,510	3,003	11,860

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

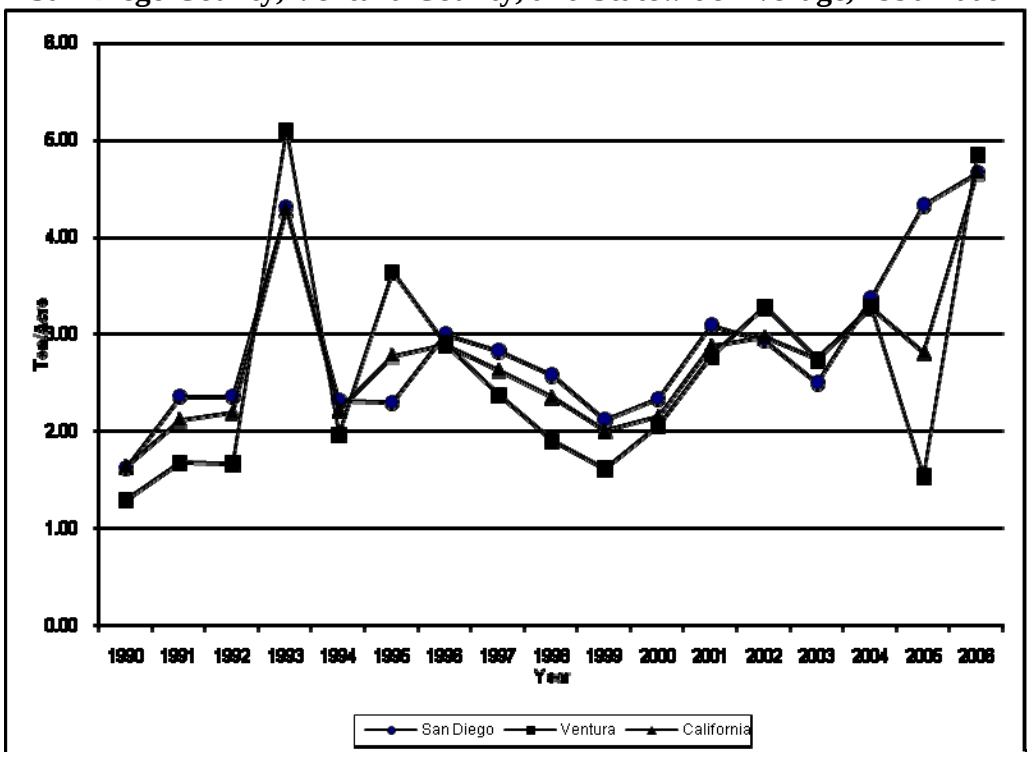
Competitive situation. Ventura County produced 25% of the value of California's avocado crop in 2006 (Table IV-7). California accounted for 97% of the value of U.S. production that year, so Ventura County accounted for 24% of national production. Florida and Hawaii are the other avocado-producing states. California yields tend to be lower than those in Florida, in part due to the differentiated products grown in the two states; Florida produces primarily green-skinned varieties, while California produces primarily Hass avocados (ERS, 2006). On average, the U.S. was the third largest producer of avocados worldwide over the 2003-2005 time period (ERS, 2006), behind Mexico and Indonesia.

Imports are substantially more significant than exports in the U.S. avocado market. In 2006, U.S. exports were valued at less than 3% of production, while imports accounted for slightly more than 40% of domestic sales. Mexico, Chile and the Dominican Republic were the largest suppliers of U.S. imports. At the end of 2004, trade barriers restricting the importation of Mexican avocados to the U.S. were largely lifted, which allowed Mexico to increase its U.S. sales substantially. In 2006 barriers restricting the importation of U.S. avocados to Mexico were also lifted, although the importance of this action to the avocado market as a whole is much smaller.

New varieties and improved production practices, such as denser plantings, have allowed U.S. avocado production to increase in spite of a reduction in total acres (ERS, 2006). Figure IV-8 plots annual avocado yields for San Diego County, the leading avocado-producing county,

Ventura County, and the rest of California. While yields are affected by weather, pests, etc., there appears to be a slight upward trend over the 1990-2006 time period. Figure IV-9 plots annual avocado acreage for San Diego County, Ventura County, and the rest of California. Ventura County's 2006 avocado acreage was at its lowest level since 2001. Some new avocado plantings have replaced Valencia orange groves in Ventura County (ERS, 2006).

Figure IV-8. California Avocado Yields:
San Diego County, Ventura County, and Statewide Average, 1990-2006



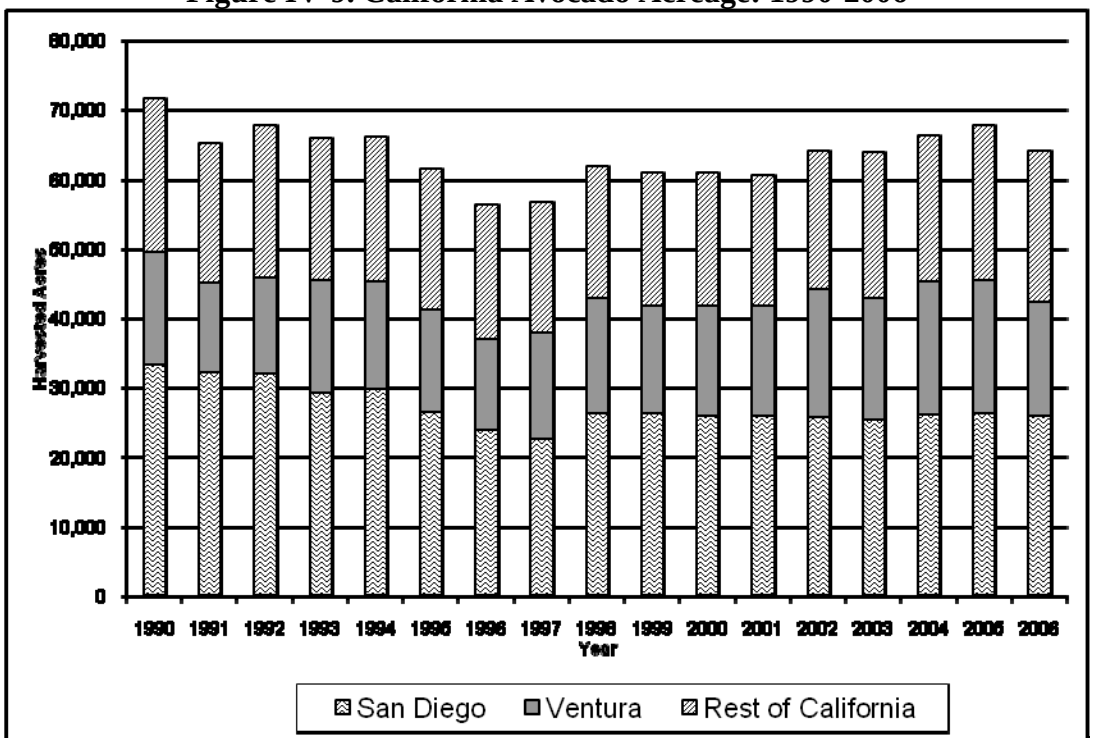
Source: http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp.

Domestic demand for avocados is increasing. Per capita avocado consumption has increased by 7.2 percent annually since 1990 with the increase attributed to an increasing Hispanic population, an increasing interest in ethnic foods among the broader population, an increased interest in healthy foods, and promotional and educational efforts by the industry (ERS, 2006). Consumption has been increasing faster than domestic production (ERS, 2006). Carman and Craft (1998) estimate a farmgate demand elasticity for avocados of -0.75. Green (1999) estimates a farmgate demand elasticity of -0.86.

Although the demand for avocados is inelastic, the steady increase in annual consumption in spite of constant to declining real farmgate prices, along with the factors thought to be driving the increase suggest that demand is shifting outward, and that there may be the potential for Ventura County to increase its avocado production substantially, replacing acreage currently planted to crops that use preplant soil fumigation relatively intensively. Success in differentiating California's Hass avocado production from the production of other varieties could reduce the price effect of increased production by Ventura County. Current water shortages and

the recent loss of avocado acreage in San Diego County may provide more favorable market conditions for Ventura County growers in the short term.

Figure IV-9. California Avocado Acreage: 1990-2006



Source: http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp.

Raspberries

Raspberries were Ventura County's sixth largest crop in terms of total value of production in 2006. Value of production per acre was $54,392, ranking it among the top four crops, along with cut flowers, nursery production, and tomatoes.

According to CDPR estimates using PUR data, under the 2004 baseline scenario raspberries accounted for 1% of total peak season VOC emissions from preplant soil fumigation in Ventura County. Of these emissions, 81% were due to methyl bromide and 19% to chloropicrin. Raspberries' 2004 intensity of fumigant use was among the five highest among major crops: 56 pounds per planted acre.

Using only the low emission application methods specified in the January, 2008 regulations reduced estimated peak season VOC emissions from preplant soil fumigation of raspberries by approximately 25%, slightly reducing its share of estimated VOC emissions from pre-plant fumigation.

Alternatives for reducing VOC emissions from fumigation. Preplant soil fumigation is an important tool in managing arthropods, weeds and diseases. The University of California

Integrative Pest Management Guidelines (UC IPM) highlights the use of fumigation in dealing with root weevils, Armillaria root rot, Phytophthora root rot, and Verticillium wilt. The standard soil treatment is a combination of 14 gallons of Telone and 200 pounds of chloropicrin per acre (UC IPM, 2005). Due to the high per-acre value of fresh raspberries, the use of VIF to reduce VOC emissions from pre-plant fumigation may be economically feasible. See the strawberry crop profile for additional information regarding VIF.

There is no single alternative to preplant fumigation of raspberries, although cultural practices that can aid in the management of individual pests and diseases have been identified. For root weevils, an application of parasitic nematodes may be used (UC IPM, 2006). UC IPM recommends the removal and destruction of plants, roots, and stumps infected by Armillaria root rot along with the installation of barriers. Buried barriers constructed of plastic, ditches, or strips of land planted with non-susceptible plants can help prevent the spread of the disease. Although these strategies slow the spread of the disease the removal of all infected material is difficult to achieve (UC IPM, 2006).

Raspberries are highly susceptible to Phytophthora root rot. The only alternative to soil fumigation offered by UC IPM is to plant in soil that is not infested and which has good drainage. Studies conducted elsewhere evaluate other cultural practices. Many authors highlight the use of raised beds, which improves drainage, with another method of disease prevention. Wilcox, Pritts, and Kelly (1999) recommend the use of raised beds, the fungicide metalaxyl, and resistant varieties after studying the combination of several methods for controlling Phytophthora root rot in New York raspberries. The authors warn that any agricultural practice that increases soil moisture should be monitored closely. Maloney et al. (2005) find that a gypsum amendment, a source of calcium, complements the use of fungicides and raised beds. Pinkerton et al. (2002) found that soil solarization in managing root rot in strawberries and raspberries is effective in the cooler, northern regions of the U.S. The authors argue that solarization may become a component in a pest management strategy that includes the other cultural practices mentioned in the studies above.

Verticillium wilt is difficult to manage even with fumigation. Growers should not plant raspberries in fields that have a history of the disease or have been historically planted with crops that are susceptible to the disease. Furthermore, growers should also not plant on land that is likely to contain high levels of fungus such as fields with significant populations of pigweed, nightshade, and lambsquarter (UC IPM, 2006). Infected fields should be planted with non-host crops for twenty or more years before susceptible crops are grown. For organic production, solarization and crop rotation are acceptable methods for managing Verticillium wilt (UC IPM, 2006). Based on experiments with other crops, solarization alone tends not to be considered efficacious on the cool California coast.

Competitive situation. Ventura County produced 43% of the value of California's raspberry crop in 2006. California acreage doubled between 1999 and 2005. Although raspberries are produced in many states, California, Oregon and Washington grow eighty percent of national production. Washington was the primary American producer of raspberries until 2004 when California overtook it. In 2004, California raspberry acreage was only half of Washington state acreage, while yields were nearly three times as high. Oregon acreage has been declining since 1992

(Pollack and Perez, 2006). Over ninety percent of Washington and Oregon raspberries go to the processed market while approximately 95% of California raspberries go to the fresh market (Pollack and Perez, 2006). Consequently, this discussion focuses on the fresh market.

Imports rose six-fold between 1992 and 2005. The majority of fresh raspberries enter the U.S. market from Canada, Chile, and Mexico, although the majority of Canadian imports are subsequently processed in the U.S. According to the USDA, domestic production accounts for 80% of the fresh raspberries consumed in the U.S. (Pollack and Perez, 2006; Buccola and Gopinanth, 2004).

Consistent with the growth in California production, the fresh raspberry market has grown rapidly over the past decade. According to the USDA, domestic production of fresh raspberries grew at an annual rate of 29% from 2001 to 2005 while U.S. per capita consumption of fresh raspberries has almost tripled since 1990. The increase in consumption is attributable in part to product development which introduced new varieties that improved the quality and availability of raspberries (Pollack and Perez, 2006). Another contributing factor is that real farmgate raspberry prices have trended downward over this period. To the extent that this price decrease has been transmitted to retail prices, the increase in fresh raspberry production is due to a decrease in real price.

While no studies estimating the own-price elasticity of demand were found in the literature, the demand for fresh raspberries is almost certainly elastic due to the availability of many close substitutes and the relatively high per unit cost of raspberries compared to substitute fruits. Consequently, if Ventura County fresh raspberry production declines substantially in response to the 2008 fumigant use regulations then the price of raspberries will not increase substantially in response. Revenues will decline. On the other hand, because raspberries are such a high-value crop growers have a considerable economic incentive to maintain production levels through reducing VOC emissions from fumigation through the adoption of lower-emission products and methods, including the use of VIF, as well as potentially reducing application rates and adopting cultural practices other than preplant soil fumigation that aid in pest management.

