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# The 2014 drought: Impacts on San Luis Obispo County Agriculture

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## Introduction

The drought of 2014 has been one of the most severe in recent decades on the Central Coast. Drought conditions have been observed throughout much of California and the West, but the Central Coast including San Luis Obispo County has been one of the most stricken regions. The extreme lack of rainfall in the County in the early- and mid-winter led to the area being categorized as in 'Exceptional' drought severity conditions by late winter. As the spring and summer have passed, the area has remained under 'Exceptional' drought severity conditions.

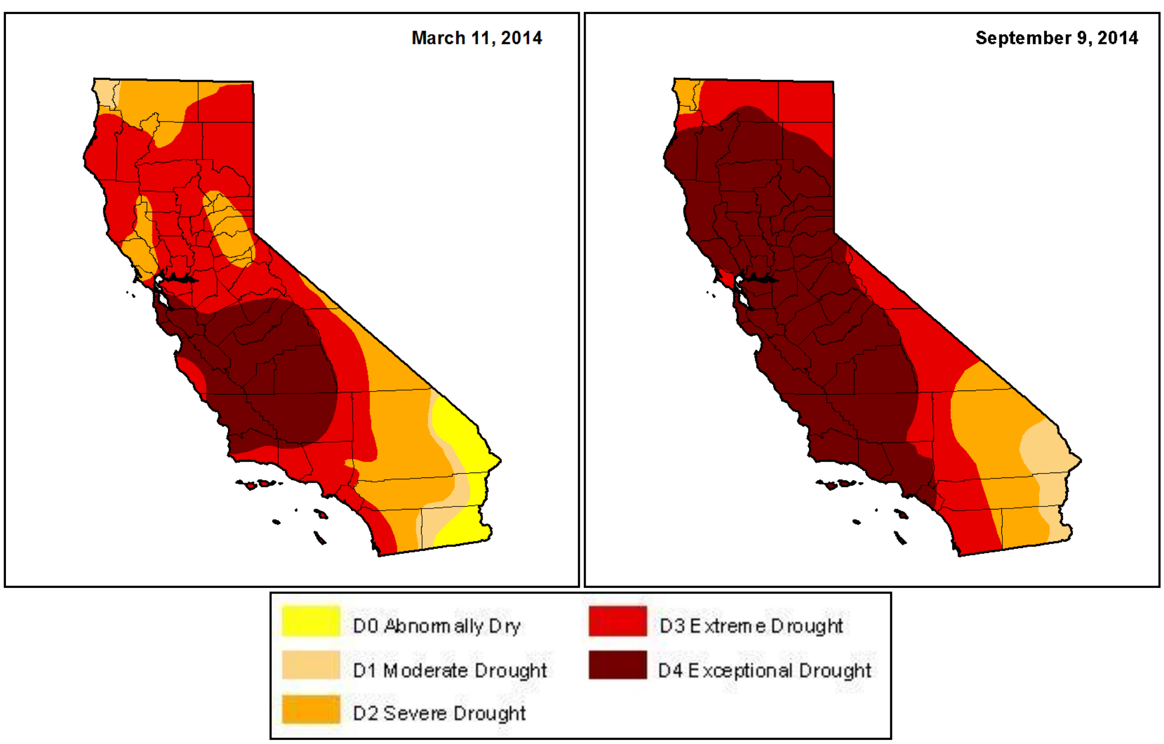


*Figure 1. Progression of the drought intensity from late winter to late summer 2014.*
*Source: US Drought Monitor website,* [*http://droughtmonitor.unl.edu*](http://droughtmonitor.unl.edu)

This article describes some of the principal impacts that this drought has incurred on the agricultural industries of the County, with particular focus on the relationship between local agricultural production and the groundwater resources that provide the majority of the irrigation water in the region. The heavy reliance upon groundwater for irrigation sets this area apart from most other regions of California, where surface water sources have a more dominant role in supplying agricultural irrigation needs. An clear understanding of how the current drought conditions are playing out in the different farming sectors and situations within the County will help all parties make the most prudent management decisions if the current drought conditions continue, or if they return with similar severity in the future.

**A brief history of agricultural water development in the County**

The earliest agriculture in San Luis Obispo County relied primarily on non-irrigated crops, with limited irrigation from surface water sources. The major crops during this period included dry farmed grains (wheat and barley), fruit and nut orchards, and rangeland cattle.

Exploratory drilling in the late 1800's indicated that groundwater existed in numerous areas, particularly overlying what is now known as the Paso Robles Groundwater Basin. Many of these early wells were often artesian, with water flowing to the surface under pressure and thus not requiring any additional pumping. This abundant water made possible the cultivation of crops such as alfalfa and irrigated pasture, which in turn supported animal husbandry industries such as dairies.

As an increasing number of wells were installed, the artesian flows gradually diminished and pumping was required to extract water from lower depths. Innovations in high-pressure submersible pump technology allowed for the pumping of groundwater from deeper depths in the groundwater basins. The cost of installing deep wells and the energy cost of lifting water to the surface and pressurizing it for delivery in an irrigation system remain quite significant for a farming operation. These costs are not justifiable for all crops. The relatively low economic returns per unit of applied water for crops such as irrigated grains have precluded them from being grown in the county on a large scale; for this reason, grain production in this region has remained non-irrigated to this day, even when that production occurs on land overlying the groundwater basin. Pasture for animals can generate a higher economic return per unit of applied water, and thus irrigated pasture is practiced on a limited scale in the County.

More recent agricultural industries such as wine grapes, strawberries, and cane berries will generate relatively large economic returns per unit of applied irrigation water. Therefore even considering the relatively high costs of groundwater pumping in the County the use of such water is economically justifiable for these and other high-value crops.

