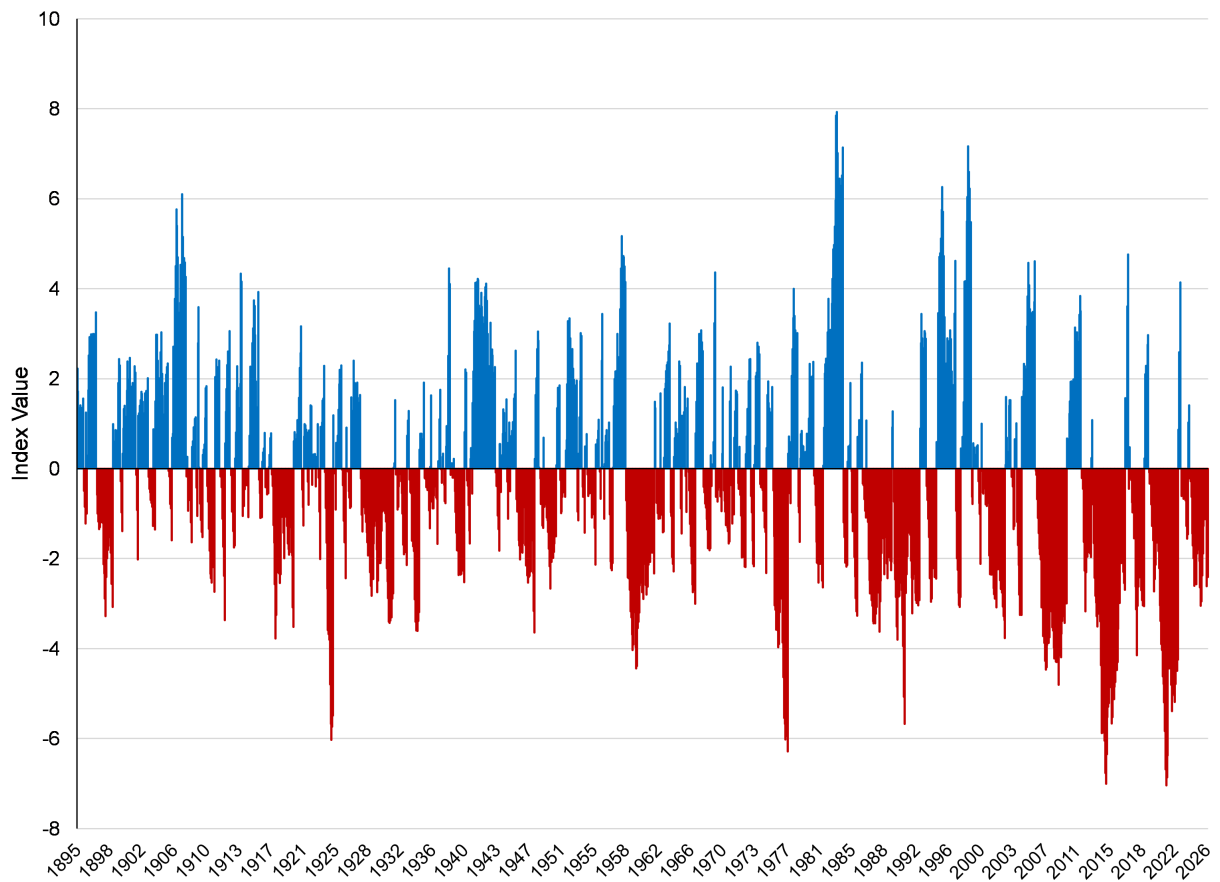


2.3 Drought

Droughts are prolonged periods of water shortage. In California, climate change has intensified droughts, making them hotter, longer, and more difficult to recover from. The multi-year, record-setting droughts of 2012–2016 and 2020–2022 created unique challenges for people, ecosystems, and the state’s water security. Drought conditions abated in 2023 but returned in some parts of the state in 2024, 2025, and 2026.

