United States Department of Agriculture
Southwest Regional Climate Hub and California Sub Hub
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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

Almonds

Prunus dulcis (Rosaceae)

California currently produces 100% of the nation's commercial almond crop and more than 80% of the world's almond crop [2]. California almonds – grown almost exclusively in the Central Valley (Figure 1) – were a $5B industry in 2012, approximately double their value only a decade earlier. Although often considered together with other tree nuts such as walnuts and pistachios, almonds are closely related to stone fruit (e.g., peaches, plums, apricots, cherries; genus *Prunus*). The majority of almonds in California are grafted onto peach (*P. persica*) or peach-almond hybrid rootstock [3].

Almonds are native to the Middle East and Central Asia; they thrive on cool winters and warm, dry summers [4]. Most almond varieties require 200-400 annual chill hours (hours below 7.2°C (45°F)) for optimal yields, less than most other stone fruit. Almonds depend upon bees for pollination, with the exception of a very few recently released self-pollinating almond cultivars.

Water: The average California almond orchard uses about 40 inches of irrigation water per year [5], which is similar to other fruit and nut orchards and represents a one-third reduction compared to 20 years ago. These reductions are due to techniques such as microsprinkler, drip irrigation and monitoring of crop evapotranspiration and soil moisture [6]. Almond farmers sometimes have to use deficit irrigation, a drought survival strategy that reduces irrigation by applying water during vital phenological stages at the expense of more drought-tolerant stages. While this strategy reduces yields, it allows trees to survive and continue producing until more water becomes available [5].

Temperature: Luedeling et al. [7] predicted trends in decreasing chill-hours in the Central Valley and concluded that almonds were only slightly vulnerable, as they have more modest chilling requirements than other stone fruit (about 200-400 hours, compared to 500-1000 hours). Luedeling et al. predicted that many suitable almond growing locations would remain by mid- to late-century. The future extent of winter fog loss is an important and unknown variable in this question [8].

Lobell and Field [9] went beyond a simple analysis of the chill-hour threshold and noted that almond yields seem to be inversely related to February nighttime temperatures. They proposed that warm February temperatures shorten the blooming window and hamper pollination. However, in their analysis, the benefits of warmer springs and summers partly canceled out the negative yield effects of warmer winters, for an overall yield reduction of about 10% by 2030 in the absence of adaptation (Table 1).

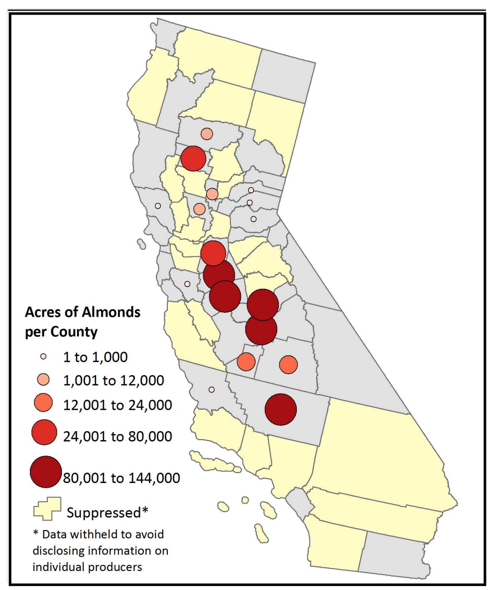

Figure 1. Acres of almonds grown in CA in 2012 (820,000 total bearing acres) [1].

Other factors: Because almonds depend on bees for pollination, any factor that harms bees – whether climate-related or not – can harm almond yields. Bee populations have declined in recent years due to a poorly understood combination of diseases, parasites, pesticides, and possibly other factors; now, in California, drought has curtailed bees' food supply [10]. Encouraging native pollinators may be a helpful management strategy to supplement pollination by honeybees [11].

Almonds are vulnerable to severe storm events, especially while flowering. A severe rain or hailstorm during peak bloom can devastate the year's crop. In older almond orchards, high winds can cause widespread lodging (tipping over) of trees. Furthermore, warm storms that deliver large amounts of rain – expected to become more common with climate change – are known to be correlated with severe fungal disease in almonds, such as shot hole and brown rot [12].

Table 1. Vulnerability of almonds to climate change in California.

Exposure	Sensitivity	Adaptive Capacity
• Temperature: Moderate change (Central Valley likely to see 2-3°C (3.6-5.4°F) rise by 2060). • Water: Decreased water availability likely. • Extreme events: Higher frequency of heat waves; possibly increased intensity of storms.	• High sensitivity to loss of chill-hours (if below threshold). • Moderate sensitivity to high summer temperatures (can cause almond bud failure). • Water needs are moderate to high and fairly inflexible. Almonds are irrigation-dependent. • Highly dependent on pollinators, so may suffer indirect consequences related to pollinator loss. • When flowering, vulnerable to extreme storm events.	• Temperature: moderate to high capacity. Some almond varieties require only about 200 chill-hours. • Water: moderate to low. Water use efficiency already highly optimized; further gains will be difficult. • Pollinators and storms: Low, due to unpredictability of these events. • Pests and diseases: Unknown

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Published 2016

California Sub Hub
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