The use of groundwater for irrigation does bring management challenges to farmers. By its nature, groundwater contains dissolved minerals or 'salts' in varying amounts. Irrigation with groundwater in this dry climate allows these salts to accumulate in the surface soils unless flushed back downward with abundant rainfall or extra irrigation. The high-value berry and fruit crops in the County are all relatively sensitive to elevated levels of these salts in the soil; high soil salinity levels will lead to lower yields and reduced crop quality, and in severe cases can cause total crop loss. Thus in all except the wettest rainfall years, growers need to actively manage soil salinity levels in order to maintain soil health and productivity over the long term.

Many other parts of California such as the Central Valley are normally supplied with developed surface water that is often delivered from distant sources to support agricultural irrigation needs. Agriculture in San Luis Obispo County receives only minimal water from such sources; the vast majority of the water for irrigation comes from local groundwater sources, with minor amounts of local surface water sources providing a small portion of the total agricultural irrigation water use in the County.

The reliance upon groundwater sources for irrigation has dictated that most irrigated cropland be located over accessible and reliable groundwater sources. This pattern of land use development has also been dictated in turn by California law pertaining to groundwater use, in that overlying landowners have had a right to use groundwater for beneficial uses such as irrigation of crops. Figure 2 shows the location of the identified groundwater basins in the county, and the location of irrigated crops relative to these basins.

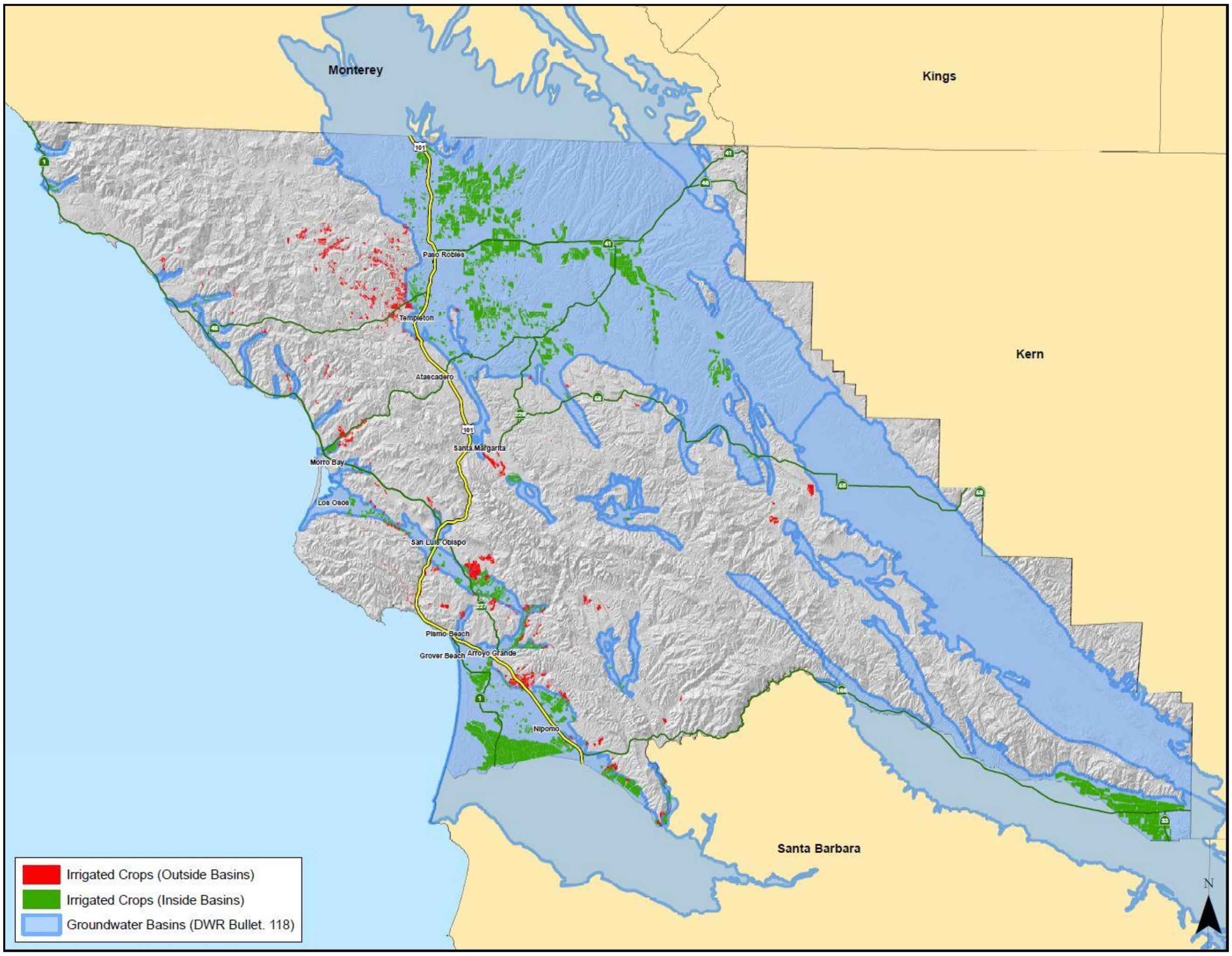


*Figure 2. Location of irrigated cropland in San Luis Obispo County with respect to defined groundwater basins from DWR Bulletin 118. Source: SLO County Agricultural Commissioner's Office*

Not all groundwater sources fare equally well in times of severe drought. The groundwater sources in the county can be broadly defined into two categories, with important implications for water availability. The large volume basins such as the Paso Robles Groundwater Basin will continue to supply water through multiple drought years, even though the increased pumping will put additional strain upon the stored groundwater resource. The small volume basins and other limited groundwater sources are more prone to dramatic reductions in supply, ultimately leading to lower well output or even complete cessation of supply.