Cut Flowers

Cut flowers were the eighth largest crop in Ventura County in 2006 in terms of total revenues from production. On a revenue per acre basis, cut flowers are the most valuable major crop. Cut flowers produced on open fields generated $57,017 per acre in value of production (VCAC, 2007).

According to CDPR estimates using PUR data, under the 2004 baseline scenario cut flowers or greens grown outdoors accounted for roughly 1.3% of total VOC emissions from preplant soil fumigation in Ventura County during the peak season. Cut flowers were among the five most intensive users of preplant soil fumigation. In 2004 50 pounds of fumigant were applied per planted acre.

Using only the low emission application methods specified in the January, 2008 regulations reduced estimated VOC emissions from preplant soil fumigation of cut flowers by approximately 25%. The share of estimated emissions was very close to constant.

Alternatives for reducing VOC emissions from fumigation. UC IPM (2002) guidelines for floriculture include the use of fumigants prior to planting in order to control soil-borne pathogens. Preplant soil fumigation is used to control fungal pathogens including *Pythium* species, Phytophthora species, and a variety of others (Ajwa, Klose and Elmore, 2006). Because growers often rotate among many flower varieties and species, the weed control provided by preplant soil fumigation is very important. Flowers planted in one production cycle can lead to volunteers becoming weeds in the next. The California ornamental industry (cut flower, cut greens and bulbs) has qualified for a critical use exemption for methyl bromide. While the industry has made substantial progress in reducing its use of methyl bromide, methyl bromide has been replaced primarily with other fumigants.

Reducing application rates would reduce VOC emissions from preplant soil fumigation. Based on a field study regarding the effects of reduced fumigation rates on Ranunculus bulb production, Ajwa, Klose and Elmore (2006) report that Midas® (33/67, 200 lbs./acre) controlled soil fungal pathogens better than methyl bromide/chloropicrin (percentages not provided, 200 lbs./acre). Yields for examined fumigants were similar, and significantly higher than the yield from the untreated control.[9] Examined fumigants reduced *Pythium spp* in the soil significantly relative to the untreated control, with a reduction of more than 85%.

The use of VIF in the floriculture industry could reduce VOC emissions from preplant soil fumigation. See the discussion in the strawberry crop profile for additional information.

Steam and solarization are potential substitutes for preplant soil fumigation. See the discussion in the strawberry crop profile for additional information.

Very limited organic flower production has been undertaken in the U.S. and in Latin America. Market conditions suggest that organic production is not a large-scale alternative to conventional production at the current time. Organic growers cite a lack of interest by consumers, wholesalers and retailers in marketing organic flowers as a major obstacle (Mark, 2007). Another consideration is that crops must be certified individually. Organic certification is much more costly for growers who have many species in their cropping system, as many flower growers do.

Competitive situation. The competitive situation facing the California cut flower industry has been very challenging, due to imports in the marketplace placing downward pressure on prices and changes in the conditions facing producers, including rising input costs and urbanization of traditional cut flower production areas on the California coast. The number of floriculture producers in California (including cut flowers and other categories) declined by approximately 10% between 2005 and 2006, from 822 growers to 732 growers (CDFA, 2007). According to a 2007 publication from the California Cut Flower Commission, there are approximately 275 cut flower growers in California (CCFC, 2007).

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[9] Fumigants examined included methyl bromide-chloropicrin (percentages not specified, 200 lbs/acre), Inline® (300 lbs./acre), Midas® (33/67, 200 lbs./acre), and chloropicrin (100, 200 lbs./acre). Two treatments were tested for each fumigant: the fumigant alone, and the fumigant followed by a drip application of metam potassium (KPAM, 30 gallons/acre). An untreated control and a treatment including only a drip application of metam potassium were also tested. In total, there were ten treatments (Ajwa, Klose and Elmore, 2006).

California produced $303.3 million of cut flowers in 2005 (CDFA, 2007). U.S cut flower production was $413.96 million (ERS, 2007b).

Exports are a minor source of sales for U.S. cut flower producers. 2005 cut flower and bulb exports were $27.2 million, of which fresh cut flowers were $22.4 million (ERS, 2007b).

Imports account for the majority of sales of cut flowers in the U.S. While California's cut flower production is about three-fourths of total U.S. production, California's cut flower production accounts for only about one-fourth of cut flowers sold in the U.S. (Onofrey, 2007). In 2005, imports of cut flowers totaled $708.9 million (ERS, 2007b). Colombia was the single largest import supplier, selling $418.2 million. Ecuador is the second largest supplier, providing $129.3 million in imports. The EU, the third largest source, is considerably smaller, supplying only $68.2 million in imports (ERS, 2007b).

Imports have led to reduced California production of major categories of cut flowers: California produces less than 5% of the carnations and chrysanthemum sold, and less than 10% of the roses sold (CDFA, 2007; Onofrey, 2007).

One way growers have responded to foreign competition has been to focus their production on flowers that are difficult to ship long distances, which is a source of comparative advantage for domestic growers (CalTrade Report, 2004). Sales of California cut flowers increased between 2005 and 2006, due to additional sales of lilies, gerbera and tulips (CDFA, 2007). More broadly, product differentiation efforts focus on promoting the greater quality and freshness of California flowers relative to imports.

Domestic consumption of cut flowers is limited. While per capita information is not collected, annual per household consumption is around $10 per household, and only about 30% of U.S. households purchase fresh cut flowers each year (CCFC, 2007).

Assessing the potential impacts of the 2008 fumigant use regulations on cut flowers is particularly challenging, given its competitive situation. Over time, imports have replaced U.S. production of major cut flower categories, such as carnations. Plant breeding innovations or changes in transportation technology may lead to major sources of imports being able to compete with U.S. producers in other categories as well, such as gerbera. Domestic consumption of cut flowers is limited on a per capita basis. Clearly the industry is facing broad competitive challenges. Reducing the use of pre-plant soil fumigation under the 2008 fumigant use regulations may affect growers' ability to respond to these challenges, but the broader issues make it difficult to disentangle precise relationships. Furthermore, because flowers are a very high-value crop on a per-acre basis in Ventura County, it may be feasible for growers to use VIF on most of their acreage without eliminating profitability.

Peppers

Bell peppers were Ventura County's ninth largest crop in terms of total value of production in 2006. The value of production per acre was $15,360, ranking peppers sixth.

Peppers accounted for less than 1% of VOC emissions from preplant soil fumigation in Ventura County in the peak season in 2004. Including both bell and spice peppers, the intensity of use of preplant soil fumigation per planted acre ranked peppers in the top five among the major Ventura County crops: 57 pounds per acre in 2004.

When only low-emission application methods are used, peppers are projected to continue to account for less than 1%.

Alternatives for reducing VOC emissions from fumigation. Preplant soil fumigation is an important tool for weed control in peppers. Transplanted bell peppers do not compete well with weeds for the first 40-60 days following transplanting, and currently registered pre-emergence herbicides do not control the full spectrum of relevant weeds (Smith and Le Strange, 2005). Fumigation can provide broad spectrum control. Peppers are used in crop rotations in order to increase revenues per acre as well as for pest control benefits. Preplant soil fumigation for peppers can benefit the cool-weather crops that follow, such as lettuce and cabbage.

Peppers are sometimes grown under plastic mulch, although not always. The plastic mulch provides some limited weed control, so technically and economically alternatives for reducing VOC emissions from preplant soil fumigation may differ across the production systems. The use of VIF and reduced MB-PIC doses (96 and 196 kg/ha) was demonstrated to provide equivalent control of *Cyperus rotundus* and *Cyperus esculentus* (purple and yellow nutsedge) and equivalent yields to the use of polyethylene mulch and a commercial dose of 392 kg/ha of MB-PIC in Florida (Gilreath, Motis, and Santos, 2005). Smith and Le Strange (2005) report experimental results regarding pepper yields and weed control for various herbicide treatments, and conclude that Goal Tender (and potentially Outlook) applied to beds prior to planting combined with flumioxazin-impregnated fertilizer post-planting showed promise as a weed control system for pepper production without plastic mulch in the Gilroy area. Hairy nightshade was the most common weed at this trial location.

Competitive situation. Ventura County produced 13% of the value of California's fresh pepper crop in 2006 (Table IV-8). California accounted for 49% of the value of U.S. production that year, so Ventura County accounted for 6% of national production. Although peppers are produced in many states, California and Florida account for the majority of the crop.

Table IV-8. Value of Annual Production, Imports and Exports: Fresh Peppers, 2004-2006

Fresh Peppers
1,000s of $

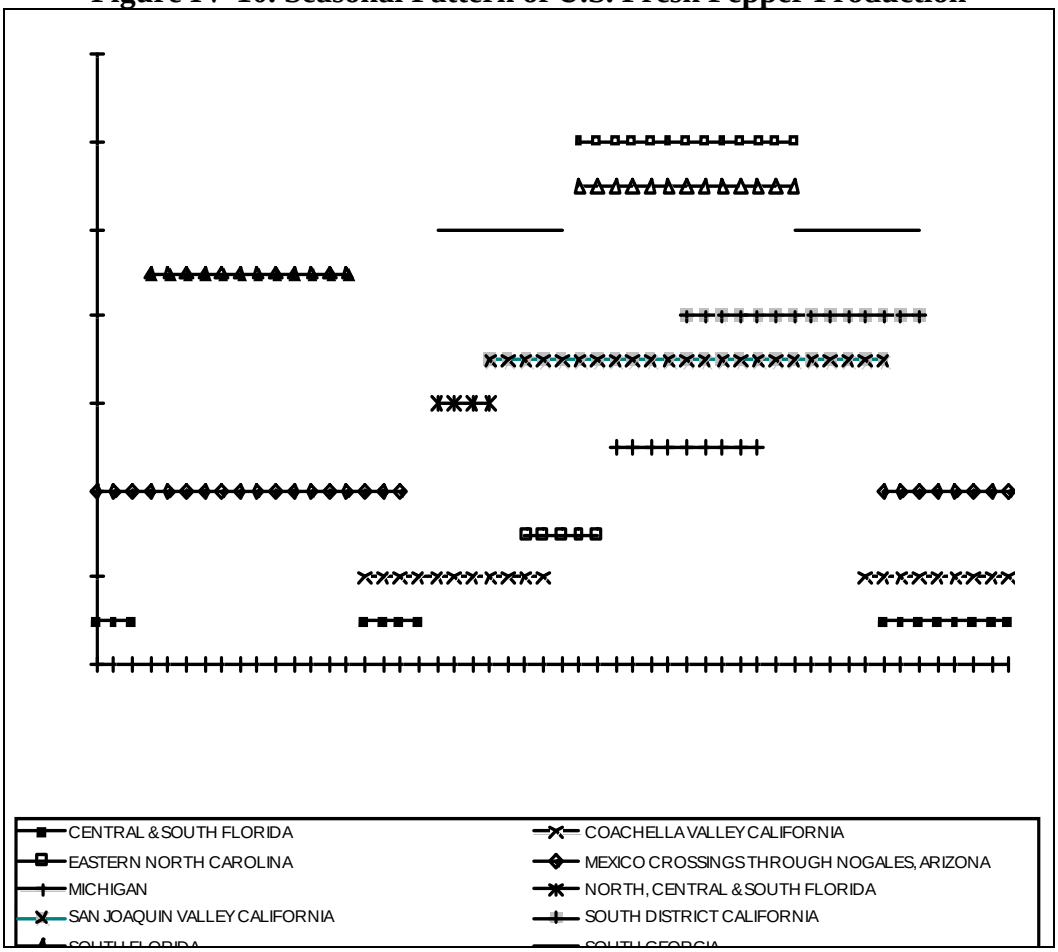
	2004	2005	2006
Value of Production			
Ventura County	34,628	23,053	38,138
Other California	183,073	205,087	251,575
Other US	299,255	294,988	299,430
Total	516,956	523,128	589,143
Imports	663,566	687,415	750,932
Exports	89,459	90,482	80,882

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Pepper imports are substantial. In 2006, imports were about 25% greater than domestic production. Domestic production is highest during the summer and imports are highest during the winter. Mexico, Canada and the Netherlands were the largest suppliers of U.S. imports in 2006. Pepper exports are negligible compared to domestic production and imports. Canada and Mexico were the largest importers of U.S. bell peppers.

Figure IV-10 depicts the seasonal pattern of U.S. pepper production. California's South District, which includes Ventura County, produces peppers from mid-August through the end of November. It competes with other U.S. production regions and Mexico; at all points in its market window it has at least one competitor.

Figure IV-10. Seasonal Pattern of U.S. Fresh Pepper Production



Source: Agricultural Marketing Service, USDA shipping point data from www.marketnews.usda.gov

U.S. fresh market bell pepper per capita consumption has been stable over the past several years. Between 1999 and 2003, annual per capita bell pepper consumption averaged 6.81 pounds. Since then it rose to a maximum of 7.09 pounds in 2005, falling most recently to 6.76 pounds in 2007 (ERS, 2008b). Henneberry, Piewthongngam, and Qiang (1999) estimate a positive own-price elasticity of demand for green peppers (0.84), contrary to the prediction of economic theory that the quantity demanded of a good will decrease when its price increases.

The steady per capita consumption of fresh peppers suggests that growth in domestic demand will be no faster than growth in population. Very little information is available in the existing literature regarding the elasticity of demand for bell peppers. Overall, there is little to indicate that a substantial increase in Ventura County bell pepper production would benefit producers.

Valencia Oranges

Oranges were Ventura County's tenth largest crop in terms of value of production in 2006, and generated $4,444 per acre in revenues. The majority of orange acreage is Valencia oranges which generated a slightly higher $4,509 per acre in revenues.

Oranges did not account for any VOC emissions from preplant soil fumigation in 2004. For the years 2004-2006 fumigant use was reported only in 2005. 0.6 pounds of fumigant per planted acre were used.