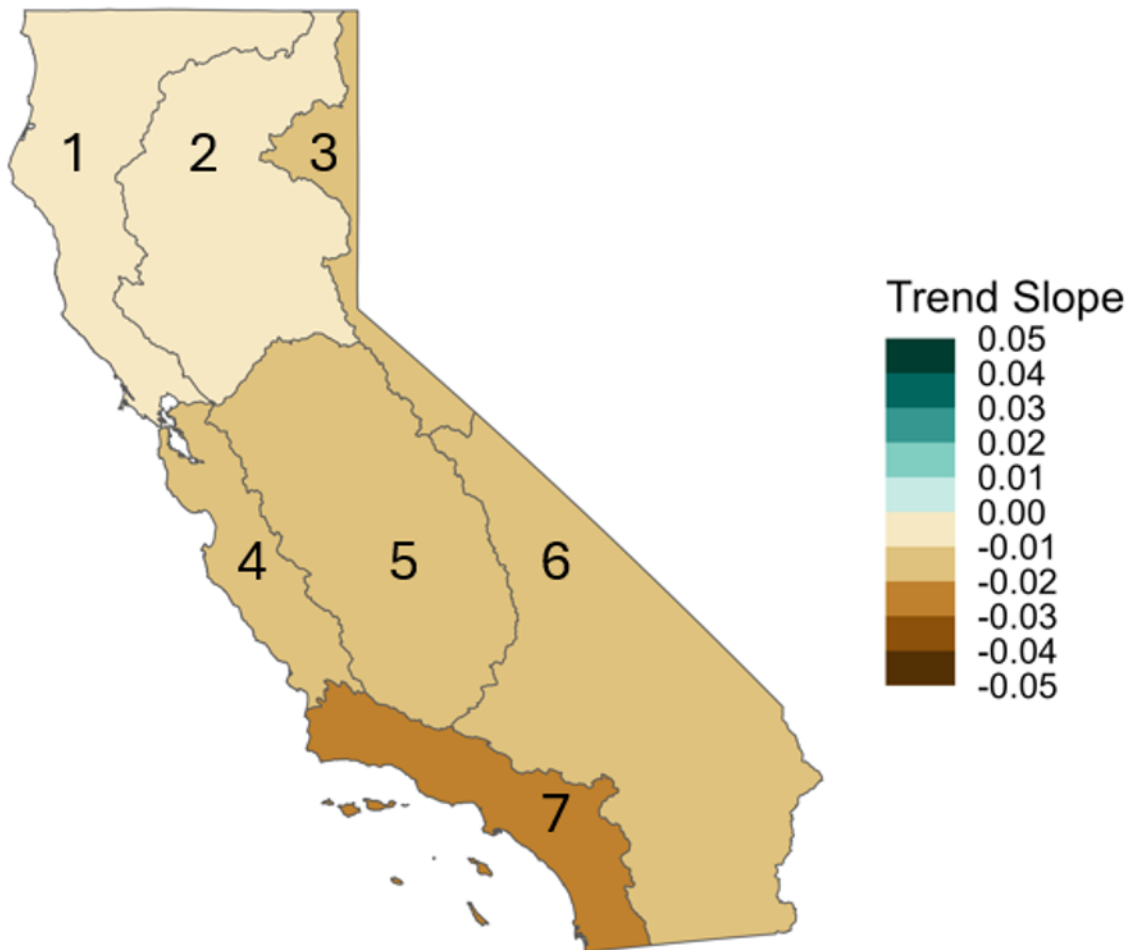
Figure 2.3.1. California Palmer Drought Severity Index (PDSI).



Monthly PDSI for California from January 1895 to May 2026 are presented in the graph below. Values greater than 0 (shown in blue) represent wet months. Values less than 0 (shown in red) represent dry months. Source: NOAA (2026)

