

Drought and Forests in California

Background



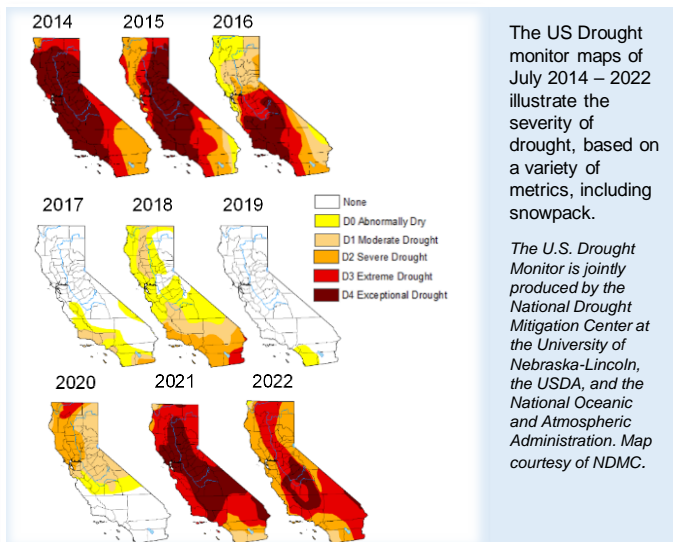
About one-third of California is covered in forests. From the redwoods of the northern coast to the oak woodlands of the foothills, California’s diverse climate, soils, and geography support a wide range of forest ecosystems¹. Most of these forests are adapted to periodic drought as a feature of the state’s Mediterranean climate. However, warming trends, dense tree cover from fire suppression tactics, and the increasing long and intense droughts are threatening their stability, with especially pronounced impacts observed on the west side of the Sierra Nevada Range and in low to mid-elevation forests².

Significance of Snowpack

Snowpack in the Sierras has long served as a natural form of water storage. Its slow melting has long provided a stable water source for forests, keeping them hydrated into the summer months. Earlier snowmelt periods mean that the forests experience a longer dry season, leaving trees water-stressed and more vulnerable in the long-term. Though the current snowpack is larger than in 2015 (when the snowpack was at zero by the end of May), the decline continues (April 2022 snowpack was at 35% of average levels)³. Coupled with higher air temperatures, which melt snow-pack and increase evapotranspirative water demand, the drought is proving severely damaging for California’s trees. Indeed, the combination can even be fatal for them.

Increased Tree Vulnerability

Tree mortality is rarely attributed to a single cause; it is often a combination of conditions and agents. Extreme drought can eventually kill trees directly through cavitation or carbon starvation, but more often drought weakens trees and makes them more susceptible to woodboring pests. For example, the number of trees killed by bark beetles in California tends to jump after several years of inadequate precipitation⁴. When the trees are weakened by drought, they are often unable to produce enough defensive resin or pitch to counter bark beetle attacks. According to estimates from the US Forest Service annual aerial surveys of tree health, about 1.26 million trees died in 2021⁵. Although tree mortality has declined since peaking in 2016, mortality levels are still substantially higher than pre-2010 levels.



The US Drought monitor maps of July 2014 – 2022 illustrate the severity of drought, based on a variety of metrics, including snowpack.

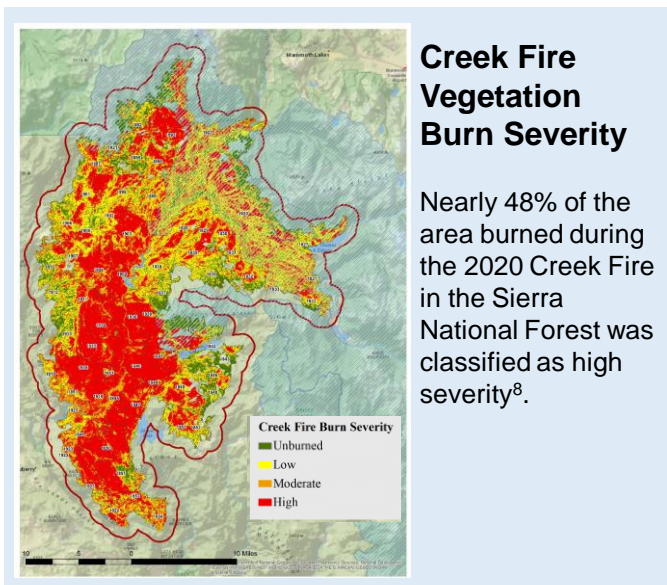
The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the USDA, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.

