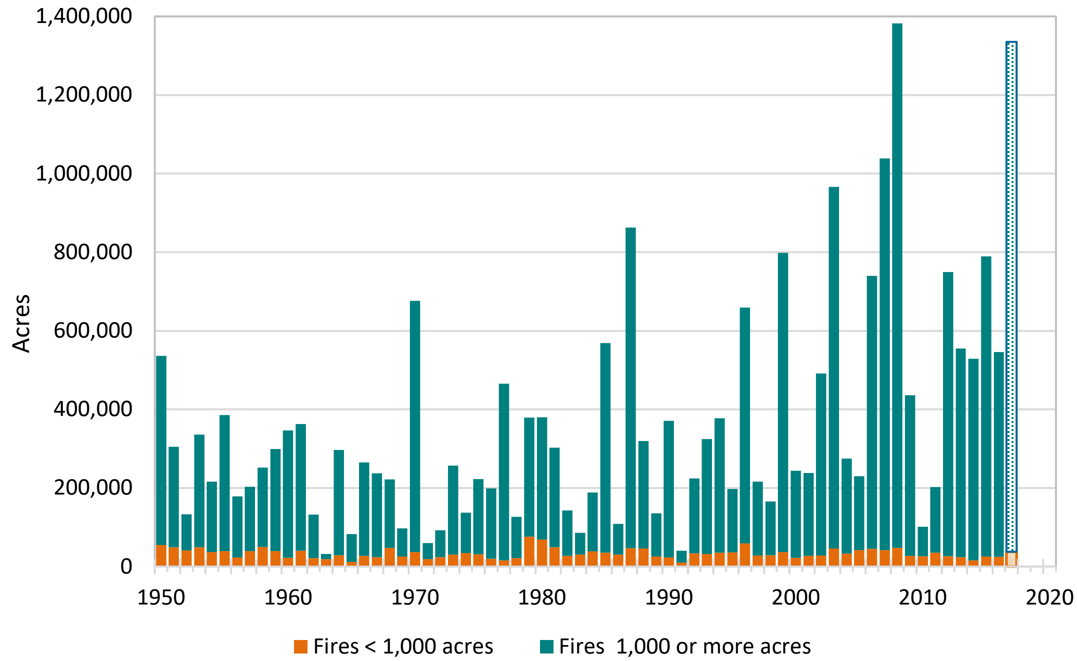
WILDFIRES

The area burned by wildfires across the state is increasing in tandem with rising temperatures.

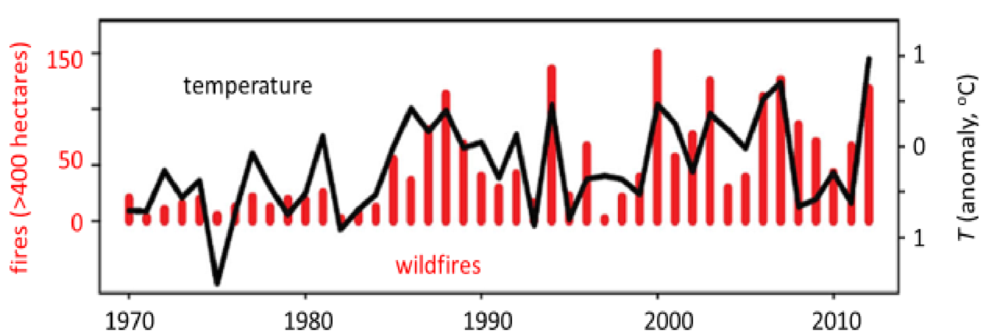
Figure 1. Statewide annual acres burned, 1950-2017*