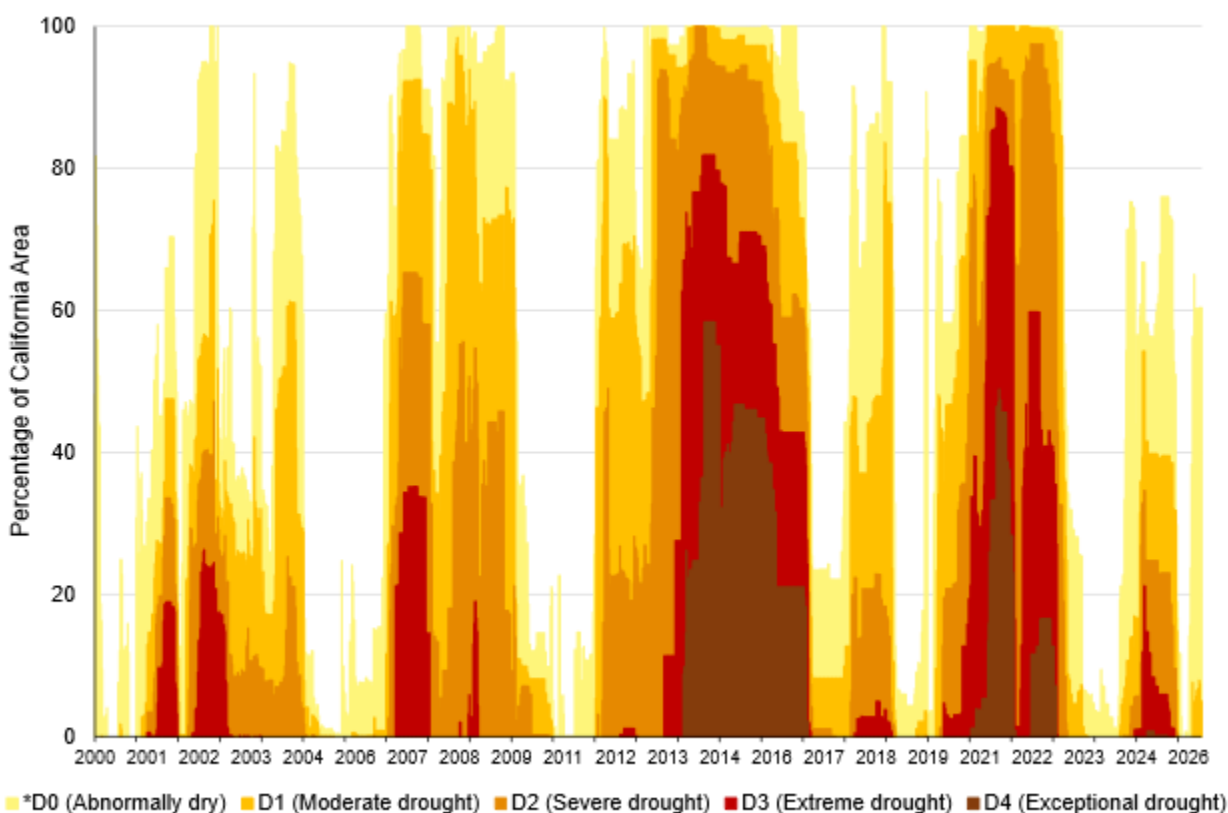


Figure 2.3.2. California PDSI Trends.



The map shows trends in annual average PDSI for each California climate division from 1895 to 2024. Colors range from dark blue (a trend to wetter years) to dark brown (a trend to drier years), indicating a trend toward drier conditions. Climate divisions are geographical regions with consistent, long-term weather patterns of temperature and precipitation. The numbered climate divisions are as follows: 1) North Coast; 2) Sacramento; 3) Northeast Interior Basins; 4) Central Coast; 5) San Joaquin; 6) Southeast Desert; 7) South Coast. Source: NOAA (2026)

Figure 2.3.3. Percentage of California Land Area in Drought



This figure shows the percentage of California's land area impacted by different levels of drought severity from 2000–2026 according to the U.S. Drought Monitor. At each point in time, the colored bars represent a fraction of the total land area classified in each drought category, with darker colors indicating more severe drought conditions. Source: U.S. Drought Monitor (2026)

What does the indicator show?