Recharge of the groundwater basins in the County is wholly dependent upon local rainfall. The rainfall patterns and amounts are highly variable across the County; the high elevations of the Santa Lucia Range can receive well over 40 inches of rainfall per year, while the eastern portion of the County will typically receive less than 10 inches per year on average. In addition to the amount of rainfall in a given year, recharge of the groundwater sources will also be affected by the pattern of rainfall; low-intensity or short duration storms that result in little deep percolation or stream flow will be less effective than will storms that produce deeper percolation and more sustained stream flow. Many of the small basins in the coastal valleys can recharge relatively quickly with several years of abundant rainfall that produce sustained stream flow, while recharge of the large basins will generally happen more slowly.

The ability to apply supplemental irrigation is a key factor in achieving the current high level of crop production in the County. The value of all non-irrigated crops (small grains, walnuts, etc.) is only about 1% of the total value of all crops grown in the County (source: 2013 SLO County Crop Report). Therefore the lack of sufficient rainfall that reduces the production of these non-irrigated crops will have a relatively small overall economic impact. However, drought conditions that reduce irrigation water supplies will be expected to have much larger impacts on the total crop value in the County. These impacts will be observed more readily in irrigated crops that are not overlying the large groundwater basins. Figure 3 indicates the respective acreage of the different irrigated crop categories that either overly a defined groundwater basin, or that do not overly a defined basin and therefore utilize groundwater from another source or utilize captured surface water. Figure 4 indicates the economic value of each irrigated crop category, again differentiated by the source of water used for irrigation.

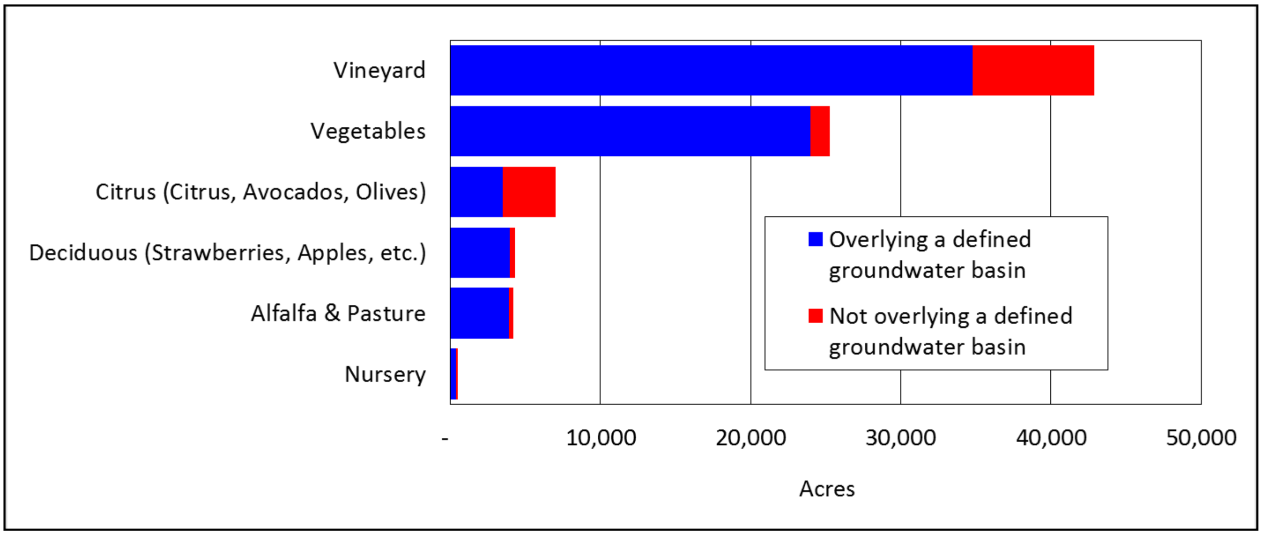


*Figure 3. Irrigated agricultural acreage overlying or not overlying a defined groundwater basin in San Luis Obispo County. Source: SLO County Agricultural Commissioner's Office.*

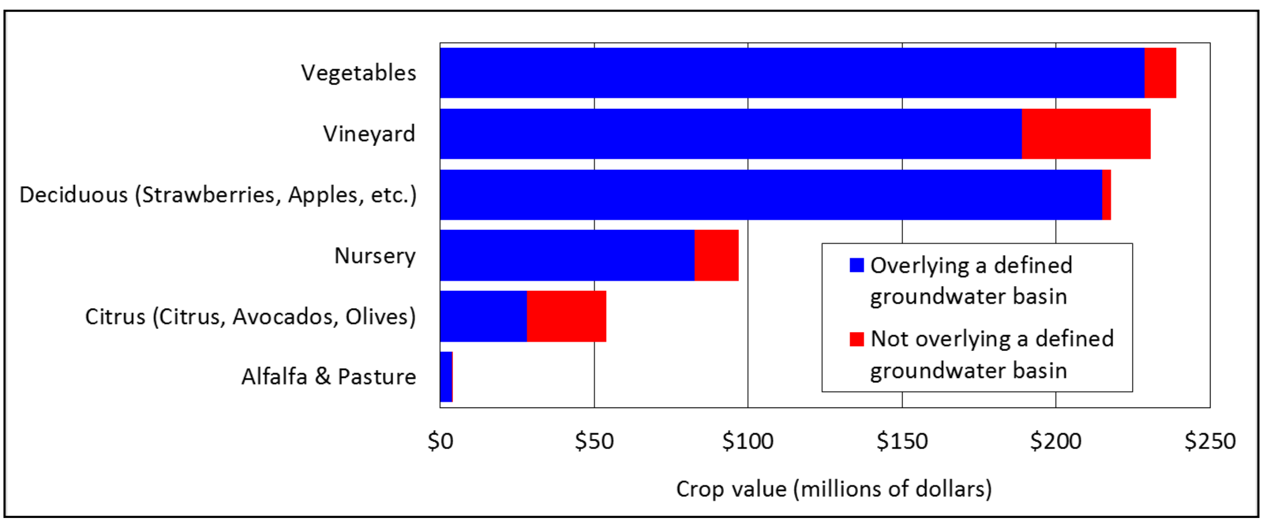


*Figure 4. Total crop value from irrigated acreage either overlying or not overlying a defined groundwater basin in San Luis Obispo County. Source: SLO County Agricultural Commissioner's Office.*