Alternatives for reducing VOC emissions from fumigation. UC IPM guidelines are common across citrus crops. See the discussion in the lemon crop profile.

Table IV-9. Value of Annual Production, Imports and Exports: Valencia Oranges, 2004-2006

Valencia Oranges
1,000s of $

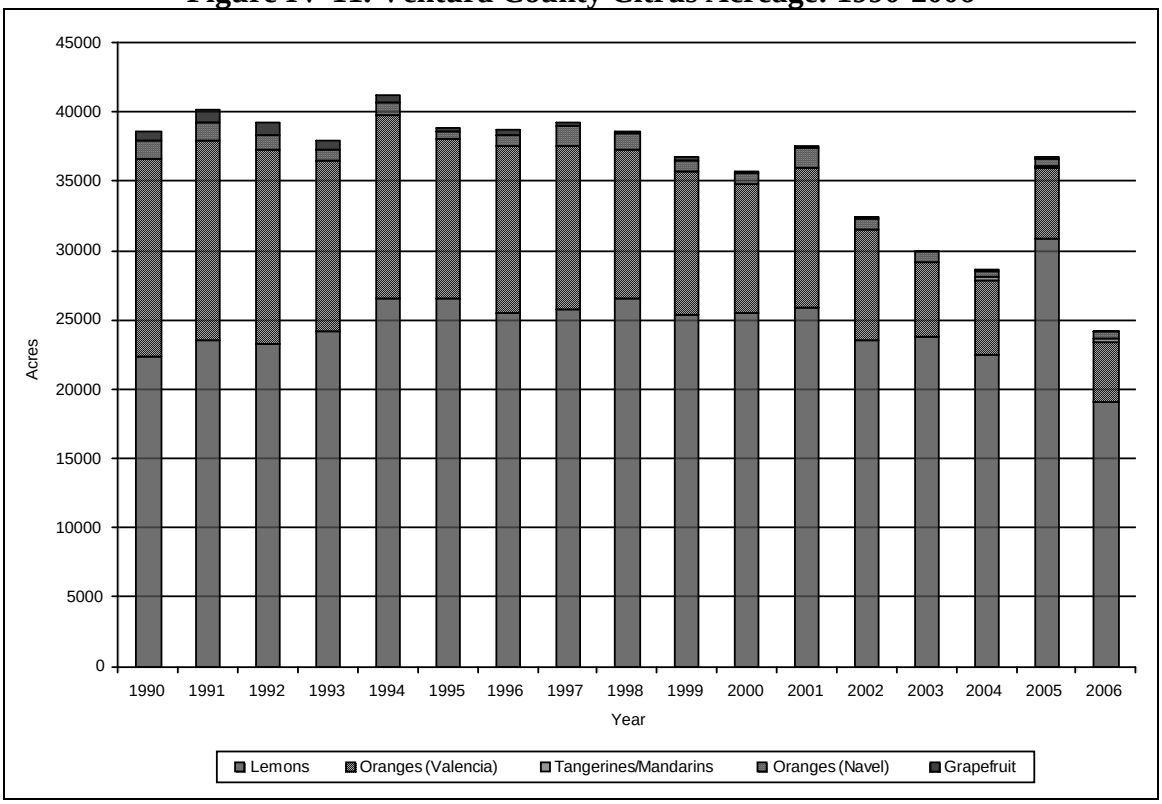
	2004	2005	2006
Value of Production			
Ventura County	20,525	23,248	19,734
Other California	359,635	255,805	330,475
Other US	673,654	461,299	659,010
Total	1,053,814	740,352	1,009,219
Imports	58,786	68,455	80,612
Exports	362,985	379,446	403,807

Sources: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ , http://www.fas.usda.gov/USTrade/USTImHS6.asp?QI=

Competitive situation. This discussion focuses on fresh Valencia oranges, rather than the orange juice market. Ventura County produced 6% of the value of California's Valencia orange crop in 2006 (Table IV-9). California accounted for 35% of the value of U.S. production that year, so Ventura County accounted for only 2% of national production. Imports were relatively small. Major countries of origin for Valencia oranges included South Africa, Australia and Mexico. Exports, on the other hand, accounted for roughly 40% of production. Major importers of U.S. Valencia oranges included Canada, South Korea and Japan. Exports to Canada and Japan have been declining, while exports to South Korea and other countries, including China, Malaysia and Mexico, have been increasing (ERS, 2007a).

Over the past few years, Ventura County's Valencia orange acreage has decreased, as has California's. Demand for the fruit has shifted in as consumers have increasingly chosen citrus fruits that are seedless and easier to peel (ERS 2007b). Consistent with the shifts in demand, Ventura County growers have increased tangerine acreage over the same time period. Figure IV-11 reports changes in the acreage of various citrus crops in Ventura County from 1990 to 2006.

Figure IV-11. Ventura County Citrus Acreage: 1990-2006



Sources: Ventura County Annual Crop Reports (2002-2006), California County Agricultural Commissioners' Data available at http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp.

Domestic fresh orange consumption has remained more or less stable since 2000, excluding the 2005-06 season when fruit quality was affected by freezes and fresh orange consumption declined (ERS, 2007a). In contrast, export demand has increased. Between the late 1990s/early 2000s and the 2002/03 to 2005/06 period, exports have increased from an average 24% of total supply to 29% (ERS, 2007a). In 2004, per capita annual fresh orange consumption was approximately 12 pounds (USITC, 2006).

Estimates of the (uncompensated) own-price elasticity of demand for oranges at the farmgate level suggest that demand is moderately inelastic, with values in the -1 to -0.50 range. Huang (1986) estimates an own-price demand elasticity of -1.00. Richards, Gao and Patterson (1999) estimate an own-price demand elasticity of -0.85. Nuckton (1978) estimates an own-price elasticity of -0.72. Price and Mittelhammer (1979) estimate an own-price elasticity of -0.66.

Estimates of the retail own-price elasticity of demand for oranges are higher, indicating that retail purchase demand for oranges is elastic. You, Epperson, and Huang (1996) estimate an own-price demand elasticity of -1.14 for fresh oranges. Nuckton (1978) estimates an own-price elasticity of -2.76.

Overall, market conditions have led to a decline in orange acreage in Ventura County and California. Growers are replacing oranges with other citrus crops. Given the broader forces

driving this shift, it is unlikely that growers will shift additional acreage into oranges specifically in response to fumigant use regulations.

V. Market Trends Affecting Ventura County Agriculture, and Other Crops with the Potential to Increase Acreage

Ventura County growers produce a wide variety of commercial agricultural crops. Besides the top ten crops discussed in section III, there are a number of other crops that account for substantial acreage and/or value of production. In 2006, 29 crops had over $1 million in sales, as did the livestock category (VCAC, 2007).[10] California's growers, including those in Ventura County, tend to be very responsive to market forces, and will often alter their production mix in terms of its crops and/or crop varieties in response to changes in relative profitability. If the 2008 CDPR fumigant use regulations reduce the profitability of crops that use preplant fumigation, economic theory predicts that growers will reduce their production of these crops and increase their production of other crops. Growers may also reduce their production of crops that are planted after crops that use preplant fumigation in order to benefit from the residual effects of fumigation.

In this section, we discuss some market trends that may affect Ventura County crop choices, and then examine some specific crops that appear to be well-placed to benefit from these trends but are not in the top ten crops discussed in section IV.

Market Trends

There are many trends with the potential to affect Ventura County crop choices. In this subsection we focus on seven: increasing input costs and input supply limitations, regulation of agricultural production, international market considerations, macroeconomic conditions and prices for major agricultural commodities, consumer concerns regarding health and nutrition, consumer concerns regarding food safety, and consumer interest in the sustainability of food production. Because the purpose of this report is to assess the potential effects of a specific set of regulations applying to Ventura County that does not affect all crops in the same manner, the primary objective of this subsection is to identify factors addressing crop choice and acreage allocation in Ventura County, rather than to address all factors affecting the overall competitiveness of Ventura County agriculture or California agriculture.

Input markets. Like other agricultural producers worldwide, Ventura County growers are facing increased costs for energy and agricultural chemicals. The net effect on the competitiveness of Ventura County growers will depend on the efficiency with which they use these inputs, and the crops they produce; if their marginal revenue products of energy and chemicals are high then increasing input costs alone will not cause them to be uncompetitive.

There are issues, or potential issues, regarding the availability and price of three other inputs: land, labor and water. The availability and price of agricultural land overall will be addressed in section VII. Another concern regarding agricultural land is limits on the supply of land that is

[10] In addition to the top ten crops discussed in the previous section, in descending order of value of production these crops were greens, cabbage, lettuce, vegetable transplants (included in the total value of nursery stock), spinach, cilantro, broccoli, oriental vegetables, onions (all), beans (all), radishes, orchids (included in the total value of nursery stock), carrots, parsley, cucumber, beet, poinsettia (included in the total value of nursery stock), navel oranges and kale (VCAC, 2007).

suitable for specific crops. Section II provided information on the distribution of Ventura County agricultural soils by soil capacity class and the soil classes used to cultivate major crops. Overall, there appears to be few limits on growers' ability to substitute among crops of all types on high-quality soils. Citrus and avocados can be cultivated on lower-quality land than the other crops considered. Crop choice is more restricted in these areas. California's agricultural press has often discussed a shortage of agricultural labor. Sometimes this shortage is linked to changes in immigration patterns due to border and immigration law enforcement. The extent to which this shortage is real, rather than perceived, is uncertain. Wages for agricultural workers have risen very little over the past few years in real terms, which is not consistent with employers responding to a shortage (Martin, 2007). Finally, after a second winter of limited precipitation California is facing reduced surface water supplies, and a drought has been declared officially. Section II provided a discussion of Ventura County's major water supplies. While Ventura County agriculture will undoubtedly be affected, any crop-specific effects are difficult to determine at this point in time.

To the extent that these input cost and availability factors have differential effects on Ventura County growers, their overall competitiveness will be affected. For this analysis, the more relevant point is that if these factors have different effects on different crops, growers' acreage allocation decisions will be affected. For example, if there was a severe labor shortage, growers would tend to reduce their production of crops that are highly labor-intensive per unit of value of output and increase their production of less labor-intensive crops.[11]

Regulation. This report addresses a specific set of regulations regarding the use of pre-plant soil fumigation. Growers are subject to a variety of other regulations, such as worker safety regulations and food regulations. In addition to direct effects on costs, growers must also bear the cost of recordkeeping associated with regulatory compliance. To the extent that regulatory costs differ across crops they may affect growers' acreage allocation decisions.

International market considerations. The best-recognized effect of international markets on domestic agricultural producers is as a source of competition, often from lower-cost producers. Another effect, however, is as a source of additional consumers. Both effects have been observed when trade barriers are eliminated, depending on the commodity and the country. A related consideration is that some U.S. crops have a quality advantage in certain international markets. For example, U.S. lemons are perceived in some Asian markets as being high quality. More broadly, as incomes rise in China and India consumers will demand higher-valued food products. Domestic producers may not be able to produce sufficient output of the requisite quality to meet this demand, leading to new export opportunities for Ventura County and other U.S. agricultural producers.

Macroeconomic conditions and prices for major agricultural commodities. As overall economic conditions worsen, the demand for food will change. To the extent that changes in the prices of major agricultural commodities are not driven by the same forces that affect the prices of specialty crops, these price increases may affect prices obtained by Ventura County growers.

[11] Reducing production of crops that are labor-intensive on a per unit of value of output basis does not necessarily imply a reduction in the production of crops that are labor-intensive on a per acre basis. If the latter also have high revenues per acre, it may even increase profits to increase the acreage allocated to these crops.

The major force driving the outcome will be the net effect on consumers' demand for specialty crops. There are two offsetting effects on consumer demand identified by economic theory: the substitution effect and the income effect. If products made with major commodities (for example, products with substantial corn syrup content) become relatively more expensive, then consumers will substitute away from such products in favor of products such as fruits and vegetables. If products made from major commodities become relatively cheaper then consumers will substitute away from fruits and vegetables. On the other hand, all food prices are rising, in part due to the market trends already identified. This reduces consumers' overall food purchasing power; for any given expenditure on food, they purchase less. Given current economic conditions and rising unemployment, many consumers are seeking to economize on expenditures on food. Further, consumers' purchases of products made from specialty crops may be more responsive to changes in their income and food expenditures than their purchases of products made from major agricultural commodities, suggesting a greater percentage reduction in the money spent purchasing products made from specialty crops. Broadly speaking, these effects may be interpreted as an "income effect". The net change in purchases of products made from specialty crops, and hence the net effect on Ventura County growers of these crops, will depend on the relative magnitudes of the income and substitution effects. Most likely these effects will vary by crop.

Population trends. Government analysts have identified an immigration-based increase in the number of members of ethnic groups who eat vegetable-focused diets as one cause of the increase in per capita vegetable consumption over the past twenty years, along with changes in other population characteristics, such as the age distribution and household size (Lucier et al., 2006). A related trend is the tendency for the consumption of fruits and vegetables unfamiliar to the majority of Americans, and the consumption of familiar crops in unfamiliar products to be introduced through a specific ethnic group or groups, and then spread into the rest of the population, sometimes becoming mainstream. In 1991, for example, salsa replaced ketchup as the nation's best-selling condiment.

Consumer concerns regarding health and nutrition. Consumers indicate an increased awareness of the importance of consuming fruits and vegetables for nutritional and health reasons (Guthrie et al., 2005), and increased nutrition awareness has been linked to increased consumption of fruits and vegetables (van Dillen et al., 2007). However, sixty percent of Americans still consume less than the recommended five servings a day of fruits and vegetables (Guenther et al., 2006). Due to the importance of fruits and vegetables in Ventura County, this trend is a very relevant one. If consumers' fruit and vegetable consumption increases in response to their increased awareness of the benefits of doing so, demand for these products would increase considerably. In order to meet the guidelines, consumers would have to more than double fruit consumption and increase vegetable consumption by a fourth (Lucier et al., 2006).