Two key metrics, the Palmer Drought Severity Index (PDSI) ([Figure 2.3.1](#) and [Figure 2.3.2](#)) and the U.S. Drought Monitor, are commonly used to track drought conditions in California. The PDSI, developed in the 1960s, measures relative dryness based on precipitation and temperature (IDMP, 2023). Values at or below -4 reflect severe drought. The more recent U.S. Drought Monitor integrates a broader set of data – precipitation, streamflow, reservoir levels, temperature, soil moisture, vegetation health, snowpack, and expert input – and classifies drought severity using five categories, from



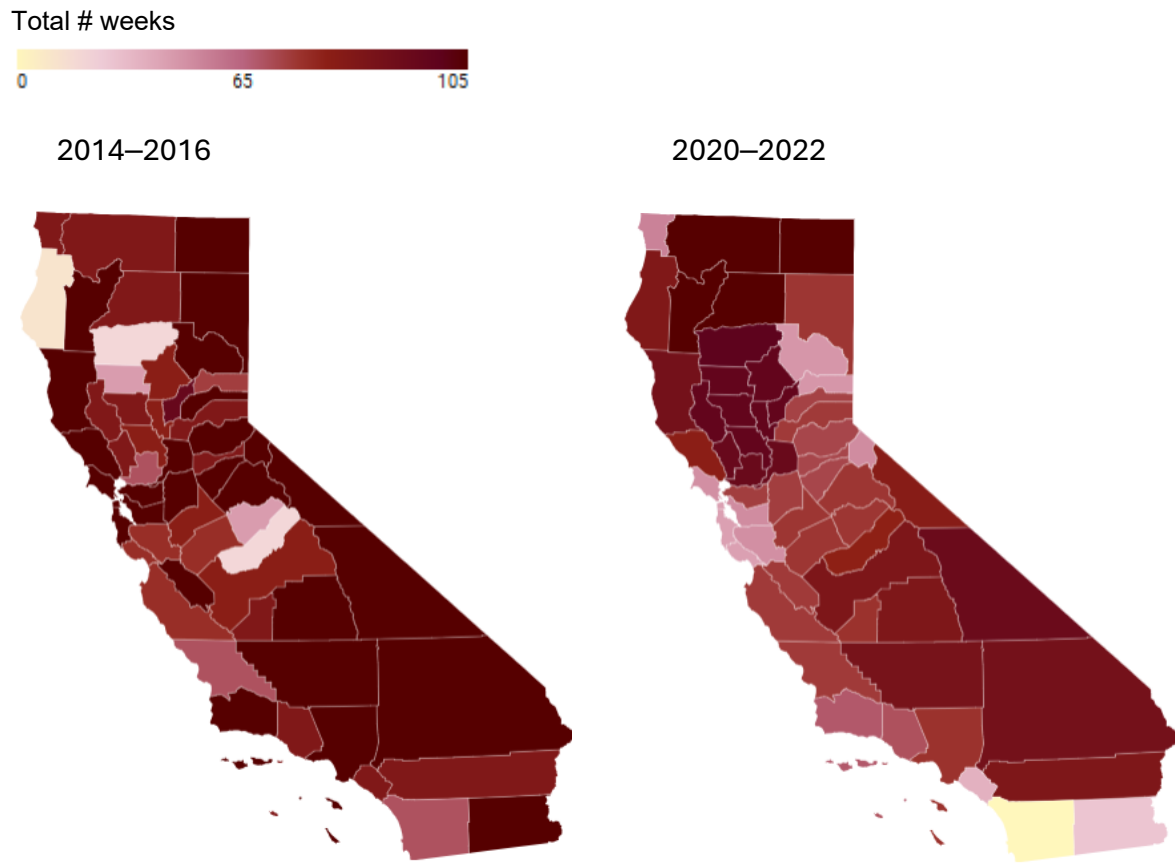
D0 (abnormally dry) to D4 (exceptional drought) (U.S. Drought Monitor, 2025). **Figure 2.3.3** shows the percentage of California's land area affected by each drought severity level since 2000. Both the PDSI and U.S. Drought Monitor track drought in natural water systems and are thus directly relevant to climate trends. In addition, they are applicable to activities that rely on unmanaged water systems like dryland farming and grazing.