**Impacts of the current drought**

The current drought conditions have had unequal impacts on local agricultural production systems, depending upon whether or not the crops are irrigated, and what the source of the irrigation water is. Non-irrigated crops have generally suffered the most extensive and severe production losses. Crops irrigated from large groundwater basins have maintained normal production levels if growers applied additional water to make up for the lack of rainfall, however elevated salinity levels may be causing yield declines even with adequate irrigation in some areas. Crops irrigated from smaller groundwater sources (identified small basins or other water-bearing formations) have more commonly experienced significant reductions in water availability, with some sources becoming completely dry in severe cases.

The remainder of this report describes the impacts of the recent drought conditions in more detail for the major crops in the county as well as oak woodlands, and provides some strategies for responding to the drought conditions.

## Vineyard production

In assessing the impacts of the recent drought conditions on vineyard production, three different production scenarios need to be address separately, due to their different water supply conditions:

- Vineyards supported by irrigation water from large groundwater basins (e.g. much of the region east of Paso Robles)

- Vineyards supported by irrigation water from relatively limited groundwater sources (e.g. much of the region west of Paso Robles, and some coastal areas)

- Vineyards primarily dry-farmed

Water supplies in the large groundwater basins have remained available over the duration of the recent drought, even though declines in the groundwater levels have been observed in recent years. Impacts and concerns for vineyard production are the following:

- Increased irrigation pumping is required to make up for the lack of rainfall; this places more strain on the basin water supply, and can be expected to exacerbate conditions of groundwater decline. If growers do not increase irrigation applications to make up for the lack of rainfall, then vineyard production will diminish proportionately. In a typical vineyard east of Paso Robles, rainfall may provide approximately one-third of the total annual vineyard water use, thus the lack of rainfall will be expected to require significant increases in the applied irrigation to maintain normal production levels.

- The application of additional irrigation water increases the total amount of salts added to the vineyard soil each year, as groundwater is the primary source of these salts. Without adequate winter rainfall, the leaching of salts from the soil profile is reduced; this in turn increases the root zone soil salinity levels, potentially resulting in both osmotic and toxic impacts on the vines. The osmotic effects cause a reduction in overall vegetative growth and likewise a reduction in the amount of fruit produced. The toxic effects on vine tissue lead to a loss of functional leaf area in the late summer, causing degraded fruit quality as without active photosynthesis vines cannot produce adequate sugar to fully ripen the fruit. Additionally, the loss of effective shading from necrotic leaves can result in significant sunburn and heat damage to the fruit, also lowering fruit quality and value. Under extended drought and salinity conditions, the toxic effects can become severe enough to kill the vines as tissue salt levels exceed vine survival tolerance levels.

Water supplies in the limited groundwater source areas are typically showing more strain due to the recent drought conditions, with significant reductions in available water occurring in many areas. Impacts and concerns for vineyard production are the following:

- Water supplies that may have been adequate in the early part of the growing season may gradually diminish or even disappear altogether as the season progresses, forcing growers to reduce or even cease irrigation. This exposes the vines to severe water stress. The earlier this stress occurs, the more potential damage that may occur. Late onset of stress, during fruit ripening, can lead to degradation of fruit quality if stress leads to leaf necrosis and subsequent fruit dehydration, sunburn and difficulty accumulating sugar. Earlier onset of stress, during the initial stages of berry growth, can also affect the bud differentiation and diminish the fruitfulness of the vines the following year. Very early onset of stress, during the initial shoot growth period and the spring bloom period, can severely affect the vine canopy growth and fruit set that year; this in turn will lead to significantly reduced cropping levels, in addition to the negative effects previously listed.

- Vines grown under significant water stress conditions can be more prone to suffer damage due to pests such as spider mites, and can be less resilient to climate stresses such as early cold snaps fall.

- In areas that receive relatively larger amounts of winter rainfall and subsequently need to apply smaller amounts of irrigation water, the accumulation of salts in the soil is usually a minor concern.

The lack of rainfall in the dry-farmed vineyard areas will have the most immediate and direct impact of any production system:

- The potential for crop production of a given year is directly proportional to the amount of rainfall received the previous winter. Thus in very dry years, the vines will compensate by producing relatively little foliage and correspondingly smaller amounts of fruit.

- If a grower of a dry-farmed vineyard is predicting that winter rainfall levels will be low, they should make plans to reduce the shoot number the following growing season. Otherwise, the vines will produce large amounts of short shoots with inadequate foliage to ripen their crop load. This shoot reduction can be accomplished most easily at pruning, but this obligates the grower to make the shoot number decision fairly early; late winter rains may contradict the early winter conditions, such as occurred in the winter of 2013/2014, and it is impossible to "put buds back on the vine" once cut off. Another strategy is to prune to the normal bud number, and to do more aggressive shoot thinning later in the spring to lower the final shoot count. This choice obligates the grower to pay for this shoot thinning labor.

- Practices which conserve as much as possible of the rainfall stored in the soil profile for later use by the vines are one of the few strategies that growers have to try to maintain normal production levels in dry farmed areas. If in typical years a cover crop is grown later into the spring, the growth of this cover crop can be terminated early or eliminated altogether if doing so does not lead to unnecessary erosion risks. This will help conserve more moisture in the soil profile for later use by the vines.

- In non-irrigated vineyards in the region, soil salinity is rarely a concern because the main source of salts (irrigation water) is not applied.

