



USDA Regional Climate Hubs: California Sub Hub

Effects of Drought on Forests and Rangelands in the United States:
A Science Synthesis



Drought Impacts on Forests and Rangelands in the California Region

Overview:

California's climate: The forests and rangelands of California are known for their unique diversity of plant flora, natural landscapes, wildlife, and ecosystems resilient to a variety of environmental stresses. California has a Mediterranean climate, with most precipitation falling during the October-April wet season, and so California's ecosystems are well-adapted to seasonal drought. Multi-year droughts are a recurrent feature of California's historical and geologic records. However, climate change is expected to exacerbate California's naturally occurring droughts via warmer temperatures¹ and possibly also via changes in atmospheric circulation².

Water supply in California: The forested watersheds of the Sierra Nevada mountains provide almost two-thirds of the state's water supply, much of which is first stored as snow and later captured in reservoirs for domestic, agricultural and environmental use. Sierra snowpack is predicted to decline by 30% to 70% by the end of the century due to global warming, and this decline has already begun. Although future changes in overall precipitation are still uncertain, the Sierras will probably receive a higher ratio of rain to snow, causing higher and earlier peak runoff and potentially overwhelming existing water infrastructure³. By contrast, late spring and summer streamflow may decline, stressing forest and rangeland ecosystems. Statewide temperature increases will cause lower soil moisture in summer, slower growth in some tree species, lower fuel moistures, and increased area burned by wildfire.

The current drought in California:

- California's ongoing severe drought began in late 2011 (Figure 1). On 17 January 2014, California governor Jerry Brown declared a drought state of emergency.
- Calendar year 2014 was California's third driest year on record, and water year 2015 (1 October 2014 - 30 September 2015) was the hottest and driest on record.
- In April 2015, snowpack levels in the Sierras were the lowest ever recorded. Snowpack provides about a third of the water used in California.
- In 2015, the USDA Forest Service estimated more than 22 million trees had died in California due to the drought and associated outbreaks of bark beetles⁴. Tens of millions more trees are threatened. Governor Brown declared a forest health state of emergency on 30 October 2015.

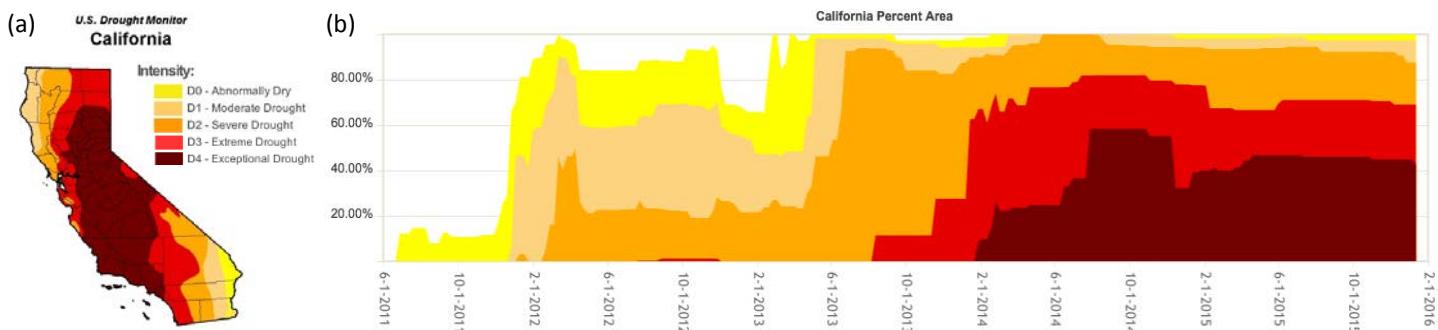


Figure 1. US Drought Monitor data for California: (a) drought map as of January 12, 2016; and (b) the percentage of the state in different drought categories between June 2011 and January 2016. Source: <http://droughtmonitor.unl.edu/>.

Drought Impacts:

- **Drought exacerbates many of the disturbances that shape forest ecosystems in California.** Wildfires will increase in frequency and severity. Many (though not all) forest pests and pathogens are predicted to have more serious impacts during drought.
- **Large changes in forest structure and composition will occur,** influencing many of the goods and services provided by forest ecosystems. Soil moisture deficits will retard tree regeneration, tree growth and production of tree defensive mechanisms. Droughts may accelerate the spread of some non-native plant species in California and hamper the spread of others.
- **Drought will reduce vegetative cover in many watersheds,** leading to increased erosion and stream sedimentation in some areas.
- **The productivity of California rangelands will be threatened,** as good forage production depends on a combination of rainfall and moderate temperatures that sustain soil moisture throughout winter and spring.
- **Cold-water fish species will face increased heat stress** as drought and withdrawals for other uses cause low flows and high water temperatures. Thermally-sensitive species may be extirpated in some locations.
- **Increased conflict among water uses is likely,** as water availability will become increasingly uncertain in the future and many surface water supplies are already over-allocated (by a factor of five or even ten in some of California's river basins⁵).

Adaptation to Drought in Forests and Rangelands:

California has a great diversity of forest and rangeland types (Figure 2), and drought adaptation actions must be location-specific. General principles to increase drought resilience in California forests and rangelands include:

- Manage forest stand density to limit competition for water and reduce risk of stand-replacing wildfire
- When reforesting an area, consider likely future as well as current climate, and select trees with genetic characteristics that confer tolerance to environmental stress
- Manage rangelands to maintain and enhance soil health, species diversity, and riparian habitats
- Ensure ongoing support for and access to drought assistance plans for land users (for example, the USDA Farm Service Agency's Livestock Forage Program for ranchers suffering from drought)



Figure 2. Several California forest types (L to R): Sierra mixed-conifer forest; deciduous oak woodland; Ponderosa pine forest.

Conclusions:

- California forests and rangelands are already adapted to drought to some degree, but future droughts will become more severe due to climate change, and adaptive actions are necessary.
- Drought may reshape California's ecosystems via increases in tree mortality, along with an increase in severity and frequency of forest fires.
- Changes in land management and water infrastructure can avoid some of the worst impacts of drought.

¹ Williams, A.P.; R. Seager; J.T. Abatzoglou; B.I. Cook; J. E. Smerdon; and E.R. Cook (2015). "Contribution of anthropogenic warming to California drought during 2012–2014." *Geophysical Research Letters* 42:6819–6828, doi:10.1002/2015GL064924.

² Cook, Benjamin I.; Toby R. Ault; and Jason E. Smerdon (2015). "Unprecedented 21st century drought risk in the American Southwest and Central Plains." *Science Advances*, 12 Feb 2015. doi:10.1126/sciadv.1400082.

³ Sierra Nevada Conservancy (2014). "The State of the Sierra Nevada's Forests." <http://www.sierranevada.ca.gov/our-work/docs/StateOfSierraForestsRpt.pdf>

⁴ "Governor Brown takes action to protect communities against unprecedented tree die-off." October 30, 2015. <https://www.gov.ca.gov/news.php?id=19180>

⁵ Grantham, Theodore E., and Joshua H. Viers (2014). "100 years of California's water rights system: patterns, trends and uncertainty." *Environmental Research Letters* 9 (2014). doi:10.1088/1748-9326/9/8/084012

To learn more about California Climate Hub visit: <http://www.climatehubs.oce.usda.gov/california>

To read the full report *Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis* visit: <http://go.usa.gov/cEtd9>