California has undergone two unprecedented droughts in recent decades: the 2012–2016 drought and the 2020–2022 drought. As part of a long-term drying trend (**Figure 2.3.1**), California experienced its driest periods from 2014 to 2016 (during the 2012–2016 drought) and from 2020 to 2022 (the entirety of the 2020–2022 drought). The 2012–2016 drought in California ended with unusually high precipitation in 2017. Drought conditions began developing again in early 2020, persisted through the 2021 water year (October 2020 to September 2021), and continued into the 2022 water year, producing an extremely dry 3-year period. This coincided with a period of anomalously warm temperatures and low precipitation.

Characterized by unusually warm temperatures and low precipitation, these periods of “hot droughts” are becoming more common in western North America (King et al., 2024). All areas of California are experiencing a long-term drying trend, with the south coast drying the fastest.

In the 2022 water year, over 90% of the state experienced severe drought for most of the year (42 weeks). Conditions changed sharply in early 2023 after a series of nine atmospheric rivers delivered over 32 trillion gallons of rain and snow in just three weeks (NOAA, 2023). Drought conditions remained mild through 2024 but increased again in 2025, with 25% of the state under severe drought for 17 straight weeks by mid-May in 2025. Every drought has its own unique pattern of extent, duration, and intensity. The U.S. Drought Monitor shows that while many counties in California faced more weeks of severe drought in 2014–2016 than in 2020–2022, some counties, primarily those in the north, such as Siskiyou, Shasta, Humboldt, Glenn, and Tehama, endured more weeks of severe drought in 2020–2022.



Figure 2.3.4. Drought Conditions in 2014–2016 and 2020–2022.

The maps show the total number of weeks that counties in California experienced severe drought during the 2014–2016 and 2020–2022 water years based on the U.S. Drought Monitor. Source: U.S. Drought Monitor (2025)

Why is this indicator important?

Droughts have wide-ranging environmental, social, and economic impacts – disrupting water supplies for cities, agriculture, hydropower, and ecosystems. Snowpack (see the *Snow-Water Content* chapter), snowmelt runoff (see the *Snowmelt Runoff* chapter), freshwater (see the *Salmon River Water Temperature* chapter), and groundwater resources are all affected – disrupting ecosystems and impacting human health and well-being. Dry vegetation, for instance, provides more fuel for large and destructive wildfires (see the *Wildfires* chapter). Climate change impacts on dry vegetation have



contributed to larger wildfires in California and an earlier start to the wildfire season (Madakumbura et al., 2025).

The record droughts of 2012–2016 and 2020–2022 contributed to widespread tree mortality, wildfires, fish die-offs, and harmful algal blooms. They also strained water systems, exacerbated drinking water shortages, reduced farm deliveries, and increased groundwater use (Sum, 2024; Hartman et al., 2025).

Drought disproportionately affects communities that are low-income, rural, or comprised of people of color, as well as California tribes (SWRCB, 2021a). These marginalized groups face greater risks from impacts such as water contamination, job loss, loss of resources, and air pollution (Pacific Institute, 2026). In addition, climate change will increase the likelihood of drought and heatwaves occurring simultaneously (Tripathy et al., 2023).

Tribal Connection 2.3.1

The interconnected lifeways and homelands of the Pala Band of Mission Indians in San Diego County have been deeply impacted by drought. *“In the past 30 years, Pala has had 12 years during which they experienced severe drought conditions [...]. Drought, combined with climate change-driven extreme heat, season shifts, and insect and pest outbreaks can weaken plants, trees, and forests or shift growth patterns [...]. Pala Environmental Department staff note declining numbers of Englemann (Quercus engelmannii) and coast live oak (Quercus agrifolia) trees, which are considered culturally important (Pala, 2019). [...]. The Pala reservation is home to endangered or threatened plant species including Parry’s tetracoccus (Tetracoccus dioicus) and Rainbow manzanita (Arctostaphylos rainbowensis). Drought, along with increased temperature, stresses these plants and creates conditions for certain non-native, invasive species to thrive. [...]. These species can degrade habitat quality for native wildlife and contribute to increased wildfire frequencies” (Pala Band of Mission Indians, 2026).*