Strategies to address drought conditions in vineyard production:

- The above negative effects can be minimized by using strategies to reduce the vineyard irrigation requirement. These include limiting the use of actively growing cover crops in the spring, controlling weeds throughout the season, and avoiding heavy fertilization that can lead to excessive leaf canopy growth and subsequently larger water requirements to maintain that leaf canopy. If sprinkler frost protection is used, alternative protection practices such as wind machines or alternative ground floor management may be warranted to help save water.

- If dealing with an older vineyard that is a candidate for renovation, the process of cutting the vines back to short trunks and re-growing the entire canopy will allow those vines to use less water during that first season while the vine structure is being regrown. This may afford a useful amount of water savings to help maintain adequate irrigation supplies for other plantings. This type of renovation results in zero crop during the year of the renovation, but a nearly full harvest will be expected in the following year.

- Dropping water tables can lead to reduced efficiency of the well pump. Reconfiguration of the pump may be necessary to maintain acceptable pump performance and energy efficiency.

- The accumulation of salts in irrigated soils under drought conditions will create increasing problems over time if not managed. Without adequate leaching rainfall, additional irrigation leaching fractions will need to be supplied in order to flush salts from the root zone.

*Figure 4. Winter irrigation applied to a vineyard over the Paso Robles Groundwater Basin. This irrigation helped make up for inadequate winter rainfall and also leached the root zone of excess salts. Source: Mark Battany*

**Strawberry production**

Strawberry growers continue to use available groundwater although with concern for future availability. Current impact of the drought on strawberries:

- Strawberries require 21-24 acre inches of water and rainfall accounts for 3-6 acre inches during the normal rainfall years. Rainfall leaches salts away from the root zone while meeting irrigation needs. Compared to three years ago, it is estimated that there is up to a 10% increase in some salts especially calcium and magnesium due to the current drought conditions. This could lead to 5-10% reduction in fruit yields, but severe salt injury could cause higher losses. Additionally, plants would be vulnerable to pests and diseases which could lead to further yield reduction.

- Strawberries are very sensitive to salinity and frequent irrigation is practiced to prevent the accumulation of salts in the root zone. Growers are aware of diminishing groundwater resources and are carefully monitoring water and salinity levels. Extra irrigation to push out salts from the root zone results in nutrient leaching.

- These practices are expected to continue as long as groundwater is available and acreage could diminish if groundwater becomes unavailable.

Strategies to address drought conditions in strawberry production:

- Continue to monitor groundwater levels and provide irrigation to meet water needs as well as to leach out salts.

- Monitor health of plants and regularly scout for pests and diseases which might require more timely treatment actions than usual because plants are already under stress.

- Check nutrient levels in the soil and plant and compensate as needed if irrigation is causing nutrient loss.

- Modify leaching fractions based on salt levels and plant maturity to flush salts away from the root zone.

- Reconsider acreage planted based on groundwater availability to minimize losses.

**Vegetable production**

Vegetable growers are experiencing the impact of the drought conditions on their production and currently relying on available groundwater.

- Water needs for vegetables vary from about 7 to 36 acre inches based on the crop and location. Rainfall during a normal season contributes up to 24 acre inches depending on the crop and season.

- Drought conditions resulted in increased salinity, which has caused 10-20% reduction in yields of some crops and a significant increase in pest and disease pressure. Some growers are managing without any yield losses.

- Some growers have already reduced their acreage by 10% or more while others continue to maintain the current acreage.

- Reducing or completely avoiding pre-irrigation is currently practiced by some growers to cope with water shortage. This practice has also increased salinity in the soil and increased weed populations.

- Some have reduced fertilizers or are choosing ones with less salt content.

- In order to monitor the salinity and nutrient levels, additional expenses are incurred for water, soil, and plant analysis. Increased weed, pest, and disease problems have also increased the management costs.

- Some growers are prepared to reduce acreage up to 25% if drought conditions continue.

Strategies to address drought conditions in vegetable production:

- Continue regular monitoring of groundwater levels, salinity conditions, nutrient status, and provide irrigation and fertilizers as appropriate.

- Regularly monitor for pests and diseases and make timely management decisions.

- Reduce or avoid sprinkler irrigation and use drip irrigation as much as possible.

- Continue to reduce or avoid pre-irrigation to conserve water.

- Modify leaching fractions based on the current salt and crop conditions and administer irrigation as needed.

- Modify acreage to suit future water availability.

## Avocado production

Avocados are the most salt and drought sensitive of our fruit tree crops. They are shallow rooted and are not able to exploit large volumes of soil and therefore are not capable of fully using stored rainfall. On the other hand, the avocado is highly dependent on rainfall for leaching accumulated salts resulting from irrigation water. In years with low rainfall, even well irrigated orchards will show salt damage. During flowering there can be extensive leaf drop due to the competition between flowers and leaves when there is salt/drought stress. In order to reduce leaf damage and retain leaves, an excess amount of water is required to leach salts out of the roots zone. The more salts in the water and the less rainfall, the greater leaching fraction. Drought stress often leads to diseases, such as black streak, bacterial canker, and blight (stem, leaf, and fruit). Defoliation leads to sunburned trees and fruit which can be severe economic losses.

Strategies to address drought conditions in avocado production:

- Ensure that the irrigation system is at its greatest potential and is maintained. Avocados are grown on hillsides and pressure regulation is extremely important and is frequently neglected.

- Significantly prune trees to reduce leaf area. Avocado can be a very large tree, and if half the canopy is removed, there can be as much as 1/3 reduction in water use. When trees are about 15 feet tall, removing half the canopy can reduce water use by one half.

- In extreme drought conditions, the canopy can be reduced to just the skeleton branches which are white washed to prevent sunburn. Water use drops to zero, and then gradually as the tree leafs out, water can be slowly reapplied, but at significantly less amounts than with the full canopy. Stumping typically results in losing three years' worth of crop.

- In orchards that have low producing areas, because of recurrent frost, high winds, shallow soils, disease, etc. the grower could decide to completely remove those trees, thereby saving water.