Consumer concerns regarding food safety. Food safety is important to consumers. Recent food safety issues, such as the summer 2008 *Salmonella Saintpaul* outbreak[12], incidents of mad cow disease in Canada and the U.S., the contamination of spinach with *e. coli*, and the contamination

[12] As noted in footnote 14, the *Salmonella Saintpaul* outbreak was initially associated with certain types of fresh tomatoes. Jalapeno peppers and cilantro were investigated. Ultimately, the source of the outbreak was traced to jalapeno and serrano peppers grown in Mexico. US producers were cleared.

of pet food from China with aminopterin have brought this issue to the forefront of many consumers' minds. Consumers' perceptions of the safety of the food they purchase changes over time, most likely at least in part due to media coverage of specific food safety incidents. According to the Food Marketing Institute, in 2006 82% of consumer respondents to a survey said that they were "completely confident" or "somewhat confident" in the safety of food purchased at the supermarket. In the 2007 survey, that percentage fell to 66%, its lowest level since 1989 Food Marketing Institute, 2007). In 2008, confidence recovered to 81% (Food Marketing Institute, 2008).

There are two broad types of effects that food safety concerns may have on consumers' purchasing decisions. First, they may be more likely to purchase all foods from origins perceived to be safe. The direct impact of this effect on growers' acreage allocation decisions is not apparent. Second, they may alter their purchasing decisions regarding specific crops that are involved in specific food safety incidents. According to the same Food Marketing Institute 2007 survey, 71% of consumer respondents stopped buying spinach after the *E. coli* contamination incident. In this case, the direct impact on growers is negative. To the extent that such consumer reactions are long-term rather than short-term, growers may alter their acreage allocations in response to the inward shift in demand. Also, if additional regulations regarding production and handling are enacted in response to food safety incidents, then the cost of producing certain crops may increase, affecting their profitability. This effect may alter growers' acreage allocation decisions.

<u>Consumer interest in organics and sustainability of food production</u>. Organic foods are increasing their share of domestic production, although current economic conditions are slowing this trend. The increase is associated with consumers' interest in health, nutrition, and food safety. Overall, studies indicate that consumers perceive organic products to be healthier, safer, and better for the environment than conventionally produced products (Yiridoe, Bonti-Ankomah, and Martin, 2005). To the extent that it is profitable for Ventura County growers to undertake the organic certification process and engage in organic production, acreage allocations will change.

For Ventura County, an important aspect of consumers' interest in the manner in which their food is produced is the recent emphasis on the sustainability of food production. In particular, the "locavore" movement promoted by Michael Pollan and others could lead to an important competitive advantage for Ventura County growers. Ventura County is located within the "food shed" for much of the metropolitan Los Angeles area. Consequently, there is the opportunity for growers to benefit from any premium consumers are willing to pay for food produced locally. Of course realizing this benefit on more than a very small scale would require cooperation from retailers and wholesalers in order to label products as grown in Ventura County. If the effort to differentiate local production is successful, Ventura County acreage allocation would tend to shift to producing smaller amounts of a wider variety of crops in order to meet local demand, rather than producing large amounts of fewer crops in order to meet national and international demand.

Crops that May Benefit from Consumer Demand Trends

It is difficult to predict the net effects of all of the trends discussed above on specific crops. In this subsection we will focus on crops that are likely to benefit from the trends affecting consumer demand.

Lettuce. Although romaine and leaf lettuce acreage have fallen recently in Ventura County, overall demand conditions remain positive. While annual per capita head lettuce consumption has fallen from an average of 23.22 pounds per person between 1999-2003 to 20.4 pounds per person in 2007, the consumption of other types of lettuce has more than offset this decline, rising from 8.93 to 15.12 pounds per person (ERS, 2008b). The increased popularity of bagged salads has been one factor driving this increase. Salad tends to be considered a healthy product. Fast food chains, including McDonald's, introduced salads as a major part of their effort to offer healthy choices in addition to their traditional fare. Ventura County lettuce growers have the opportunity to sell very fresh specialty lettuce to buyers in Los Angeles and elsewhere in California. However, any major increase in production will face seasonal competition from major lettuce growing areas in California and Arizona. Such competition may be one factor affecting the recent decline in Ventura County lettuce acreage. Another off-setting consideration is that some metam sodium use was reported in lettuce in the 2004 base period. To the extent that the 2008 fumigant use regulations affect the profitability of lettuce production either directly or through the alteration of the use of preplant soil fumigation for crops commonly rotated with lettuce any effects of increased demand may be offset.

Spinach and other dark leafy greens. In spite of consumers' reaction to the spinach *E. coli* contamination incident, per capita consumption of fresh spinach rose from an average of 1.32 pounds per person in 1999-2003 to 2.04 pounds per person in 2007. Press reports of nutrition and health research have identified dark leafy greens as an important part of a healthy diet. Demand for other dark leafy vegetables such as various types of kale is likely to shift outward. This shift will increase the quantity demanded at any given price, offering an opportunity for Ventura County growers to increase production without reducing its price. Of course, growers in other regions may identify the same market opportunity. An important off-setting consideration is that some use of metam sodium was reported in Ventura County in 2004. If the profitability of these crops is reduced due to the 2008 fumigant use regulations, then this may offset the effects of an outward shift in demand for Ventura County growers.

Specialty vegetables. Ventura County produces or has the potential to produce many high-value crops that are not reported in federal or sometimes even state statistics. For example, the value of Ventura County's cilantro production in 2006 was $8.5 million, or $5,698 per acre, higher than avocados and Valencia oranges. Given the growing immigrant population in California and the U.S., and given the increasing popularity of cuisines utilizing cilantro, demand for this product is likely to shift outward substantially. This outward shift will increase the quantity of cilantro demanded at any given price, offering an opportunity for Ventura County growers to increase cilantro production without reducing its price. As noted in footnote 18, however, cilantro was investigated as a source of the summer 2008 *Salmonella Saintpaul* outbreak. This association may negatively impact cilantro consumption, although the length and magnitude of any such effect is uncertain.

Another illustration of the potential for increased Ventura County production of specialty vegetables is Asian vegetables (sometimes referred to as "Chinese vegetables'), which appear to be another set of crops with an increasing demand. Growers in other regions of California are important producers of these crops, and will be significant competitors in the national market. Ventura County's proximity to the greater Los Angeles area may be an advantage. Acreage has increased substantially.

Tangerines. Ventura County perennial crop growers have the opportunity to diversify into specialty fruit crops. For the purposes of this report, we focus on tangerines (including mandarins), a perennial crop which is increasing acreage rapidly, and for which federal and state data regarding its competitive situation are available.

Tangerines were not among Ventura County's ten largest crops in terms of revenues in the 2004-2006 period. Only 253 acres were harvested in 2006 and total revenues were $1,829,000, leading to $7,229 in value of production per acre, substantially more than Valencia oranges.

Tangerines accounted for less than 1% of VOC emissions from preplant soil fumigation in 2004. As a perennial crop sometimes utilizing pre-plant soil fumigation, VOC emissions from fumigants are highly dependent on acres of new plantings. In turn, plantings are driven by competitive considerations, discussed below and in the sections regarding lemons and Valencia oranges.

Alternatives for reducing VOC emissions from fumigation. UC IPM guidelines are common across citrus crops. See the discussion in the lemon crop profile.

Competitive situation. Tangerines' competitive situation should be placed in the larger context of the competitive situation of U.S. citrus. Growers' and consumers' decisions regarding various citrus fruits are interrelated. Tangerine acreage has grown in California and in Ventura County in recent years, while acreage in other citrus, especially Valencia oranges, has declined. Tangerines are still a negligible share of total citrus acreage in Ventura County, as reported in the Valencia orange crop profile in section IV. The most recent California Citrus Acreage Report, which is from 2005, reported 216 bearing acres and 482 non-bearing acres of tangerines in Ventura County. Statewide, almost half of all 2005 tangerine acreage was non-bearing: 11,834 of 24,038 acres (NASS, 2006). Tangerine plantings are driven by the fruit's popularity with U.S. consumers. Presently, much of the demand for clementines and other tangerines is filled by imports (ERS, 2007a; ERS, 2007c). The acreage expansion has been rapid, especially for a long-lived perennial crop.

Price and Mittelhammer (1979) estimate a farmgate own-price elasticity of demand for tangerines of -2.10. It is worth noting that due to changes in the demand for tangerines over the past three decades it is likely that demand has become less elastic; however, because tangerines are a differentiated product within the citrus market it seems unlikely that demand has become very inelastic, or even moderately inelastic. Most likely demand will continue to be elastic. This hypothesis is supported by the slightly own-price elastic (-1.03) demand for all citrus estimated by Henneberry, Piewthongngam and Qiang (1999).

Based on competitive considerations, there is the potential for Ventura County growers to continue to expand tangerine production without a large negative effect on the price. However, citrus producers in the San Joaquin Valley are responding to the same competitive considerations. To the extent that seasonality in market windows reduces the intensity of competition, other California producers will not be able to capture fully the gains that could be obtained by Ventura County producers.

VI. Cropping Patterns and Implications for Post-Regulation Crop Choices

Section IV examined major crops, and section V identified other individual crops that may benefit from market trends. Another perspective to consider is the impact of the regulations on individual growers, many of whom produce multiple crops. We do not have access to data on individual growers from the Census of Agriculture or other sources at the present time. Consequently, we utilize CDPR's PUR database to provide us with a rough proxy of cropping patterns by grower identification number in 2005. Differences in cropping patterns may lead to differences in grower responses to the need to reduce VOC emissions from fumigation.

This procedure is subject to a significant caveat. PUR data are not reported by production entity but by grower identification number. Every property operator must have a grower identification number. Consequently it is difficult to interpret the relationship between the two. One operator (or household including an operator) may have more than one Census production entity. The 2002 Census of Agriculture definition of a farm is "any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year." The number of farms in the 2002 Census of Agriculture is substantially larger than the number of grower identification numbers in the 2002 PUR database. In 2002, the Census of Agriculture reported 1,877 farms selling crops, including greenhouse production. The 2002 PUR database reported pesticide applications for 663 grower identification numbers. Table VI-1 compares the two data sources for some major Ventura County crops.

Table VI-1. Number of Ventura County Agricultural Entities by Crop: Census of Agriculture and PUR data, 2002

Crop	***2002 Census of Agriculture (farms producing)***	***2002 PUR data (unique grower identification numbers)***
All Crops	1,877	663
Strawberry	73	74
Lemon	556	245
Nursery	204*	102**
Celery	16	30
Tomatoes	30	9
Avocados	1,012	264
Raspberries	13	7
Bell Peppers	16	23

*Nursery, greenhouse, floriculture, aquatic plants, mushrooms, flower seeds, vegetable seeds, and sod harvested, total.

**Site names including Christmas tree, mushroom, nursery-greenhouse flowers, nursery-greenhouse plants in containers, nursery-greenhouse transplants, nursery-outdoor flower, nursery-outdoor plants in containers, nursery outdoor transplants, and turf/sod.

Sources: COA, 2002. PUR data.

In spite of these substantial differences we use the PUR data to identify production patterns by grower in terms of "clusters" of commodities grown. Because we do not use the data to estimate quantities of any sort, such as acres or production, the difference in the number of growers producing each crop between the two sources is less important. It is a concern only if certain crops are omitted consistently from the PUR data in one crop cluster but reported in another, or if a given crop in a single cluster is never reported. In the former case, differences among producers could be distorted, which in turn could affect the identification of clusters. In the latter case, the omission would distort the crop choices that tended to be selected by growers within an identified cluster. Given the four very broad clusters identified, neither consideration is a major concern. We also note that there are always a few growers that do not precisely fit into any cluster; generally these growers produce a very wide variety of crops. For the remainder of this section, for expositional convenience we will use "grower" to refer to "grower identification number."

Reported Pesticide Use by Grower Identification Number: Other Crops Associated with Specific Major Crops

Strawberries. Of the 93 grower identification numbers with reported pesticide use on strawberries in the 2005 PUR database, 56% (52 growers) reported applications to strawberries only. Another 25% (23 growers) reported applications to strawberries and one other site name. Subject to the many caveats regarding the use of these data, these percentages suggest that strawberry growers are relatively specialized in terms of the crops they produce. Examination of the other listed site names reinforces this suggestion. Of co-reported site names for strawberries, 33 observations were for "SOIL FUMIGATION/PREPLANT" in 2005. For 19 of the 23 strawberry growers reporting pesticide use on only two site names, pre-plant soil fumigation for an unspecified crop was the second site. Raspberries accounted for three of the remaining growers.

Avocados. Of the 279 grower identification numbers reporting pesticide use on avocados in the 2005 PUR database, 42% reported applications to avocados only. Another 41% reported applications to avocados and one other crop. Subject to the caveats regarding the use of these data, these percentages suggest that avocado growers are relatively specialized in terms of crop production, and tend to grow either avocados or avocados and citrus crops. Pesticide use on lemons was reported by 141 grower identification numbers reporting pesticide use on avocados. Pesticide applications to oranges (45 growers), tangerines (7), and grapefruit (4) were reported for grower identification numbers also reporting pesticide use on avocados.

Lemons. 232 grower identification numbers reported pesticide use on lemons. Slightly less than a third (71) reported pesticide use on only lemons. 47% (110) reported pesticide use on lemons and one other crop, usually avocados or, less commonly, oranges. As with avocados, these numbers suggest that lemon growers are relatively specialized in the production of perennial crops, especially avocado and citrus. Although some lemon growers also reported pesticide use on annual crops, no distinct pattern emerged. No

single annual crop had pesticide use reported by more than four grower identification numbers with reported pesticide use on lemons.

