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

Lettuce

Lactuca sativa (Asteraceae)

California and Arizona together produce 95% of the nation's lettuce, a remarkable logistical achievement considering the high perishability of the crop (Figure 1). The 2012 lettuce crop was worth nearly $2B, making it the region's second most valuable annual crop after strawberries. Western Arizona and inland Southern California dominate production in December, January, and February; the rest of the year, most lettuce comes from the California coast [2]. Lettuce is chilled immediately after harvest and transported in refrigerated trucks.

Lettuce is a cool-season crop, and ideal growing temperatures are 22.8°C (73°F) in the daytime and 7.2°C (45°F) at nighttime [3]. Warm temperatures can contribute to bolting (rapid elongation and flowering of the stalk), which makes the lettuce head unattractive and bitter. Temperatures in the range of 32-37°C (90-99°F) can cause bitterness almost immediately even if the lettuce is not physiologically ready to bolt [4].

Irrigation requirements depend on where and how the lettuce is grown. In the inland deserts, the lettuce crop receives about 36 inches of water (usually delivered via furrow irrigation) to reach maturity, which takes 70–130 days depending on the season and variety. On the Central Coast, furrow irrigation is rarely used; a sprinkler-irrigated lettuce crop receives 18-24 inches of water; and a drip-irrigated lettuce crop receives only 12-18 inches of water [3]. Drip irrigation has been increasing in recent years and currently supplies water to 30% of lettuce grown in the Salinas Valley.

Lettuce is moderately salt-sensitive and is susceptible to a variety of pests, fungi, bacteria and viruses. These include aphids, caterpillars, downy mildew, Verticillium wilt, and corky root [3]. Many lettuce pathogens can be mitigated by crop rotation, avoiding overhead irrigation, and ensuring soil never becomes saturated.

Temperature: In a past analysis, Lobell et al. [5] observed no climate-related trends in California lettuce yields over their study period (1980-2003), but they did note that warmer-than-average October and April temperatures (planting time and harvest time, respectively) tended to improve yields. Jackson et al. [6] predicted that warmer winters in California might result a longer growing season and thus greater productivity for lettuce (Table1). Deschenes et al. [7] concurred, predicting a 7.8% increase in California lettuce yields by 2070-2099. However, these analyses may overlook more subtle effects of warming, such as the fact that warm nights can promote abnormally rapid growth that in turn can cause tipburn in lettuce (a disorder in which calcium cannot be transported quickly enough to the growing leaf edge, causing it to shrivel and blacken) [8].

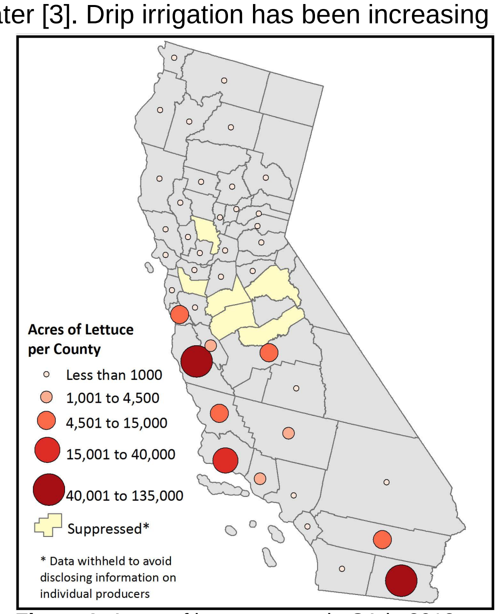

Figure 1. Acres of lettuce grown in CA in 2012 (232,842 acres). Not shown: 64,500 acres in AZ. [1]

The most important temperature risk to lettuce may not be from slightly warmer winters, but rather from occasional hot days that exceed its tolerance. A bolted, bitter, or badly wilted lettuce crop has little to no commercial value, and although timely irrigation can help reduce heat stress, it cannot always prevent it. Lettuce varieties that are more heat-tolerant and bolt-resistant may be increasingly needed in the future.

Water: Although an individual lettuce crop does not use a great deal of water, the cumulative water demand of lettuce is still immense for several reasons: 1) it covers a very large amount of acreage in the Southwest; 2) several lettuce crops can be grown per year on the same land; and 3) it is often grown in arid areas where it is completely irrigation-dependent. Improving irrigation efficiency could be achieved with increased adoption of drip irrigation as compared to sprinkler or furrow irrigation. Another possibility is to select lettuce varieties with particular canopy architectures that reduce transpiration and improve water use efficiency [9]. Also, because water quality is likely to decline along with water quantity, it may be necessary to develop salt-tolerant lettuce varieties especially for coastal regions where saltwater intrusion is a problem.

Other factors: Significant floods sometimes occur in the Salinas Valley, the most productive region. A major flood in the Salinas River in 1995 destroyed tens of millions of dollars' worth of lettuce in the field [10], and the risk of such catastrophic events may increase under future climate change. Climate change may also affect some of the diseases and pests that damage lettuce, but few details are known at this time.

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

Exposure	Sensitivity	Adaptive Capacity
• Temperature: exposure depends on location (California coast may see 2°C (3.6°F) rise, inland deserts 3°C (5.4°F) rise by 2060). • Water: Decreased water quality and quantity likely; saline groundwater due to saltwater intrusion. • Extreme events: more heat waves; more flooding possible; fewer frosts.	• Can benefit from slightly warmer winters, but harmed by high temperatures, especially if above 32.2°C (90°F). • Moderate to high sensitivity to water limitations. Irrigation-dependent and salt-sensitive. • These sensitivities may be reduced or amplified due to changes in pests and pathogens.	• Temperature: likely moderate adaptability. Adjusting planting and harvest timing may help avoid heat. • Water: likely moderate adaptability. More drip irrigation possible; some varieties have higher water use efficiency. • Pests and pathogens: Unknown. • Extreme events: lettuce will benefit from fewer frosts.

References

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Published 2016

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