- White kaolin applied to leaves has been shown to reduce leaf temperatures and water loss. This can be used, but under the direction of the packing house, since if it is applied to fruit, it is very difficult to remove.

*Figure 5. An avocado orchard that has been stumped due to lack of water supplies. Source: Mark Battany*

**Citrus production**

Citrus is much less sensitive to salts and drought than avocado, partially because of its greater rooting depth. However, it is much more sensitive than deciduous fruit trees, resulting in smaller fruit and lower prices when drought cannot be addressed with adequate irrigation water. Drought also makes the trees more susceptible to leaf drop, and sunburned fruit.

Strategies to address drought conditions in citrus production:

- The strategies for citrus are very similar to those for avocado. It is much more sensitive to pruning to reduce water use than avocado. Typically removing half the canopy results in half the water use. Because of thus greater control, citrus is rarely stumped.

- By reducing canopy size, production can be maintained, often without loss of fruit size.

- Kaolin clay can effectively reduce water use and can be applied soon after harvest without the problem of coating fruit making its removal difficult at the packing house.

**Small and limited resource specialty crop farm production**

Small and limited resource farms experience many of the same changing water supply / salinity vs. winter rain challenges discussed earlier related to vineyards on large groundwater basins. In addition to these changing environmental circumstances however, the situation on small and limited resource farms is also further exacerbated by additional factors of the production and marketing systems that characterize Central Coast small farms. As a result, these smaller and more limited resource farm operations often have more restrictions generally than the larger operations and a more limited range of responses to the drought conditions:

Many small farms begin with more marginal water supplies and occasionally, also water quality compromises. They tend to design irrigation systems to function at the outer limits of their more restricted water supplies. The effect of this is that even minor short-falls in water quantity or quality can have a more marked effect at production or quality.

- Small-scale operations lose the benefits of economies of scale that larger operations often experience and tend to concentrate on low volume, higher value niche products. These products are generally fresh market products destined for specialty markets in metropolitan areas.

- Fresh products are more sensitive generally to moisture stresses than many commodity or processed crops such as wine grapes or olive for oil and many of the higher value niche crops (e.g. berries, snow peas, baby vegetables, etc.) maintain their high market value because they are extremely demanding to grow and highly perishable.

- Higher value fresh market niche crops often have very demanding and strict post-harvest quality requirements; many of which are affected by even minor moisture fluctuation (e.g. calyx color / freshness on sugar peas, berry size, plumpness, firmness, shelf-life).

- Profitability of many specialty crops is directly linked productivity over a long period (e.g. edible pod peas, raspberries, blackberries, blueberries) and this implies keeping the plant healthy and flowering and fruiting over an extended period. The "limited resources" often also involves capital limitations for financing new or deeper wells.

- Other more general moisture stress effects may also affect that characteristics of the specialty products that have marked effects on quality and productivity (e.g. specialty peppers require adequate foliage and vegetative development to protect from sunburn; Napa cabbage sizing and lushness is expected in the market place for reliable marketing)

Strategies to address drought conditions in small-scale limited resource specialty crop farm production:

- As small and limited resource farm operations plan new plantings, strict attention must be paid to assuring adequate supplies and quality of water to produce the crop at profitable yield estimates. This includes careful attention to assure the typical quality standards of the market place that are critical to sales and price expectations. With many niche specialty crops, even limited moisture stress can have dramatic adverse effects on harvest timing, productivity, harvest season length and / or fruit quality and each of these factors can reduce sales expectations.

- Small scale and limited resource growers of specialty crops will also benefit from the many of the general recommendations for increasing irrigation efficiencies and managing salinity described earlier. The higher value and special moisture sensitivity of these crops however will dictate much closer attention to details to assure secure water supplies. The potential financial losses could be quite serious because of the delicate nature, sensitivity and unit value of these specialty crop products.

**<u>Range forage production</u>**

Annual forage production has been monitored in San Luis Obispo County since 2001. The figure below shows how dramatically annual forage production was reduced in 2014 relative to a wet year.

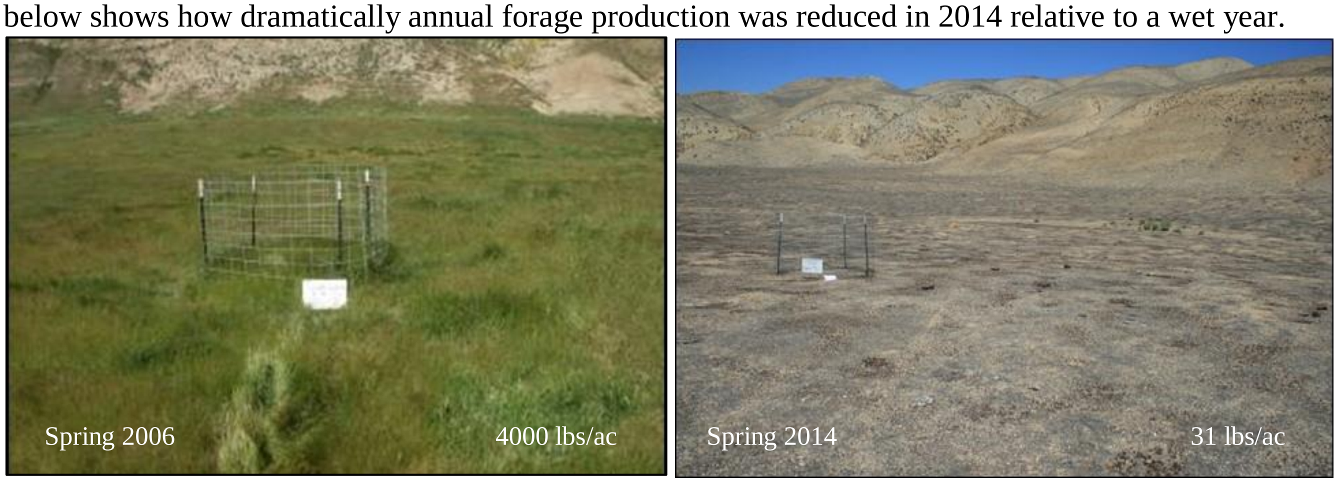


*Figure 6. Spring forage production in Eastern San Luis Obispo County, demonstrating the dramatic differences between the relatively high rainfall winter of 2005/2006 (left) compared to the extremely dry winter of 2013/2014 (right). Source: Royce Larsen*