Drought and Fire

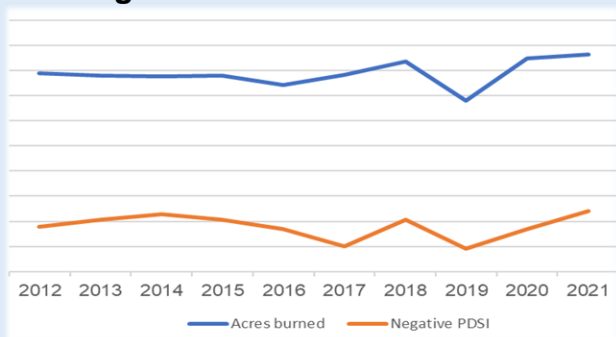
Drought stress, exacerbated by warmer temperatures, is causing tree mortality and lowering the moisture content of forest fuels, increasing vulnerability to fire. Several studies have linked the recent increase in fire severity and length of the fire season to spring/summer temperatures and the percentage of the year that snowpack is present². The Palmer Drought Severity Index (PDSI) and similar drought indicators have been utilized successfully to predict wildland acres burned⁶.

From 2012 – 2016, California experienced its most severe drought in a millennium. In 2021 the state entered into another severe drought. Thus, it is not surprising that 5 of the largest wildfires in the state’s recorded history have occurred in the last decade⁶. The Creek Fire (right) burned nearly 400,000 acres in 2020 and in 2021 the Dixie Fire became the largest wildfire in the state’s recorded history, burning over 960,000 acres⁷.

The influence of drought on fire is further illustrated by plotting the number of acres burned on wildlands in California and the PDSI (below).



Drought and Fire in CA: 2012 - 2021



Log transformed wildland acres burned vs. negative PDSI, indicating drought affects fire behavior and spread. *Note: y-axis values omitted as they do not reflect actual values.* Data courtesy of [Climate Engine](#) and the [California Department of Forestry and Fire Protection](#).

Land Management and Fire

Long-term fire suppression has led to changes in forest structure and a build-up of surface fuels, which increases the potential for large, destructive fires. The density of young trees has risen, while density of large trees has fallen by about 50% since the 1930s².

Young trees are inherently more susceptible to fire and when they are also densely packed together they compete heavily for moisture, contributing to increased drought stress and likelihood of fire.

Species composition has also shifted in many forests as a result of fire suppression practices, resulting in more shade-tolerant firs and fewer fire resilient pines². This degradation of forest quality only adds to water-stress from the drought, increasing fire risk.

Finally, the continued expansion of the wildland-urban interface (human developments adjacent to wildlands) can also increase the frequency of ignitions and make fire harder to suppress.

- <https://ucanr.edu/sites/forestry/files/78650.pdf>
- https://www.fs.usda.gov/psw/publications/documents/psw_gtr237/
- <https://cdec.water.ca.gov/>
- https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5384837.pdf
- https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd985397.pdf
- <https://iopscience.iop.org/article/10.1088/1748-9326/ac6886/meta>
- <https://frap.fire.ca.gov/mapping/gis-data/>
- https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd1054275.pdf

How can we protect forests during the drought?

- Selectively thinning in high-risk regions to promote species & age-class diversity and improve resiliency.
- [Ensuring defensible space around forest homes.](#)
- Supporting the use of wood and other products of forest health projects.
- Monitoring forest pest conditions and acting quickly to remove trees weakened from pests.

What options and resources are available for forest landowners?

- Contact [CALFIRE](#), [UCCE](#), or [Registered Foresters](#) to develop a forest mgmt. plan.
- Seek financial assistance from local government, [Fire Safe Council](#), or [state Conservancies](#) for forest health improvement projects.
- [Forest Service forest health specialists](#)