Ecosystem and human interactions

Forests and aquatic ecosystems are especially vulnerable to ecological drought. During 2020 and 2021, low streamflows with high water temperatures and salinity threatened already declining salmon and steelhead populations (Shimabuku and Kammeyer, 2022; CNRA, 2021). Drought has also led to widespread tree mortality (see the *Tree Mortality* chapter), shifts in vegetation (see the *Vegetation Distribution Shifts* chapter), and increased wildfire risk, especially in northern California, where water-stressed trees have added to fuel loads. Drought further impacts bird species, reducing habitat, water, and food sources. In response, some bird species have shifted into human-managed landscapes, like Central Valley farmland (Goldstein et al., 2024).

Drought impacts of ecosystems disproportionately affect people who depend on these natural resources. People most reliant on annual rainfall usually experience the impacts of drought first. A single dry year can impair dryland farming or livestock grazing that depend on unmanaged water supplies (DWR, 2015). Drought impacts on local habitats place additional burdens on rural populations that depend on them for food, firewood, or their livelihood (Taylor et al., 2024; Roos, 2018). The loss of culturally significant animals and plants can have profound impacts on Tribes who rely on them for traditional foods, medicine, and cultural practices.

Managed water systems

Domestic water supply

During the 2012–2016 drought, large urban water districts with diverse supplies avoided major disruptions, while more than 100 small water systems and 2,000 domestic wells—mostly in low-income, rural, and often Latino/a communities of the Central Valley and Sierra Nevada foothills—ran dry (Lund et al., 2018; PPIC, 2016, 2021). Climate change and rising temperatures further strained domestic supplies by increasing evaporation from surface reservoirs and reducing available surface water (Friedrich et al., 2018). Drought also worsens water quality, further limiting access to safe, reliable, and affordable drinking water. It does so through saltwater intrusion and elevated levels of contaminants and pathogens, disproportionately affecting small systems and vulnerable communities. For example, in the San Joaquin Valley, droughts from 2007–2020 increased nitrate and arsenic concentrations in majority Latino/a water systems (Sum,



2024). Rising water costs compound these challenges: by late 2020, 1.6 million households carried water debt averaging \$500, with low-income families and communities of color hit hardest during the COVID-19 recession (SWRCB, 2021b). Utilities also faced revenue losses and disaster damages, as evidenced by the destruction of Paradise’s water system during the 2018 Camp Fire (Bohn et al., 2020; Chow et al., 2021).

Hydroelectric power generation

Drought reduces the generation of hydroelectricity, which depends on snowmelt runoff and rainfall. Under extreme drought, electricity generation from individual fossil fuel plants can increase up to 65% in the western United States, mainly due to the need to compensate for reduced hydropower (Qiu et al., 2023).

Agricultural water supply

During the 2012–2016 drought, reduced water deliveries forced farmers to leave more than 500,000 acres fallow, with major losses to orchards, vineyards, and farm jobs. The decreased water availability also drove an increased reliance on groundwater, the state’s largest agricultural water source and a lifeline for communities and wetlands.

Increases in the crop water demand in the San Joaquin Valley over the past forty years caused half of the cumulative agricultural water balance deficits, exacerbating water reliance on groundwater supplies and variable surface water levels. This phenomenon of climate-induced increased crop water, or *invisible water surcharge*, has increased crop water demand in the San Joaquin Valley by 4.4% from 1980 to 2011 — the annual volume >800 gigalitres, the equivalent volume of a major local reservoir. San Joaquin Valley is a critical region for global fruit and nut production, and increased crop water demand adds a stressor to supply sustainability (Moyers et al., 2024).

Decades of groundwater overdraft have left 65% of wells statewide in decline, caused widespread subsidence in the San Joaquin Valley (where some areas sank up to 28 feet by 1970), and reduced aquifer capacity with every subsequent drought. As climate pressures intensify, meeting [Sustainable Groundwater Management Act](#) goals to halt overdraft and bring basins into balanced levels of pumping and recharge by the 2040s will be increasingly difficult, potentially requiring the permanent following of half a million



acres. Concurrently, overpumping continues to degrade rivers, wetlands, infrastructure, and ecosystems.