*Figure 7. Locations of the forage production monitoring sites in San Luis Obispo County. The year each site was established are as follows: 2001 - Adelaida, Camatta, Cambria, Carrizo, Huasna , and Morro Bay; 2003 – Shandon; 2004 - Bitterwater , Soda Lake; 2010 – Creston, Pozo; 2013 - Cayucos, San Miguel, Templeton, Bitterwater-2, Topaz B3, Topaz ST, and Pozo-2. Source: Royce Larsen*

Forage production has been monitored at a number of rangeland sites throughout the County as indicated in Figure 7 above. The total forage production is monitored at these sites, but only the "available forage" is reported here. Available forage is the amount of forage that is available for consumption by livestock. This is the total biomass produced at peak production minus the amount that should be left behind to maintain productivity of the site. The unused biomass remaining at the time the first significant fall rains begin is called "residual dry matter" (RDM). Proper amounts of RDM influences how productive annual grassland will be in the following season, and helps protect against soil erosion and nutrient loss. The amount that should be left depends on the soil, slope, and rainfall zone.

The average available forage for this county during 2014 was 5% of the long-term average, or a 95% loss (Figure 8 on the following page). There was some forage available in the Adelaida area, then along the mountains toward Atascadero to Santa Margarita (e.g. the highest rainfall zones in the county. However, forage production was well below average at these locations also. All other plots sampled either had no available forage (i.e. 100% loss of normal production) or a very high percent loss (Figure 9 on the following page). There was a little forage available around the county on some northern aspects, or in swales with deeper soils, but this was also limited this year.

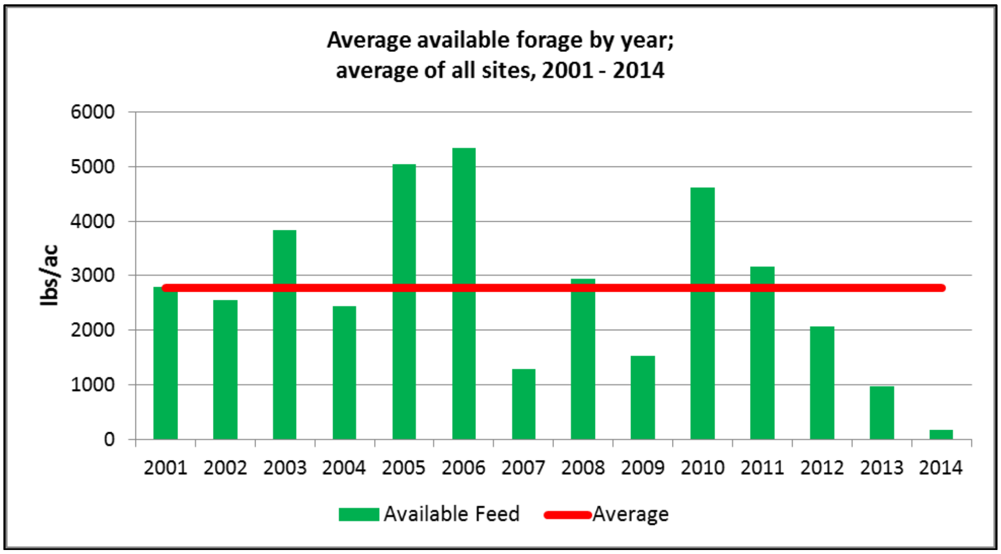


*Figure 8. Available forage for livestock in San Luis Obispo County; average of all sites and years monitored. Source: Royce Larsen*

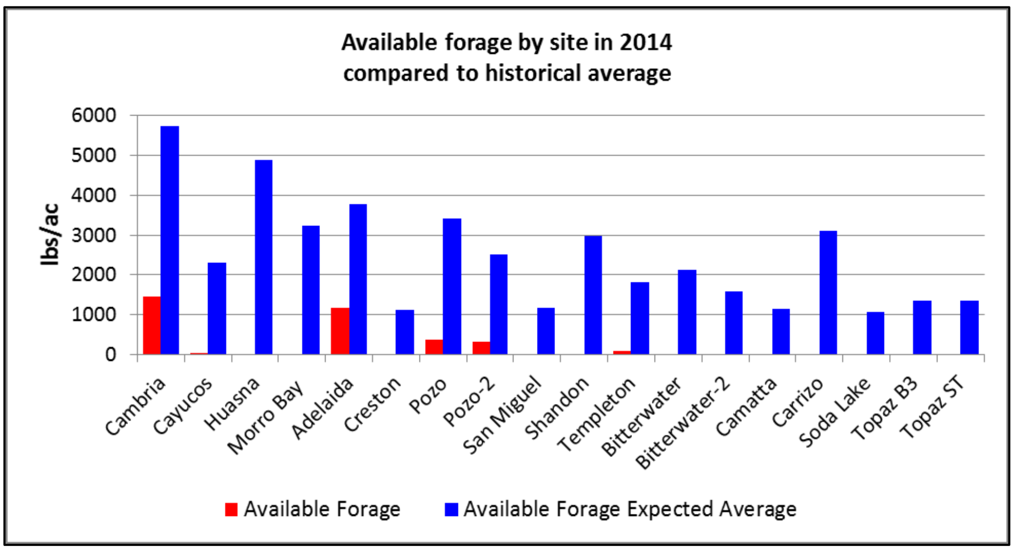


*Figure 9. The available forage for livestock in 2014 compared to the historical average at each monitoring site in San Luis Obispo County. Source: Royce Larsen*

This condition has had monumental impacts on the livestock industry with approximately 75%, or more, of all cattle being removed from the County. The cattle have either been sold, or moved out of state to other pastures. In addition to serious reductions of available forage this year, there will not be enough RDM this fall, which will result in a high percentage of bare ground. This means there will be an increased risk for erosion this coming winter if we receive large and intense rain storms early in the fall. It also means that when rains return, poorer seed production and poorer ground cover may require several seasons of conservative use to return rangeland pastures to normal productivity. Also, it will take several years for the industry to rebuild their herds.