Vegetables. In total, pesticide use on at least one vegetable site name was reported for 58 grower identification numbers in 2005. Grower identification numbers with reported pesticide applications to vegetables tended to report pesticide applications to more crops than those reporting pesticide applications to strawberries, avocados and lemons. Only nine grower identification numbers reported applying pesticides to tomatoes in the 2005 PUR database. One reported pesticide use on tomatoes only, and another reported pesticide use on tomatoes and one non-production site (right of way). The remaining seven reported pesticide use on six or more crops in addition to tomatoes. Cabbage, celery and leaf lettuce were the most common co-reported crops (five reports each). Of the 24 grower identification numbers reporting pesticide use on celery in the 2005 PUR database, all but one reported pesticide use on multiple other crops, most commonly including peppers, lettuce, and/or cabbage. One grower identification number reported pesticide applications to four site names. The remainder reported applications to five or more sites.

Nursery and floriculture. In total, pesticide use on at least one nursery or flower site name was reported for 75 grower identification numbers in 2005. The site names and the number of grower identification numbers with reported pesticide use for each site are reported in Table VI-2.

Table VI-2. Number of Grower Identification Numbers Reporting Pesticide Use on Nursery and Floriculture PUR Sites, 2005

PUR Site Name	*Number of grower identification numbers*
Christmas tree	2
N-grnhs flower	11
N-grhs plants in containers	12
N-grnhs transplants	8
N-outdr flower	25
N-outdr plants in containers	21
N-outdr transplants	12
Turf/sod	6

Source: PUR data.

Growers tend to be specialists within the broad nursery and floriculture category. Of the 75 grower identification numbers reporting pesticide use on at least one of these sites, 56 reported pesticide use on only one. Another 17 reported pesticide use on two sites within this set, one reported pesticide use on three of these sites, and one reported pesticide use on four. Six of the 17 reporting use on two sites reported use on N-grnhs flower and N-outdr flower. Only two of the 19 reporting pesticide use on two or more sites reported applications to only outdoor sites. The remaining 17 reported both greenhouse and outdoor pesticide use.

Grower Clusters

We categorize growers into four groups: strawberry, avocado and citrus, vegetable, and nursery and floriculture. Given the differences in crop choices, it is likely that different clusters will focus on different options for reducing VOC emissions from preplant soil fumigation. Prior to this discussion, we will note that analysts within CDPR project that most acreage intended for fumigation will be fumigated in 2008 using lower emission fumigants and/or application methods and/or application rates than those specified in the emission allowance requests (CDPR, 2008b). This would mean that growers would be able to fumigate more acreage. In economic terms, the emission allowances would "bind' growers' production choices less than they would if growers limited themselves to the fumigation plans indicated in the emission allowance applications. Our discussion here will assume that growers' decisions *are* affected; section VIII will address the 2008 emission allowance allocations.

Strawberry growers are mostly specialists. Assuming that they will not choose to diversify into vegetable production or into perennial production (beyond perhaps devoting additional acreage to raspberries), then their most likely short-term response is to adopt lower-emission fumigant application methods, including VIF, in conjunction with crop rotation through leasing ground in or out to vegetable growers. In the longer term, if alternatives such as solarization, steam or a combination of the two can be developed to become economically feasible then growers may adopt these alternatives.

Another possibility is that growers may choose to shift strawberry production out of Ventura County to alternative production areas. There are factors that affect the attractiveness of this choice. Due to urbanization the ability to increase strawberry acreage in San Diego and Orange counties is limited. Consequently, provided growers choose to remain in California, acreage would have to move north. If growers move north their production would no longer have the same timing as Ventura County production, which will alter returns. While the development of new cultivars may move the "market window" for more northern locations, this is by no means a certainty in the short term.

However, before concluding that strawberry growers are likely to respond so drastically to the 2008 fumigant use regulations, it is worth recalling the discussion of their acreage expectations in the strawberry crop profile in section IV. The increase in fall-planted acreage necessary for the acreage in the 2008 emission allowance requests and the 2008 acreage report to be consistent is itself consistent with intentions to utilize lower emission preplant soil fumigation methods.

Growers producing avocados and/or citrus tend to specialize in these perennial crops. Their use of fumigation is limited to citrus replant. The emission quotas may cause growers to tend to replant their citrus groves at a slower rate. Under this scenario, growers' ability to respond to changing market conditions by replacing other citrus crops with tangerines and other newly popular products may be inhibited.

The third group of growers produces primarily vegetable crops. Many produce a variety of products. To some extent these growers are well-placed relative to the regulations; many of their products are not fumigated. On the other hand, some crops such as tomatoes are fumigated and these growers often rotate their crops with strawberries via leasing cropland in or out to strawberry growers. Pre-plant soil fumigation for strawberries has a residual effect that can help control pests for the crops that follow, such as lettuce. Regardless, these growers, for the most part, have the ability to respond to market conditions through flexible production choices. Consequently, they may be able to increase acreage in non-fumigated crops in response to decreased strawberry acreage, or in response to their own reduced fumigant availability. The emerging crops discussed in section V are, for the most part, crops that would be adopted by this group of growers.

The final group of growers produces nursery crops and cut flowers. This group is very heterogeneous in terms of its crop mixes, so it is difficult to generalize regarding their responses to the emission allowances. Clearly the growers who will be affected most are those who use preplant soil fumigation. In the 2008 emission allowance application process, requests were received for preplant fumigation for 23 acres of turf or sod and 312 acres of flowers from a total of ten growers (CDPR, 2008b). Using 2006 average value of production per acre values, these requests represent $0.71 million and $17.79 million in production, respectively. Fumigated acreage for flowers was considerably lower in 2004-6 than the request for 2008, which was also the case for other crops. As noted by CDPR (2008b), this may be due to growers shifting acreage that was recorded as preplant fumigation without a specific crop in previous years into specific crops for their 2008 emission allowance requests.

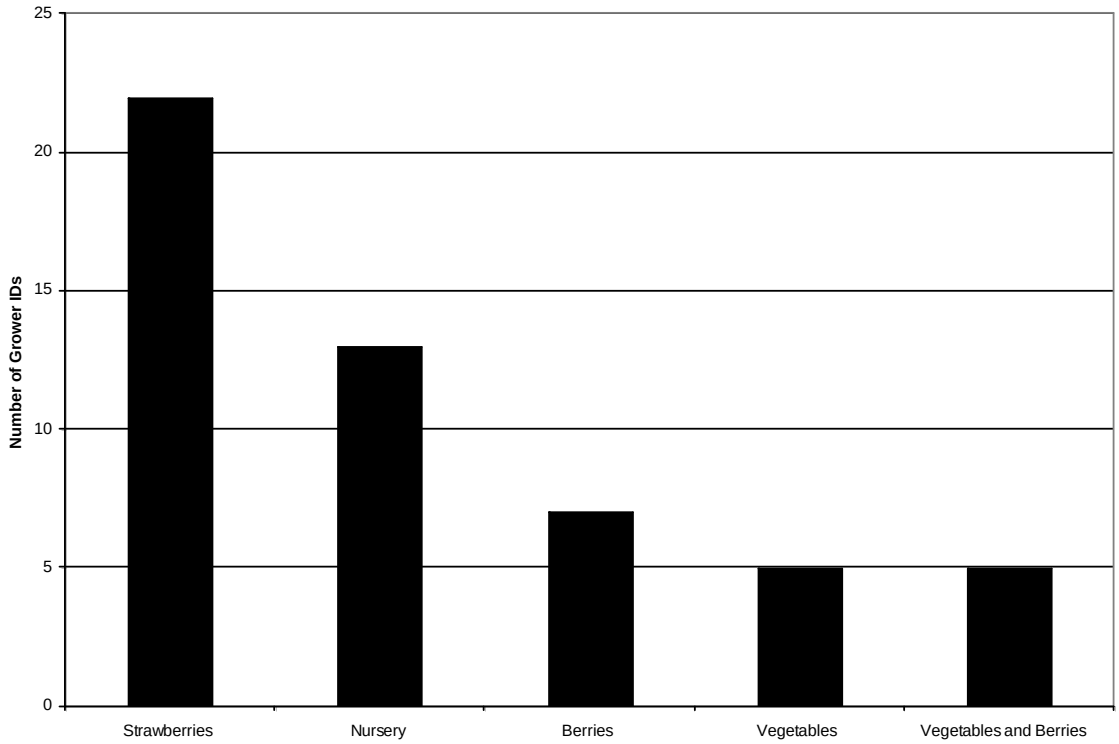
Crops Grown by Grower Identification Numbers Reporting Preplant Soil Fumigation for an Unspecified Crop

We end this section with a short discussion of the crop choices associated with the reporting of preplant soil fumigation use without a specified crop. As noted in section IV, one difficulty in assessing the intensity of use of preplant soil fumigation for individual crops is the use of the "Soil Application, Preplant-Outdoor (Seedbeds,Etc.)" site name category in pesticide use reports. Fields fumigated under this category are eventually planted to one or more crops. Linking the use of this category to other site namess for which pesticide use is reported by an individual grower identification number provides a sense of which crops are likely to have an intensity of fumigant use estimate that is biased downward. Of course, this analysis does not provide any information regarding the magnitude of the bias because it does not include information on acreage, specific fumigant product, application rates, or the allocation of acreage across crops for growers producing multiple crops.

Subject to these caveats, Figure VI-1 summarizes the crops for which pesticide applications are reported by the 52 grower identification numbers that also report using preplant soil fumigation without specifying the crop. The growers are separated into five crop categories: those reporting pesticide use on strawberries (22 grower identification

numbers), those reporting pesticide use on one or more nursery (including flowers) crops (13 grower identification numbers), those reporting pesticide use on more than one berry crop (7 grower identification numbers), those reporting pesticide use on one or more vegetable crops (5 grower identification numbers), and those reporting pesticide use on one or more vegetable crops and one or more berry crops. For the purpose of defining these categories we ignore reported pesticide applications to rights of way, uncultivated agricultural land, and ditch banks. Also, one of the 5 grower identification numbers included in the vegetable crops only category reported pesticide use on sugar beets, a field crop, in addition to 8 vegetable crops.

Figure VI-1. Number of Grower Identification Numbers Reporting Fumigant Use under the "Soil Application, Preplant-Outdoor (Seedbeds,Etc.)" Site Category by Crop Choice: 2005



Source: PUR data.

Field-level analysis. 100 unique fields are associated with reporting preplant soil fumigation without identifying the crop. In order to obtain more detailed information regarding which crops were likely grown after the fumigation, we examine all crops produced. Of the 100 fields, no pesticide applications to any specific crop were reported for three. Table VI-3 categorizes the fields for which preplant soil fumigation without an identified crop is reported by the crop or crops for which pesticide use is also reported. The reported fumigated acres without an identified crop are also included in the table. In contrast to Figure VI-1, we separate fields for which pesticide use is reported for one or more crops and for ditch banks, uncultivated agricultural land or rights of way from fields for which pesticide use is reported for that crop(s). We refer to the latter applications as

non-production. Also in contrast to Figure VI-1, at the field level all nursery-category applications were to flowers (in some case to greenhouse as well as outdoor flowers for a given field).

Table VI-3. Crops for which Pesticide Use Was Reported on Fields for which Fumigant Use under the "Soil Application, Preplant-Outdoor (Seedbeds,Etc.)" Site Category Was Also Reported: 2005

Crop Choice	Number of Fields	Fumigated Acreage, No Crop Specified
Strawberries	41	1,920
Strawberries+Non-production	6	293
Strawberries+Raspberries	1	27
Raspberries	6	51
Flowers	9	20
Flowers+Non-production	1	2
Vegetables	17	175
Vegetables+Non-production	14	259
Vegetables+Strawberries	1	152
Vegetables+Strawberries+Non-production	1	34
No Use Reported	3	93

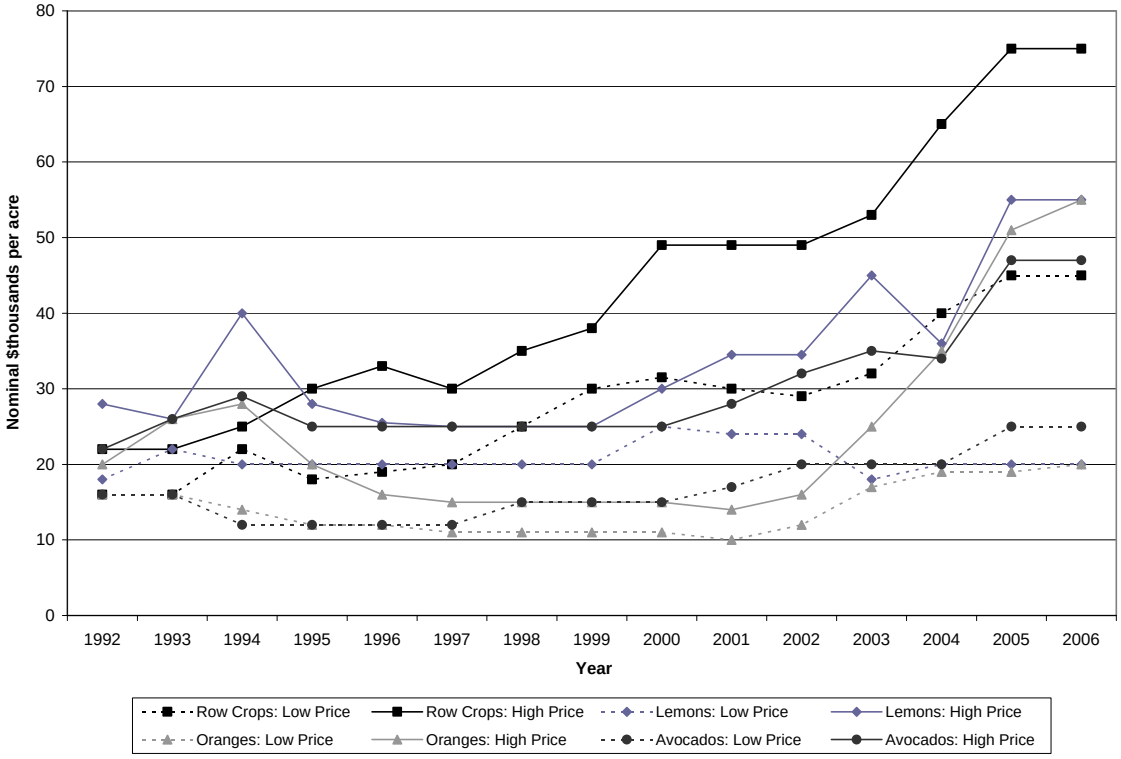
Source: PUR data.