Tribal Connection: Drought 2.3.2

The *Impacts of Climate Change on the Big Valley Band of Pomo Indians* report discusses the impact of increased groundwater pumping during drought on freshwater systems and species. They write: “*Water scarcity also impacts local agriculture, stressing crops such as pears, walnuts, and grapes. Increased reliance on groundwater to support agriculture in areas near the [Big Valley] Rancheria reduces the volume of surface water entering streams where Clear Lake Hitch, an endemic and culturally significant fish, spawn [...]. Clear Lake Hitch have been forced to adapt to a very brief period of suitable stream conditions for their annual spawning run, as water diversions and a changing climate have caused streams to prematurely dry [...]. Increased drought and rapid climate change due to warming temperatures will likely accelerate this trend, causing further spawning failures*” (Big Valley Band of Pomo Indians, 2026).

Human health

Droughts adversely impact human health in multiple ways, including reduced access to safe, reliable, and clean drinking water (Bell et al., 2018). Reduced water quantity during periods of drought can lead to:

- Decreased water flow
- Promotion of pathogens that favor warm, stagnant environments (Paz, 2015; see the *Vector-Borne Diseases* chapter)

Consumption or contact with water containing pathogens, such as *Vibrio* species, may result in ear, eye, wound infections, diarrheal illness, and death (Trtanj et al., 2016).

Water conservation behaviors during the 2012–2016 drought, such as reduced handwashing and food washing, also increased the risk of communicable diseases (e.g., enteric disease and influenza) and exposure to pesticide residues (CDC, 2016a, 2016b, 2017).



Drought-related environmental changes also affect air quality and disease dynamics. Swings from extreme drought to extreme precipitation contribute to spikes in cases of Valley Fever in California (Camponuri et al., 2025; also see the *Valley Fever* chapter). In addition, drought increases air pollution from wildfires and dust storms (DWR, 2015). Under dry conditions, winds tend to transport inhalable soil particles, leading to unhealthy air quality.

Tribal Connection 2.3.3

Both the Bishop Paiute Tribe (Bishop Paiute Tribe, 2026) and the Big Pine Paiute Tribe who are in Payahuunadü, or the Owens Valley, have noted increases in airborne dust and harmful particulate matter during droughts which impact Tribal members' health. A Big Pine Paiute Tribal member writes, *"Droughts have become commonplace in the area. The dry soil leads to dust, which often affects the breathing of all community members; there are a number of elders with lung issues and a growing number of cases of children with asthma and other breathing issues. The soil is alkaline and causes clouds of dust that are very irritating to the eyes, throat and lungs"* (Big Pine Paiute Tribe, 2026).

Drought also affects surface water quality. A visible surface water quality impact during the 2012–2016 drought came in the form of more frequent harmful algal blooms. These blooms appeared in freshwater bodies throughout the state, from the Klamath River in the north to Lake Elsinore and the Salton Sea in the south (CNRA, 2021). Certain bloom-forming organisms, such as cyanobacteria, produce toxins that adversely impact people and their pets. In humans, exposure to these toxins can lead to a wide array of symptoms including skin rashes, blisters, vomiting, and abdominal pain (CWQMC, 2021; OEHHA, 2025). In pets, exposure can be lethal (CNRA, 2021).

Exposures to algal toxins can occur through ingesting contaminated water or food, or by direct contact to contaminated water. Communities that rely on freshwater for drinking water or recreational are disproportionately affected.



What factors influence this indicator?

Droughts are a naturally occurring feature of California's climate and are influenced by modes of global climate variability, such as the El Niño-Southern Oscillation, regional atmospheric pressure anomalies, and the frequency of landfalling "drought-busting" atmospheric rivers. A single wet year, composed of frequent atmospheric rivers that make landfall, can terminate a persistent drought (Dettinger, 2013, Williams et al., 2024; Gershunov et al., 2025). Historically, dry winters in California have been associated with a ridge of high atmospheric pressure off the west coast, while wet winters tend to occur with a trough off the west coast (Seager et al., 2015; Guirguis et al., 2024).