## Oak woodlands

The predominant tree-sized native oak trees on the central coast are two winter-deciduous oaks (valley oak and blue oak), and one evergreen oak (coastal live oak). The current drought has resulted in many questions from the public with concerns about the effects of the current drought on a valued oak tree in the residential landscape or concern as they travel throughout the county about seeing apparently dying or dead oak trees. Water stress renders oak trees more likely to express early leaf browning and to be more susceptible to damage from native and introduced tree pests and diseases. One or more of these could be the last straw for an already stressed tree. The following are the most common areas of concern.

- Water-deficit Leaf Drop

  During dry years, leaves of blue oak trees may brown and drop much earlier than usual. Brown leaves or an almost leafless tree in the middle of August of course makes one become concerned about the health of the tree. Blue oaks are drought deciduous. The trees have adapted to severe drought by shedding their leaves—the primary source for water loss from the tree—much earlier than when soil moisture is higher. Typically, the trees re-foliate normally the following spring. The impact of repeated occurrences of early leaf drop is probably negligible.


*Figure 10. Water-deficit leaf drop during drought, and subsequent re-foliation of the same site the following year. Source: Bill Tietje*

- Oak Root Rot

  During drought we may water lawns or gardens around oaks more frequently and more heavily. Frequent watering keeps the surface soil moist, providing ideal conditions for root-rot pathogens (primarily *Phytophthora* spp.) to proliferate. Root rots are the #1 killer of oak trees in the urban environment. Keep the area under the tree canopy free of vegetation and irrigation.

- Sudden Oak Death

  Not surprisingly, "Sudden Oak Death" (SOD), a tree disease caused by an exotic fungal pathogen (*Phytophthora ramorum*), strikes fear in the oak-enthusiast's mind. SOD does kill coastal oak trees, but not suddenly, and almost surely not in the central coast counties south of Monterey County. The fungal pathogen spreads in wet springs and then in drier years, when the trees are under moisture stress, they die. However, apparently there is some environmental influence that has inhibited the spread of SOD south of Monterey County.

- California Oak Worm

  The oak worm, a moth larva, can occur in prodigious numbers some years in fairly localized areas in central coast counties. The worms oftentimes completely defoliate a coastal live oak tree, which is its primary host. As its name implies, the California Oak Worm is a California native. The oaks and the worms have learned to live with each other and, as with water-deficit leaf browning and drop, defoliated trees typically re-foliate normally the spring following the defoliation. We know that healthy trees can withstand at least 3 defoliations without significant effects.

- Oak Mortality

  Undoubtedly, the current drought is causing some oak mortality in Central Coast counties. This is the case especially for oak trees on south facing slopes and those on shallow soils where soil moisture is very low. A dropping water table is a particular concern for the valley oak, a tree with roots that extend into the water table. Of course, as the water table drops, less water is available to the tree.

*Figure 11. Drought-induced oak mortality. Source: Bill Tietje*

Strategies to address drought conditions in oak trees:

- Although there has been some mortality of oak trees attributable to the current drought, in the vast majority of cases, native oak trees will survive. Oaks are very drought tolerant.

- Unless there is an obvious nutrient deficiency, which is extremely rare in native landscapes, any fertilization of an oak is excessive. In an urban landscape, the lawn and other exotic plants which are surviving there are more nutrient demanding than is the oak. In other words, if there are enough nutrients for these plants, there are enough for the oak. If it has any effect at all, fertilizer will cause the tree to produce more foliage, thereby increasing the amount of water needed by the tree to maintain this foliage. Fertilization also tends to cause pest outbreaks.

- If the soil under your oak 12-18 inches down is dry and crumbly, the oak is out of water. A deep watering will invigorate the drought-stressed tree. Perhaps it seems ill-advised to advise the watering of an oak during a drought. But think about it a minute. If you lose the oak, you lose

10% of the value of your house. Also lost are the many ecosystem services provided by this "keystone" structure (e.g., shade, soil nutrients, habitat). These take a very long time to replace. Deep watering of the drought-stressed tree is accomplished by moving a hose under the canopy of the tree during the day for a day or two at a low flow or trickle stream, such that the water percolates into the soil. Do this once or twice during the summer to early fall with at least a month between the watering to allow the soil to dry, reducing the likelihood that fungi will attack the tree roots.

- A prudent approach to the current drought and the maintenance of tree health is to conserve existing soil moisture as much as possible. Mulching under the tree helps to control moisture by keeping the soil cool and by suppressing weed growth. The best mulch is the oak's natural leaf litter. But most commercially available plant-based mulches provide a similar benefit. Apply 3-5 inches of mulch under the tree canopy and avoid the piling of the mulch against the tree trunk.

- Some want to remove the stressed oak tree because, if dead, it may become a safety hazard or fall and damage property. In some cases this may be true and, if so, the tree should be trimmed or removed. However, in the vast majority of instances that a tree looks bad the best advice is this: "Wait & See". More than likely the tree will survive and re-foliate in spring or when water becomes more available. Our native oaks have survived through historical droughts that have been much longer and more severe than our most recent drought. Long-term climate records indicate that droughts lasting a century or more have occurred in the past in California; native vegetation has proven to be highly resilient to such conditions.