## Crop Fact Sheet series

*Excerpted from* **The Southwest Regional Climate Hub and California Subsidiary Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies** *(July 2015)*

This report describes the potential vulnerability of specialty crops, field crops, forests, and animal agriculture to climate-driven environmental changes. In the report vulnerability is defined as a function of exposure to climate change effects, sensitivity to these effects, and adaptive capacity. The exposure of specific sectors of the agricultural and forestry industries varies across the region because the Southwest is climatically and topographically diverse. The purpose of this analysis is to describe regional vulnerabilities to climate change and adaptive actions that can be employed to maintain productivity of working lands in the coming decades.

The report can be accessed here: http://swclimatehub.info/files/Southwest-California-Vulnerability-Assessment.pdf

# Citrus

*Citrus* × *sinensus* (oranges); *Citrus* × *limon* (lemons); *Citrus* × *paradisi* (grapefruit); *Citrus reticulata* (mandarins); Rutaceae


All citrus fruits are thought to be native to subtropical East Asia, but after thousands of years of cultivation, their origins are obscured. California began commercially producing citrus (primarily oranges) in San Diego and Los Angeles Counties around the turn of the last century, but now most citrus production has moved to the southern San Joaquin Valley. California now produces 30% of the nation's oranges, 90% of lemons, 48% of mandarins, and 30% of grapefruit (with Florida and Texas accounting for most of the rest) [2] (Figure 1).

As a subtropical crop, citrus trees are not often harmed by heat, but they have varying degrees of frost intolerance. Sustained temperatures below -4°C (25°F) will kill most citrus outright, and even a light frost of -1°C (30.5°F) can damage more sensitive varieties such as limes [3]. For example, the most costly extreme weather event for California agriculture in the past 30 years was the week-long freeze of December 1998, which destroyed lemon and orange groves (among several other crops) in Southern California at a cost of $682,000,000 [4].

Citrus have a moderately high annual irrigation demand of 34-36 inches per year in the San Joaquin Valley [5] and somewhat less for orchards near the coast due to cooler temperatures and fog [6]. Irrigation can cause salinity buildup, and periodic leaching with a calculated irrigation fraction is necessary to maintain tree health [5].

**Temperature:** Warmer temperatures may have some negative impacts on citrus growers, but this is probably not the highest-priority concern. Citrus are adapted to semitropical conditions, and warm summers can improve crop flavor [7]. However, higher temperatures increase evaporative demand and may exacerbate drought stress. Also, if climate change causes a decrease in normal diurnal temperature fluctuations during fruit development in the autumn, fruit color may be negatively affected because breakdown of chlorophyll and subsequent emergence of carotenoids may be impaired (L. Ferguson, pers. comm., 20 January 2015).

**Water:** Decreasing quantity and quality of irrigation water will probably be the largest challenge that citrus growers face under future climate (Table 1). The severe drought of 2014 stunted citrus fruit and killed entire citrus orchards in southern California [7]. Some citrus growers are removing healthy bearing trees because they do not have water to sustain them. By some estimates, the drought might cost the San Joaquin Valley 25% of its citrus orchards and $3 billion in profit over the next five years [8].

Citrus can do quite well under moderate water limitation. Deficit irrigation experiments have shown that mild water stress can even improve fruit quality

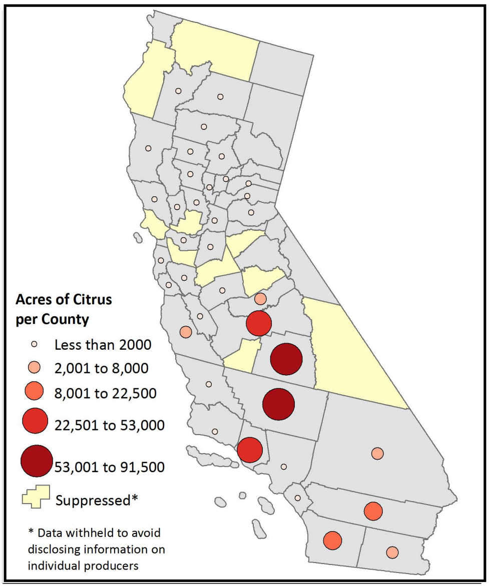


**Figure 1.** Acres of citrus grown in CA in 2012 (293,387 acres). Not shown:12,000 acres in AZ. [1]

and color without harming yields [5]. For example, one trial in an orange grove in the San Joaquin Valley curtailed irrigation to 25% of evaporative demand between May and July, thus reducing total annual water use by about one-quarter, without significantly affecting yield [9].

**Overall outlook:** Experts disagree on how much harm climate change might cause the citrus industry. Lobell et al. [10] concluded that “For oranges, walnuts, and avocados... the areas with the potential for high yields [are] dramatically reduced.” They predicted that under a 4°C (7.2°F) temperature rise, only one of the seven California counties that currently produce oranges would still be able to do so.

Medellín-Azuara et al. [11], using an economic optimization model, reached a less dire conclusion: by 2050, citrus yields will increase by about 2% in the Sacramento Valley and decrease by about 18% in the San Joaquin Valley, while total acres devoted to citrus will remain roughly constant. And Jackson et al. [12] concluded that “warmer winter temperatures may expand the range of subtropical crops like citrus.” More investigation is needed to reconcile these seemingly incongruous predictions.

**Table 1.** Vulnerability of citrus to climate change in California.

| Exposure | Sensitivity | Adaptive Capacity |
|---|---|---|
| • Temperature: Wide range of exposure due to geographical range of citrus: by 2060, coast will warm by 1.5°C (2.7°F); Central Valley 2°C (3.6°F); inland S California and Arizona 3°C (5.4°F).<br>• Water: Decreased water availability and quality very likely.<br>• Extreme events: More common heat waves; rarer frosts. | • Not sensitive to moderate warming of average temperatures.<br>• May benefit from reduction in frost.<br>• Moderately sensitive to water limitations: irrigation-dependent; water use medium-high; some flexibility for deficit irrigation.<br>• Unclear whether climate change will affect citrus pests/ pathogens. | • Temperature: Likely that no adaptation is needed.<br>• Water: moderate adaptive capacity. Further gains in water use efficiency may be possible.<br>• Pest and diseases: unknown. |

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