One caveat regarding the interpretation of the table is that the fumigated acreage for which no crop is specified does not necessarily map perfectly to the acreage for which the use of other pesticides on other crops is specified on that same field. The fumigated acreage may be larger or smaller than the acreage reported for a given crop. Furthermore, when pesticide use is reported for multiple crops on a single field the precise relationship between any one of those crops and the fumigated acreage is unclear.

VII. Development/Urbanization and Land Use

One possible response by growers to the January 2008 fumigant quotas and use regulations would be to exit agriculture. Growers who own land could sell their land for development or rent it to growers who remain in agriculture. According to the 2002 Census of Agriculture, 55% of farmland was rented or leased in Ventura County. According to CDPR (2008a), about 25-35% of acres that are fumigated currently are already within existing city limits. This section explores the market for agricultural land in Ventura County in order to assess the likelihood that land will exit agricultural production as a response to the 2008 regulations. This section discusses three basic determinants of the development of agricultural land for urban uses: the urban demand for the land, the value of the land in agricultural production, and zoning and other government regulations regarding land use.

Figure VII-1. Agricultural Land Values in Ventura County: 1992-2006



Source: California Chapter of the American Society of Farm Managers and Rural Appraisers, "Trends In Agricultural Land and Lease Values". Various Years.

Agricultural Land Prices

The value of land in agriculture depends on the profitability of its production. The price of land is the expected discounted value of all future income streams from that land, according to economic theory. Figure VII-1 displays Ventura County land prices (in nominal thousands of dollars per acre) for row crops, lemons, oranges and avocados over time. There are three trends common to all crops since 1992: the low nominal price of

land increased, the high nominal price of land increased, and the difference between the low and high nominal prices expanded. Row crops experienced the greatest absolute and percentage increase in their low and high nominal land prices. Lemon acreage had the lowest percentage increase in low and high nominal land prices over the period and the lowest absolute increase in the low nominal price of land. Avocados faced the lowest absolute increase in the high nominal price of land during this period. Oranges experienced the largest absolute and percentage expansion in the difference between the low and high price of land. Avocados and lemons had the smallest expansion in absolute and percentage terms respectively.

Section III presented information on crop values and acreage over time for major Ventura County crops. Land prices should reflect all expected future returns. Section III provides information regarding some of the annual realizations of these expected returns. If the January 2008 regulations reduce expected returns for some crops, then they will reduce the value of the land used *for those crops*. Any such effect does not necessarily imply that the value of land in agriculture will be reduced. For that to be the case, either the affected crop(s) must be the highest-valued agricultural use for that specific land or there is no capacity to switch to other crops.

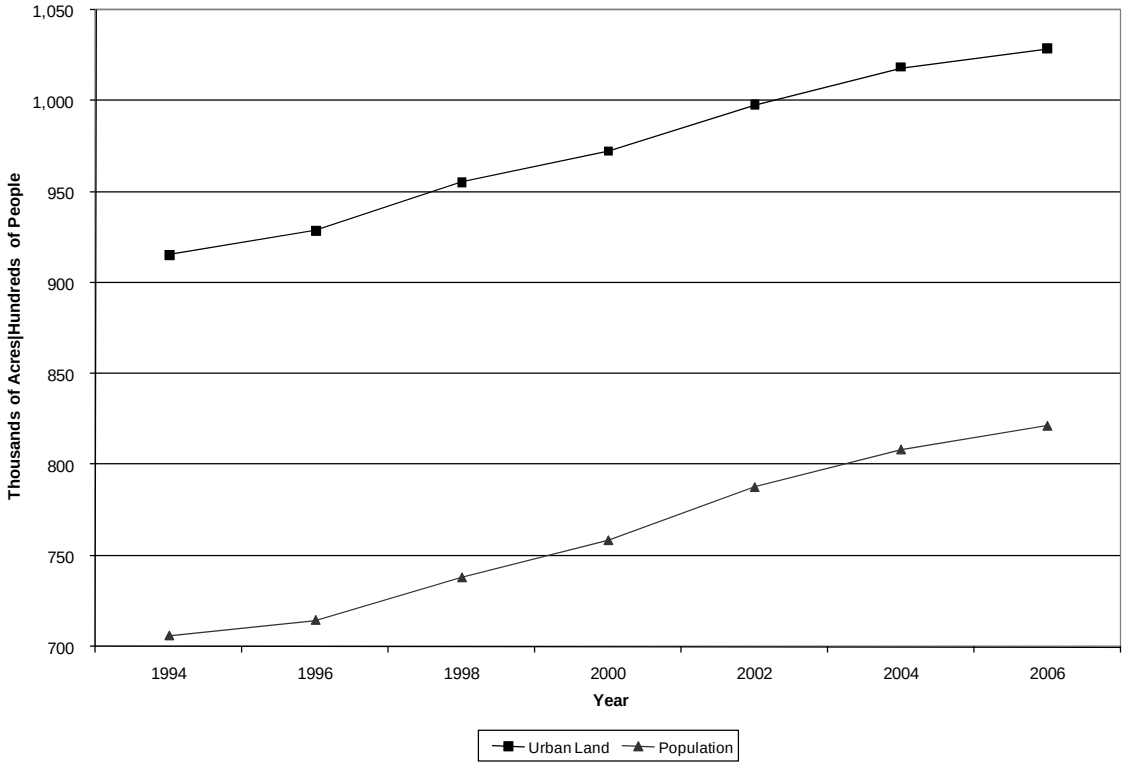
To the extent that increases in land values are common across crop categories, they may be driven by common considerations. One consideration is that most perennial crops eventually must be replanted in order to maintain economic viability. They may be removed before the end of their economic life if it is more profitable to do so. Another consideration may be the anticipated sale of the land for development. The demand for land for urbanization depends on population growth, as well as other considerations such as income, and government regulations and policies regarding development. We describe Ventura County's population growth and briefly discuss its use of programs designed to preserve land for agricultural uses. A complete discussion of all relevant and potentially relevant government regulations and policies regarding land use and development is beyond the scope of this report.

Population and Urban Land Use

Since 1970, Ventura County's population has increased by 115%, from 381,400 in 1970 to 821,698 in 2006. Population growth in Ventura County has declined over the last three decades: 40% in the 1970s, 26% in the 1980s, and 13% in the 1990s. The increasing population was associated with an increase in land used for urban purposes.[1] During the 1990s, urbanization increased by 9% from 89,118 acres to 97,236 acres (Figure VII-2). Since 2000, population growth has equaled 8% and urban growth was 6% (CDC, 2008a).

[1] "**URBAN AND BUILT-UP LAND:** Land occupied by structures with a building density of at least one unit to one and one-half acres, or approximately six structures to a ten-acre parcel." (CDC, 1996).

Figure VII-2. Ventura County "Urban and Built Up Land" and Population: 1994 to 2006



Sources: http://www.dof.ca.gov/HTML/FS_DATA/STAT-ABS/2006_statisticalabstract.pdf; http://www.dof.ca.gov/HTML/FS_DATA/STAT-ABS/documents/00Abstract.pdf; http://redirect.conservation.ca.gov/dlrp/fmmp/product_page.asp

Agricultural Land Preservation Programs

There are several agricultural preservation programs in place in Ventura County. First, "Save Open-Space and Agricultural Resources" (SOAR) is a city and county ordinance. The city ordinances create "City Urban Restriction Boundary" (CURB) lines around the city; any development for urban purposes outside the curb line and under the jurisdiction of the city requires a city vote. The county ordinance requires a county vote to change the County General Plan in order to alter any land use designation ("Agricultural", "Open Space", and "Rural") or any General Plan goal or policy relating to these designations, with some limited exceptions. The County ordinance and most city SOAR ordinances are in place until 2021 (Camarillo, Moorpark, Oxnard, Santa Paula, and Simi Valley). The City of Ventura ordinance remains in effect until 2026, and the Thousand Oaks SOAR ordinance remains in effect until 2031.[2]

The second program, the California Land Conservation Act Program (LCA), is a voluntary, land conservation program that was adopted by the state. LCA, better known as the Williamson Act, was enacted in 1965 and currently protects 58% of California agricultural land. Under the LCA, agricultural producers voluntarily establish a contract

[2] For more information, see VRMA, 2008a.

with the county in which the farmer or rancher agrees to restrict the usage of the land to agricultural purpose from ten to twenty years into the future, depending on the contract, in exchange for lower property taxes in the current year. Once approved, the contract is binding. Annual renewals are automatic unless either the county or the producer initiates the non-renewal process. Nonrenewal results in taxes gradually rising to the full rate over the remaining years of the contract and the land being no longer restricted to agricultural purposes when the contract expires. Only under rare circumstances is the cancellation of the contract allowed. To qualify for the program, a parcel of farm land must be at least ten acres of prime land (as defined by LCA), and have produced at least $500/acre of agricultural income in the past three years (VRMA, 2008b; CDC, 2008b).[3]

Determinants of Agricultural Land Prices and Land Use: Exploratory Statistical Analysis

In this subsection we present exploratory regressions regarding the determinants of Ventura County land use. We ask two basic questions. First, what factors influence the price of Ventura County agricultural land? Second, what factors influence the amount of land devoted to urban and agricultural uses? These regressions are intended to provide information regarding the statistical importance of some of the factors discussed above; however, they should not be considered a definitive analysis. The regressions use very few datapoints, based on available information. Many other factors may affect land prices and use decisions, which are not included in the statistical analysis. Changes in agricultural land preservation programs, for example, are not included, nor are zoning laws more generally. Importantly, we do not have data on land rents. Rents are the returns to land, and are the best measure of expected returns to land (Alston, 1986). Instead, we use gross returns per acre by crop. Furthermore, we include land prices as an exogenous variable in our land use regressions even though we estimate another set of regressions that include it as the endogenous variable.[4] We do so because insufficient observations are available to enable us to use preferable, although still not theoretically ideal, variables. Because the regressions are exploratory only and because we have limited data available at this time, we do not address this latter consideration.

<u>Agricultural land prices.</u> The question this analysis addresses is what determines the price of agricultural land: returns to agriculture, county population, or some combination of the two. We utilize a fixed-effects panel regression estimation procedure. The fixed effects are for the different crops for which land prices are available.

The agricultural land price analysis is conducted using annual data from 1992-2006 collected from various sources. The land value ($/acre) data are from the California Chapter of the American Society of Farm Managers and Rural Appraisers' annual publication *Trends in Agricultural Land and Lease Values*. These variables were only available for a handful of crops: avocados, lemons, oranges, and row crops. The

[3] Grazing land requires the parcel to be at least 80 acres and able to sustain a specific herd size.

[4] However, including gross agricultural returns per acre averaged across crop categories does not alter the results. Due to the very small number of observations we are precluded from using gross agricultural returns per acre by crop category.

American Society of Farm Managers and Rural Appraisers defines row crops as "farm crops planted in rows to permit cultivation during growing." All land value variables are in constant 2006 dollars, which is done utilizing the index for prices received by farmers from the USDA National Agricultural Statistical Service. The population data comes from the *California Statistical Abstract* (2000 and 2006) from the California Department of Finance. Finally, the revenue per acre data was taken from data reported by the Ventura County Agricultural Commissioner to the California Agricultural Statistics Service. The revenue per acre variables were calculated for: avocadoes, lemons, oranges and row crops. Row crop revenues are the acreage-weighted average of revenue per acre for the following crops: celery, fresh tomatoes, raspberries, bell peppers, mustard and turnip greens, cabbage head, spinach, cilantro, lettuce leaf, broccoli, lettuce romaine, lima beans, parsley, and strawberries. Like the land value variables, all revenue per acre variables are in constant 2006 dollars.

Table VII-1 reports the results of the fixed-effect panel estimation of a linear model. Revenues from each crop have a positive effect on the price of land in that crop category. The effect is statistically significant at the 1% level. County population also has a positive effect on agricultural land prices, although the effect is statistically significant only at the 10% level. Results are similar for a log-log model specification.

Table VII-1. Ventura County Agricultural Land Values, 1990-2006

Variable	Coefficient	Standard Error
Crop revenue	2.9170	0.9635*
Population	0.0799	0.0440*
Constant Term	-49014.84	31362.67

* Significant at the 1% level

The regression is based on 52 observations in 4 crop groups. The overall R-square value for the model is 0.3642, meaning that the model explains just over a third of the variation in the land price data. The F-test is statistically significant at the 1% level: $F(2,46)= 10.62$.

<u>Urban and agricultural land use</u>. The question this analysis addresses is what variables explain the amount of land in urban uses and under cultivation. We hypothesize that the county population and agricultural land prices will affect the pattern of land use. We utilize a seemingly unrelated regression estimation procedure and estimate the determinants of both land use categories simultaneously.

The land use regressions utilize data on the total amount of urban land and cropland in Ventura County from 1992-2006. The cropland variable is constructed by subtracting grazing land from total agricultural land. Land use data are collected every other year by the California Department of Conservation, Division of Land Resource Protection. All other variables utilized in these regressions are the same as in the agricultural land price

estimation, but the values are averaged for every two years of observations to match the frequency of the land use data.