Droughts of the 21st century are hotter, longer lasting, and spatially larger than previous droughts (Crausbay et al., 2017). Human-caused warming – driven primarily by greenhouse gas emissions from fossil fuel combustion, land use change, and other anthropogenic sources – has increased the likelihood of extreme droughts in California and globally (Chen et al., 2025; Diffenbaugh et al., 2015; Zhuang et al., 2024). Rare atmospheric patterns driving extreme heat and dryness have become more frequent, contributing to events like the 2012–2016 drought. Starting from 2000, the record-setting drought in the southwestern U.S. includes the driest 22-year period since 800 CE with 19-42% of the dryness attributable to climate change (Williams et al., 2022). Continued warming is expected to worsen drought conditions through declining snowpack, more variable precipitation, and prolonged dry spells (Diffenbaugh et al., 2015; Gershunov et al., 2019; Swain et al., 2025).

Rising temperatures also increase "evaporative demand" intensifying drought by drawing more moisture from soils and vegetation. Since the 1980s, most of the western U.S. has seen higher evaporative demand, and in 2021, much of California experienced the highest levels in four decades (McEvoy et al., 2020; Pottinger, 2020; NIDIS, 2021). Since 2000, warming-driven evaporative demand has contributed more to droughts in the western U.S. than reduced precipitation (Fu and Zhuang, 2025).

A warmer atmosphere also fuels bigger storms, as more water is stored in the air. The likelihood of rapid transitions between extreme wet and dry conditions (such as those seen in 2022–2023 in the Pacific Southwest), sometimes known as "climate whiplash",



is expected to happen more often (Swain et al., 2025). By 2100, climate projections suggest California will experience longer and more persistent dry periods, punctuated by fewer but intense storms that produce heavy to extreme precipitation, rather than evenly distributed seasonal rainfall (Allen and Luptowitz, 2017; Gershunov et al., 2019; Huang et al., 2020; Pottinger, 2020).

Regional geography and local climate patterns also determine the severity of droughts. The 2012-2016 drought was most severe in southern California, which has displayed greater drying trends than northern California (Dong et al., 2019). Locally, soil moisture and vegetation may delay the onset of drought. Moist soil can delay the onset of soil droughts when precipitation is low, or when there is a lack of rainfall. In addition, drought-induced vegetation loss can slow the depletion of soil moisture due to reduced water loss through evapotranspiration (Jiang et al., 2025).

Technical considerations

Data characteristics

PDSI identifies droughts by incorporating data on temperature, precipitation, and the soil's water-holding capacity. The metric takes into consideration moisture received as precipitation and moisture stored in the soil, while also accounting for potential loss of water due to evaporation. It originally developed to identify drought affecting agriculture but has since been used to identify drought associated with broader impacts, including water supply, ecosystem stress, and wildfire risk (WMO and GWP, 2016). PDSI is used to assess long-term drought patterns (NOAA, 2017). The [U.S. Drought Monitor](#) provides a big-picture look at drought conditions in the United States. As previously mentioned, along with PDSI, metrics used in the U.S. Drought Monitor include [soil moisture data](#), [streamflow conditions](#), the [standardized precipitation index](#), and [blends of various drought indicators](#).

Strengths and limitations of the data

PDSI has been in use since the 1960s and is universally used to identify drought conditions. However, it assumes that all precipitation falls as rain (Williams et al., 2015), does not account for frozen precipitation or frozen soils (WMO and GWP, 2016), and does not account for drivers of atmospheric water demand other than temperature, such



as wind speed, humidity, and solar radiation. PDSI also does not provide information on human water demand, streamflow, reservoir storage, or groundwater accessibility (Williams et al., 2015), and therefore represents drought conditions primarily in natural, unmanaged systems. The USDM integrates many types of data, including observations from local experts, as well as information about reservoir storage, and can be useful for identifying areas likely to experience drought impacts. However, it is not designed to infer specifics about local conditions.

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