United States Department of Agriculture
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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

Broccoli, cauliflower, and cabbage

Brassica oleracea (Brassicaceae)


Photo: USDA NRCS

The versatile species *Brassica oleracea* includes more than a half-dozen different crops, of which the three most important in the U.S. are broccoli, cauliflower, and head cabbage. Collectively, they are termed *cole crops.* California produces about 90% of the nation's broccoli and cauliflower [2], while cabbage production is more widely distributed; California and Arizona together account for only 29% [3] (Figure 1).

Broccoli, cauliflower, and cabbage are cool-season crops. They are grown in many locations around the Southwest, including California's central and southern coast, inland deserts, and Western Arizona. In the southern parts of this range, they are planted as winter crops, while in the northern parts, they are grown and harvested year-round. Their optimal temperature ranges are fairly narrow: 18.3-20°C (65-68°F) for cauliflower [4] and 15.6-18.3°C (60-65°F) for broccoli and cabbage [5, 6]. With prolonged temperatures above 26.7°C (80°F), cabbage may bolt [5] and cauliflower "curds" may become small and yellow [4].

Irrigation requirements vary considerably depending on the location and the irrigation method, ranging from a low of 14-24 inches for drip-irrigated cabbage on the Central Coast [5] to a high of 48 inches for furrow-irrigated cauliflower in the southern desert [4]. In general, drip irrigation can cut water use by about 25% compared to sprinkler or furrow irrigation, but drip irrigation has not always been successful in uniformly meeting crop demand under warm conditions [6].

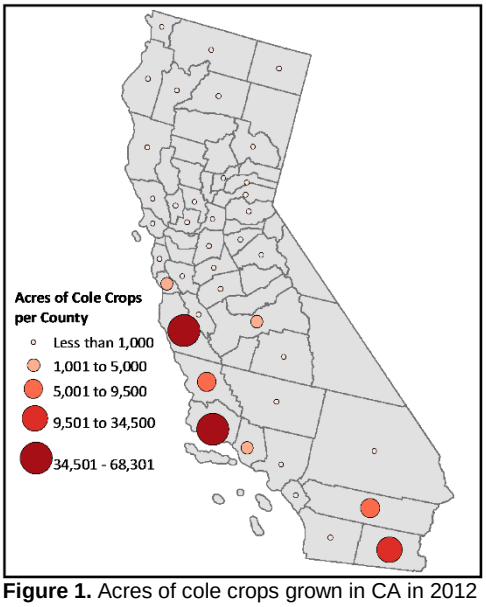

Figure 1. Acres of cole crops grown in CA in 2012 (148,449 acres). Not shown: 14,000 acres in AZ. [1]

Broccoli, cauliflower, and cabbage are attacked by an array of invertebrate pests, including aphids, beetles, cutworms, and nematodes. Broccoli and cauliflower are also prone to some bacterial and fungal diseases, including bacterial head rot and downy mildew [4, 6], whereas cauliflower in the Southwest is relatively disease-free [4] (Table 1).

Temperature: Deschenes and Kolstad [7] estimated that California's broccoli yields will increase by 39% by 2070-2099, due to the direct effects of warmer winters and, indirectly, the ability to expand growing areas in the northern parts of the state. Jackson et al. [8] postulated that broccoli production might expand to Yolo County, well north of its current range. However, even if warmer average winter temperatures benefit broccoli and its kin, spring heat waves certainly will not.

Water: Water limitations are a major concern for these crops under future climate. Their need for constant and uniform soil moisture makes drip irrigation an ineffective option in most cases, although further research and technology development may overcome some of these challenges. All *B. oleracea* crops are moderately salt-sensitive [9], so degradation of

groundwater quality will become an increasing concern, especially on the Central Coast where sea level rise may hasten saltwater intrusion.

Other factors: Because cole crops are prone to disease and insect damage, it would be useful to know how climate change might impact their major pest species. For example, high soil temperatures are known to facilitate Fusarium infection, while warm nights above 10°C (50°F) and days above 15.6°C (60°F) promote damage by Bagrada bug (O. Daugovish, pers. comm., 24 December 2014). Another concern that might increase with climate change is flooding, especially in the Salinas Valley [10].

Table 1. Vulnerability of broccoli, cauliflower and cabbage to climate change in California.

Exposure	Sensitivity	Adaptive Capacity
• Temperature: 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 temperatures above 26.7°C (80°F). • Moderate to high sensitivity to water limitation. Irrigation-dependent and somewhat salt-sensitive. • Sensitivities may be reduced or amplified due to changes in pests and pathogens.	• Temperature: likely moderate adaptability. Adjusting timing of planting and harvest may avoid heat. Northward shift possible. • Water: likely low to moderate adaptability. Greater adoption of drip irrigation may be possible. • Pests and pathogens: Unknown. • Flooding: Low, due to unpredictability.

References

1. National Agricultural Statistics Service, *2012 Agricultural Census*. 2014, US Department of Agriculture: Washington, DC.
2. Starrs, P.F. and P. Goin, *Field Guide to California Agriculture.* 2010, Berkeley, CA: University of California Press. 475.
3. National Agricultural Statistics Service, *Vegetables: Final Estimates 2008-2012*. 2014, US Department of Agriculture: Washington, DC. p. 111.
4. Koike, S.T., et al., *Cauliflower Production in California*, University of California Division of Agriculture and Natural Resources, Editor. 2009: Oakland, CA.
5. Daugovish, O., et al., *Cabbage Production in California*, University of California Division of Agriculture and Natural Resources, Editor. 2008: Oakland, CA.
6. LeStrange, M., et al., *Broccoli Production in California*, University of California Division of Agriculture and Natural Resources, Editor. 2010: Oakland, CA.
7. Deschenes, O. and C. Kolstad, *Economic impacts of climate change on California agriculture.* Climatic Change, 2011. **109**(1): p. 365-386.
8. Jackson, L.E., et al., *Case study on potential agricultural responses to climate change in a California landscape.* Climatic Change, 2011. **109**(1): p. 407-427.
9. Shannon, M.C. and C.M. Grieve, *Tolerance of vegetable crops to salinity.* Scientia Horticulturae, 1999. **78**(1999): p. 5-38.
10. Lobell, D.B., A. Torney, and C.B. Field, *Climate extremes in California agriculture.* Climatic Change, 2011. **109**: p. 355-363.

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