Table VII-2 reports the results of the estimation. Based on Figure VII-2, we included both population and its squared value as explanatory variables for both land use categories. Both are statistically significant determinants of the amount of urban land, as is the constant term. The price of agricultural land is insignificant. None of the variables have statistically significant effects on the amount of cropland at the 1% level, although the constant term is significant. The price of agricultural land was a statistically significant determinant of agricultural land use at the 10% level, and had a positive effect. Surprisingly, the net effect of population on urban land use is *negative* at the population levels observed in the sample, and the pseudo-R-squared value is 0.99.

Table VII-2. Ventura County Urban Land and Cropland, 1994-2006

	Urban Land		Cropland	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Ag. Land Price	-0.0008582	0.0340882	0.3340587	0.1925325
Population	-0.1944568	0.0179498*	0.0765554	0.1013815
Population^2	0.000000188	0.0000000161*	-0.0000000679	0.0000000909
Constant Term	136804	5086*	97447*	28729

* Significant at the 1% level

These results should be interpreted with great caution. There are only seven observations. Furthermore, as noted at the beginning of this section there are other variables that are likely to affect land use decisions. The estimated coefficients on the population variables may reflect the effects of other variables not included here.

The findings of the statistical analysis cannot be considered conclusive; indeed, they are suggestive at best given the limited number of variables and observations. Nonetheless, they do indicate that most likely county population either drives or is correlated with other factors that drive land use.

VIII. Implementing Emission Allowances: 2008 Approach and a Market Approach

In order to bring the Ventura County non-attainment area into compliance, CDPR issued emission allowances to growers for the 2008 peak emission period (May 1 to October 31). As noted in the introduction, CDPR had initially designed a compliance plan with a four-year phase-in period for emission quotas. The phase-in period was rejected by the court initially. While appealing this ruling, CDPR simultaneously implemented an emission allowance system in Ventura County. CDPR prevailed in court in August. This section has two primary components. The first component addresses the emission allowance system as initially implemented. The second uses preliminary data regarding growers' actual fumigated choices once emission permits were allocated.

As the emission allocation system was implemented initially in early 2008, growers submitted requests specifying a product, acreage and field location to the Ventura County Agricultural Commissioner. That office checked to ensure that the application method was allowed under the regulations, and to ensure that the grower controlled the field in question (CDPR, 2008b). The requests were then forwarded to CDPR, which calculated the percentage of requests that would be issued to growers as emission allowances.

CDPR (2008b) provides a detailed and useful comparison of the requested emission allowances to 2004 fumigant preplant soil applications, including product, application method, application rate, and crop. Based on recent historical use patterns, it is possible that virtually all acreage intended for fumigation will be fumigated if growers follow recent patterns of choices of fumigant, application method, and application rates, rather than the ones specified in the emission allowance requests. We will not replicate that discussion here. But, in order to motivate our discussion of the incentives the allocation process provides growers, we note the following: the vast majority of requests were for methyl bromide-chloropicrin products, although the use of methyl bromide had declined in Ventura County in recent years. In total, the kilograms of methyl bromide requested (1.7 million) equaled 33% of the 2008 critical use amounts authorized by the Parties to the Montreal Protocol (5.4 million) for the U.S. for all purposes (CDPR, 2008b; USEPA, 2007). Such levels of methyl bromide use in Ventura County would be unsustainable given the regulatory environment. (Unsurprisingly, growers utilized other active ingredients for a substantial share of applications.)

To the extent that the applied product, application method and application rate are the same across growers, a percentage reduction from requested emissions implies that the resulting emission allowances give each grower the same percentage of his or her requested emissions. If the requested fumigation is identical to the implemented fumigation, this approach will result in an identical percentage reduction in fumigated acreage across growers. However, as administered, growers are not required to use the product, application method, or application rate specified in their emission allowance requests. Consequently, normalizing requests in terms of product and rate does not result, necessarily, in the same percentage reduction in fumigated acreage across growers. Growers with greater scope to move to fumigation choices that result in lower emissions

per acre fumigated will be able to fumigate a greater percentage of their requested acreage. In other words, once emission allowances are allocated growers may utilize them in the manner that maximizes profits.

Because the emission allowances are not tradeable among growers, and because the allowances were allocated based on requests that did not include the economic value per unit of emissions, there is no reason to expect that the existing approach maximizes social welfare. In other words, the marginal benefit per unit of VOC emission allowance almost certainly varies across growers. Because growers are not required to use their requested fumigation product, application method or rate, and because data regarding profits per acre for each crop are unavailable, we cannot provide precise calculations regarding the magnitude of this distortion. Instead, we rely on the fumigation information specified in the emission allowance requests to provide a measure of the differences in the value of a unit of emission allowance in terms of the value of agricultural output produced using that unit in preplant soil fumigation. Before presenting these findings we note that the ideal measure of the value of each unit of emissions from preplant soil fumigation would be the net returns per unit. These numbers are not available. However, we also note that to the extent that net returns per acre *as a percentage of revenues* per acre are the same across crops, using revenues rather than net returns will result in the same ordinal ranking by crop even though the absolute values will be different.

Table VIII-1. Gross Crop Revenues Per Pound of Emission Allowance by Crop: Requested Preplant Soil Fumigation Products, Application Methods and Application Rates, 2008

Crop	Revenue per lb. emission allowance	Crop's total requested allowance	Cumulative requested allowance
Lemons	$ 913	13,677	13,677
Raspberries	$ 723	46,620	60,297
Avocado	$ 510	2,820	63,117
Tomato	$ 456	166,281	229,398
Flowers	$ 445	39,936	269,334
Strawberries	$ 219	1,915,340	2,184,674
Turf/sod	$ 218	3,278	2,187,952
Peppers	$ 110	187,600	2,375,552

Source: CDPR (2008b) and VCOC (2007).

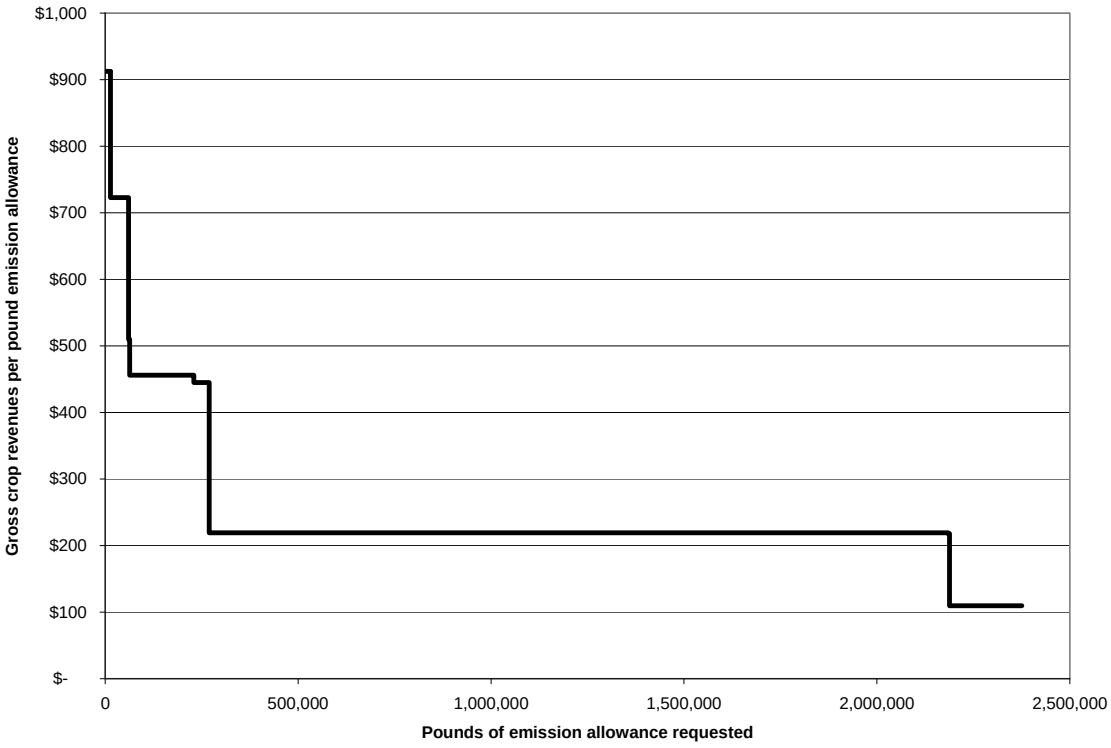
Using the minimum-emission method requested for each crop in the appendix to CDPR (2008b), we calculate the cost in lost revenues for each acre not fumigated for the eight crops for which emission allowances were requested (Table VIII-1, column 2). To do so we use 2006 revenues per acre (VCAC, 2007) for annual crops and calculate the net present value for perennial crops using a real interest rate of 5%. Because products' emission potentials vary, and application rates and methods vary, crops with the highest value of production per acre are not necessarily the crops with the highest gross crop revenue per pound of emission allowance. Flowers, which have the highest value of

production per acre, have only the fifth highest gross crop revenue per pound of emission allowance.

Implementing a market for emission allowances would facilitate the removal of the distortion in the value of a pound of emission allowance across crops. Growers would be allowed to sell allowances or to use them for preplant soil fumigation once the allowances were assigned. Initially, the state could sell emission allowances, or allowances could be allocated across growers based on historical use or other criteria. In the former case, the revenues from the sale of emission allowances could be used to cover program administration costs and fund research into means of reducing VOC emissions from fumigants, including research regarding alternatives to fumigation. Either being required to purchase emission allowances or having the opportunity to sell unneeded emission allowances to other growers will provide an incentive for growers to adopt lower emission production methods.

Figure VIII-1 uses the information from columns 2 and 4 of Table VIII-1 to plot emission requests by crop in decreasing order of **gross** crop revenues per pound of VOC emission allowance. Assuming that differences in net returns to management as a percentage of revenues across crops are sufficiently small so that the ordinal rankings are unaffected, the figure shows that a market for emission allowances would result in a substantially different allocation across crops than the 2008 process did.

Figure VIII-1. Gross Crop Revenues per Pound of VOC Emission Allowances: Requested Products, Application Methods and Application Rates, 2008



Source: CDPR (2008b) and VCAC (2007).

Because Figure VIII-1 plots **gross** crop revenues on the vertical axis these absolute values do not represent the actual price growers would be willing to pay for a pound of emission allowance. The actual market price per pound will depend on growers' net returns. If net returns as a percentage of gross revenues are the same across crops, however, the figure represents the exact **ordinal** ranking of growers' willingnesses to pay for emission allowances. If net returns as a percentage of gross revenues vary slightly across crops, then the figure still illustrates that crops can be divided into groups ordered by willingness to pay. Lemons have a substantially higher willingness to pay than other crops. Raspberries, avocadoes, tomatoes, and cut flowers have a substantially higher willingness to pay than strawberries and turf/sod, which in turn have a substantially higher willingness to pay than peppers.

If there was a market for emission allowances, lemon, avocado, tomato, flower and raspberry producers would be willing to pay enough to obtain their entire requested emission amount given the total emission allowance of 734,000 pounds allocated initially for 2008. Pepper growers would not be willing to purchase any emission allowances at prices high enough to clear the market. Some emission allowances would be purchased by strawberry and/or turf and sod growers, but they would not be willing to purchase 1,453,952 pounds of their requested allowances given the prices other producers are willing to pay. Economic theory predicts that the price of a pound of emission allowance will be determined by its marginal revenue product, which Figure VIII-1 indicates will be determined by the net returns per pound of emission allowance for strawberries and/or turf/sod.

Table VIII-2 provides some indication of the approximate values of the marginal revenue products that would determine the price of a pound of emission allowance. It reports the absolute net returns per unit of emission allowance by crop for various values of net returns as a percentage of gross returns. It also provides information regarding how large differences in net revenues as a percentage of gross revenues must be in order to alter the ordering of crops in Table VIII-1 and Figure VIII-1. For example, if net returns were 15% of gross crop revenues for tomatoes and 10% of gross crop revenues for avocadoes, then tomato growers would have a higher willingness to pay for a pound of emission allowance ($68) than avocado growers would ($51).

Table VIII-2. Net Revenues per Pound of VOC Emission Allowances: Requested Products, Application Methods and Application Rates, 2008

	Net revenue as a percent of gross revenue					
Crop	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**
Lemons	$ 46	$ 91	$ 137	$ 183	$ 228	$ 274
Raspberries	$ 36	$ 72	$ 108	$ 145	$ 181	$ 217
Avocado	$ 26	$ 51	$ 77	$ 102	$ 128	$ 153
Tomato	$ 23	$ 46	$ 68	$ 91	$ 114	$ 137
Flowers	$ 22	$ 45	$ 67	$ 89	$ 111	$ 134
Strawberries	$ 11	$ 22	$ 33	$ 44	$ 55	$ 66
Turf/sod	$ 11	$ 22	$ 33	$ 44	$ 55	$ 65
Peppers	$ 5	$ 11	$ 16	$ 22	$ 27	$ 33

In terms of which values are most likely to be applicable, we offer the following two numbers as benchmarks for net revenues as a percentage of gross revenues on average across crops. Calculations using data from the 2002 Census of Agriculture, found that Ventura County net cash farm income equaled 23.5% of the market value of agricultural products sold. Calculations based on the Economic Research Service's Farm Income data resulted in a state-level average annual percentage of net farm income as a percentage of the value of agricultural sector production for 24.0% in California for the 2000-2006 time period (ERS, 2008a). The ERS definition of net farm income reports the "entrepreneurial earnings" of farm operators, and includes both cash income and non-cash income, such as the value of home consumption.

We emphasize that all of our comparisons of the values per pound of emission allowance for various variables rely on the information in growers' 2008 emission allowance requests, which determine emissions per acre. If growers use a different set of fumigant, application method, and rate combinations than those specified in their emission allowance requests, then the value of an allowance for a pound of emissions will change. If growers of crops with relatively low gross revenues per pound of emission allowance adopt lower emission approaches than growers of the crops with the highest gross revenues per pound of emission allowance do, then the difference in their willingness to pay will decrease.

Table VIII-3 provides some relevant information regarding product name by site name. Based on preliminary 2008 PUR data from January to August 2008, it suggests that growers' actual fumigation choices were very different from those in their emission allowance requests. Of course, actual emissions per acre and hence the gross crop revenues per pound of emission allowance depend on application rates and application methods as well. One piece of information that Table VIII-3 does provide is that a diversity of products are used on a given crop, which suggests that the gross crop revenue per pound of emission allowance will be heterogeneous across growers of a given crop. In terms of Figure VIII-1, this would imply that some growers of a given crop will have a higher willingness to pay than others will. Whether or not such relative changes will be

substantial enough to change the rank order of the crop-specific values listed in Table VIII-1 and plotted in Figure VIII-1 remains to be seen.

Table VIII-3. Pre-plant Soil Fumigation Products by Crop: May-August, 2008

Site Name	Product Name
LEMON	ENZONE
N-OUTDR FLOWER	INLINE
N-OUTDR FLOWER	K-PAM HL
N-OUTDR FLOWER	SECTAGON 42
PEPPER, FRUITING	SECTAGON 42
PEPPER, FRUITING	TELONE C-35
SOIL FUMIGATION/PREPLANT	MBC-33 SOIL FUMIGANT
SOIL FUMIGATION/PREPLANT	PIC-BROM 25
SOIL FUMIGATION/PREPLANT	SECTAGON 42
SOIL FUMIGATION/PREPLANT	TELONE C-35
SOIL FUMIGATION/PREPLANT	TRI-CLOR EC FUMIGANT
SOIL FUMIGATION/PREPLANT	TRI-CON 57/43
STRAWBERRY	INLINE
STRAWBERRY	MBC-33 SOIL FUMIGANT
STRAWBERRY	NUTRAPIC
STRAWBERRY	SECTAGON 42
STRAWBERRY	TRI-CLOR EC FUMIGANT
TOMATO	INLINE
TOMATO	TRI-CLOR EC FUMIGANT
UNCULTIVATED AG	WEEVIL-CIDE TABLETS

Source: Preliminary PUR data, CDPR

For purposes of comparison, Table VIII-4 reports the same information regarding product name for these crops for pre-plant soil fumigant applications in the January to April, 2008 period. Although many factors influence growers' choice of fumigant product, substantial differences in product choices between peak ozone season applications and applications outside the regulated period could potentially be due, at least in part, to regulatory constraints. There are differences in product choices between the time periods on a per crop basis. Telone II CA was used for pre-plant treatment for lemons only in the January to April period. Basamid was only used for outdoor flowers in the January to

April period, while Sectagon was used only during the May to August period. Several products were only used for pre-plant soil fumigation for an unspecified crop during the January to April period. Nutrapic was only used for pre-plant fumigation for strawberries during the May to August period. No product was used for pre-plant fumigation of tomatoes during both periods.

Table VIII-4. Pre-plant Soil Fumigation Products by Crop: January-April, 2008

Site Name	Product Name
LEMON	ENZONE
LEMON	TELONE II CA
N-OUTDR FLOWER	BASAMID G
N-OUTDR FLOWER	INLINE
N-OUTDR FLOWER	K-PAM HL
PEPPER, FRUITING	INLINE
PEPPER, FRUITING	TELONE C-35
PEPPER, FRUITING	TELONE C-35 CA
SOIL FUMIGATION/PREPLANT	INLINE
SOIL FUMIGATION/PREPLANT	K-PAM HL
SOIL FUMIGATION/PREPLANT	MBC CONCENTRATE SOIL FUMIGANT
SOIL FUMIGATION/PREPLANT	MBC-33 SOIL FUMIGANT
SOIL FUMIGATION/PREPLANT	PIC-BROM 25
SOIL FUMIGATION/PREPLANT	TELONE C-35 CA
SOIL FUMIGATION/PREPLANT	TRI-CLOR
SOIL FUMIGATION/PREPLANT	TRI-CLOR EC FUMIGANT
SOIL FUMIGATION/PREPLANT	TRI-CON 45/55
SOIL FUMIGATION/PREPLANT	TRI-CON 50/50
SOIL FUMIGATION/PREPLANT	TRI-CON 57/43
STRAWBERRY	INLINE
STRAWBERRY	MBC-33 SOIL FUMIGANT
STRAWBERRY	SECTAGON 42
STRAWBERRY	TRI-CLOR EC FUMIGANT
TOMATO	TELONE C-35 CA
TOMATO	TRI-CON 50/50
UNCULTIVATED AG	TRI-CLOR EC FUMIGANT
UNCULTIVATED AG	WEEVIL-CIDE TABLETS

Source: Preliminary PUR data, CDPR

Effects of the Quotas on Growers' Decisions Regarding Pre-plant Soil Fumigation

In this subsection, we examine changes in the temporal pattern of pre-plant soil fumigation in Ventura County for the years 2004-2008 due to the effect of the emission quotas, using preliminary 2008 PUR data from DPR. Because the court decision overruling the initial court order was widely anticipated by August, we limit our discussion to the January-July period.

Table VIII-5 reports fumigated acreage by crop and year for the January to April and May to July time periods. Corresponding to our discussion in section VI, we also report pre-plant soil fumigation for an unspecified crop. We also report total acres for pre-plant soil fumigation on strawberries and an unspecified crop, for two reasons. First, 2008 summer-planted strawberry acres totaled 3,157 acres (CSC, 2009). This was substantially more than the reported pre-plant soil fumigated acres assigned for strawberries during the first seven months of 2008. Second, in 2005, 63% of the acreage in the 100 fields for which pesticide applications were reported for specific crops in addition to the use of pre-plant soil fumigation on an unspecified crop included applications to strawberries only, and 11% included applications to strawberries and at least one other crop.

Table VIII-5. Monthly January-July Pre-plant Soil Fumigated Acreage by Site Name, 2004-2008

	Strawberry		Pre-plant Soil Fumigation		Straw. + Pre-plant Soil F.		Pepper		Tomato		Lemon		Outdoor Flower	
Year	Jan.-April	May July	Jan.-April	May July	Jan.-April	May July	Jan.-April	May July	Jan.-April	May July	Jan.-April	May July	Jan.-April	May July
2004	639	5,337	419	703	1,058	6,040	1,052	150	258	1,055	224	3	48	69
2005	-	4,203	180	833	180	5,036	443	389	344	332	11	31	24	29
2006	76	3,416	373	1,505	449	4,921	342	193	212	510	19	68	15	40
2007	20	2,680	235	1,409	255	4,089	551	64	-	100	72	-	19	-
2008	873	1,416	1,501	443	2,374	1,859	798	33	760	217	152	24	7	41

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Tables VIII-6 to VIII-12 report the share of acreage fumigated monthly for the January to July period for the years 2004 to 2008 for the crops displayed in Table VIII-5. "Strawberry" and "Unspecified Crop" shifted a substantial share of applications outside of the peak ozone season. For the case of strawberries in particular, a substantial share of applications were shifted into April, while the percentage in May and June declined. For the other crops, the annual pattern of applications was much less consistent for the 2004-2007 period, so it is difficult to draw any conclusions regarding a change in the monthly shares of fumigated acreage.

Table VIII-6. Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Strawberry

Year	January	February	March	April	May	June	July
2004	1%	0%	0%	10%	8%	48%	33%
2005	0%	0%	0%	0%	7%	58%	35%
2006	0%	0%	1%	1%	2%	50%	45%
2007	0%	0%	0%	1%	13%	74%	13%
2008	0%	0%	0%	38%	3%	50%	9%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Table VIII-7. Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Unspecified Crop

Year	January	February	March	April	May	June	July
2004	2%	9%	8%	18%	0%	9%	53%
2005	0%	0%	0%	18%	20%	45%	17%
2006	0%	4%	7%	9%	16%	29%	35%
2007	0%	0%	5%	9%	7%	24%	55%
2008	0%	0%	40%	37%	7%	13%	4%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Table VIII-8. Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Strawberry + Unspecified Crop

Year	January	February	March	April	May	June	July
2004	1%	2%	1%	11%	6%	42%	37%
2005	0%	0%	0%	3%	10%	56%	31%
2006	0%	1%	3%	4%	7%	43%	42%
2007	0%	0%	2%	4%	11%	55%	29%
2008	0%	0%	18%	38%	5%	33%	6%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Table VIII-9. Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Tomato

Year	January	February	March	April	May	June	July
2004	0%	2%	6%	12%	36%	36%	8%
2005	0%	0%	21%	29%	27%	22%	0%
2006	0%	18%	9%	2%	66%	5%	0%
2007	0%	0%	0%	0%	0%	0%	100%
2008	0%	4%	12%	61%	0%	22%	0%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Table VIII-10. Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Pepper

Year	January	February	March	April	May	June	July
2004	0%	11%	46%	30%	12%	0%	0%
2005	6%	0%	22%	25%	43%	3%	0%
2006	0%	13%	28%	24%	5%	31%	0%
2007	0%	36%	46%	7%	5%	0%	5%
2008	0%	0%	63%	33%	4%	0%	0%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Table VIII-11. Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Lemon

Year	January	February	March	April	May	June	July
2004	0%	40%	16%	43%	0%	0%	1%
2005	0%	0%	0%	27%	7%	67%	0%
2006	0%	14%	8%	0%	2%	0%	76%
2007	0%	0%	0%	100%	0%	0%	0%
2008	20%	0%	0%	66%	0%	0%	14%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Table VIII-12 . Monthly Share of January-July Pre-plant Soil Fumigated Acreage, 2004-2008: Outdoor Flower

Year	January	February	March	April	May	June	July
2004	7%	4%	17%	12%	15%	35%	9%
2005	13%	6%	14%	11%	8%	25%	22%
2006	8%	11%	6%	2%	26%	14%	32%
2007	38%	0%	62%	0%	0%	0%	0%
2008	0%	2%	8%	4%	8%	57%	21%

Source: PUR data, various years, CDPR. 2008 data are preliminary.

Effects of the Quota Phase-in Period

As part of its plan for achieving compliance with its commitment for reducing VOC emissions from pesticide use associated with the 1994 SIP, CDPR proposed phasing in the use of emission quotas to reduce VOC emissions from fumigation in Ventura County.[5] The phase-in was not implemented for the quotas effective at the beginning of the 2008 season due to a court order enforcing the existing SIP. The court's decision was overruled on August 20, 2008, with an effective implementation date of September 3, 2008.

Under the phase-in of emission quotas, more emission allowances will be available to growers over the next few years. The immediate effect is to reduce the direct impact of emission quotas on growers. The longer-term effects pose a challenge for Ventura County growers. If the phase-in period is simply treated as a means to continue current preplant soil fumigation practices, then the only effect of the phase-in will be to reduce short-term regulatory impacts. If the phase-in period is used to identify and implement economically feasible lower-emission alternatives to current fumigation practices, then the phase-in period will also mitigate the longer-term effects of post-2012 regulations. There may be effects on the relative profitability of major Ventura County crops (and other crops), depending on the relative efficacy and costs of alternative practices available for each crop.

[5] The US EPA endorsed CDPR's phase-in proposal as being consistent with California's air quality compliance plans in mid-July of 2008 (USEPA, 2008).

IX. Summary: Assessment of the Economic Impacts of the 2008 Regulations

The impact of the regulations will vary across crops and growers. As discussed in Section IV some major Ventura County crops do not use preplant soil fumigation. Depending on their competitive situation, some of these crops could expand acreage in response to any reduction in the acreage of crops using preplant soil fumigation. Other crops that are not among Ventura County's top ten crops may also be able to expand acreage considerably, as discussed in Section V. Some of these crops have values of production per acre that compare favorably to per acre values for many of the top 10 crops. However, some of these crops either use preplant soil fumigation themselves or benefit from rotation with crops that are planted in fumigated soil.

Based on pesticide use report data, Section VI discussed likely impacts on four broad clusters of growers: strawberry growers, who often also grow raspberries; growers of perennial crops, primarily avocados and lemons; vegetable growers, and nursery and flower growers. Strawberry growers are mostly specialists, and produce a crop that accounted for the majority of VOC emissions from preplant soil fumigation in 2004. Demand for strawberries from this area is elastic, so that any price increase resulting from a decline in Ventura County strawberry production would be small. These factors would appear to indicate that strawberry growers will be negatively affected by the regulations, perhaps to a substantial degree. However, a comparison of summer planting intentions for 2008 and acreage in 2008 emission allowance requests suggests that strawberry growers did not expect substantial negative economic effects. Actual summer planted acreage in 2008 was essentially the same as intended acreage.

For growers of perennials, their replant rates may be slowed if they are unable to obtain emission allowances sufficient to match their planting intentions each year. This may affect their ability to respond to shifts in the relative profitability of different perennial crops. Vegetable growers, in contrast, have greater flexibility to respond to emission allowances below those requested by shifting their crop mix. However, their production of some crops has utilized the residual effects of preplant soil fumigation of an earlier crop for pest management. Reductions in the overall use of fumigants may affect the profitability of such crops. With the exception of turf and sod, no requests were made for 2008 emission allowances for nursery crops. Emission allocations were requested for flower production; given the difficult competitive situation facing the California cut flower industry, it is difficult to assess the effects of these specific regulations.

Fundamentally, the economic impact of the 2008 fumigant use regulations on Ventura County agriculture will depend on the extent to which it alters growers' acreage allocation decisions across crops, costs per acre, and revenues per acre. In turn, these effects will depend on growers' use of their emission allowances. The potential for substantial acreage impacts if growers use the fumigant products, application methods and rates specified in their emission allowance requests is much larger than if they use the fumigant products, application methods and rates they have utilized in recent years (CDPR, 2008). The immediate effect of the phase-in will be to reduce any short-term

losses due to the imposition of quotas. The longer-term effects will depend on whether or not the phase-in period is used to identify and adopt lower-emission production practices, and on the profitability of those practices relative to current practices.

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