**2017 data preliminary and subject to change*

Source: CalFire, 2018

Figure 2. Large Western U.S. Forest wildfires and spring-summer temperature



Source: Westerling, 2016

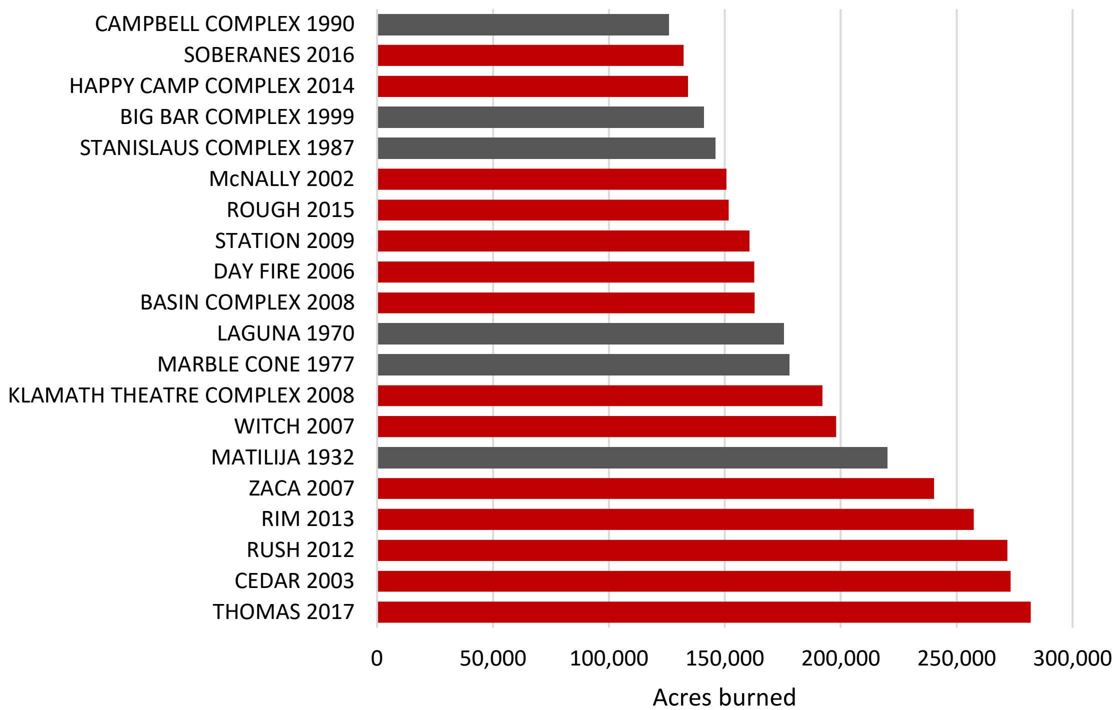
What does the indicator show?

The data presented in Figure 1 show a trend toward increasing acres burned by wildfires statewide. The total area burned annually since 1950 ranged from a low of 32,000 acres in 1963 to a high of 1.4 million acres in 2008.

Although they are fewer in number than fires affecting smaller areas, fires affecting 1,000 acres or more account for most of the area burned each year. The vast majority of wildfires are less than 1,000 acres, yet they account for only about 10 percent of the total area burned each year.

The recent increase in areas burned by wildfires in California is reflected in the fact that, five of the largest fire years since 1950 occurred in about the past decade, in the years 2006, 2007, 2008, 2012, and 2015. Moreover, 14 of the 20 largest wildfires have occurred since 2000 (Figure 3).

Figure 3. Top 20 California fires since 1932*



Source: CalFIRE, 2017

Red bar — fire occurred in 2000 or later

** Records prior to 1932 are less reliable*

Throughout the western United States, large wildfires (affecting more than 400 hectares, or approximately 1000 acres) have increased in number and acreage burned over recent decades (Westerling, 2016; Dennison et al., 2014). The number of large forest wildfires in the western US (consisting of the Rockies, the Sierra Nevada, Cascades, the Coast Ranges, and the mountain ranges of Arizona and New Mexico) has been found to be strongly correlated with mean temperatures from March through August (see Figure 2; Westerling, 2016). As with large forest fires, wildfire activity in grass and shrubland in the western US have also increased significantly over the same time period in terms of frequency and area burned (Westerling, 2016).

Why is this indicator important?

Wildfires are a natural element of California's landscape, playing a critical role in the structure and function of ecosystems. The state's native vegetation is adapted to the periodic recurrence of fire. This pattern has been significantly altered since Euro-American settlement by fire exclusion, land use practices, and development. These human influences have modified the types and distribution of vegetation. This, in turn, affects the likelihood and severity of wildfires (CalFire, 2010).

Wildfires can have a wide ranges of impacts on ecosystems. Recovery of plant communities following a fire determines biodiversity, ecosystem services, future fire activity and other ecosystem conditions. Animals exhibit a wide range of strategies in dealing with fires; recovery of animal communities is affected by the nature of the fire, along with factors such as the type of vegetation burned, the availability of refugia, and habitat fragmentation outside the burned area. Fires can affect soil, water, and carbon storage (Keeley and Safford, 2016). More frequent, expansive and exceptionally severe fires can result in habitat loss, disrupt watershed integrity, adversely impact small mammal populations, and degrade scenery.

Forests play an important part in regulating levels of atmospheric carbon (Settele et al, 2014; Gonzalez et al., 2015). Trees remove carbon dioxide, a greenhouse gas, from the atmosphere and store it through natural processes. Wildfires release carbon dioxide and black carbon into the atmosphere and in doing so contribute to increasing carbon dioxide levels and climate change. With the increasing size and intensity of wildfires, scientists are concerned that some forest lands are releasing carbon faster than they are able to store it (Schimmel and Braswell, 2005).

Wildfires threaten public health and safety, property and infrastructure. The October 2017 wildfires in Sonoma and Napa counties devastated the affected communities: 44 deaths, more than 100,000 residents evacuated, and over $9 billion in residential and commercial insurance claims, making it the deadliest and most destructive fire in the state's history (CDI, 2017). The Thomas Fire that swept through Ventura and Santa Barbara counties in December 2017 is the largest recorded wildfire in the state's history, even though it occurred outside of what has traditionally been considered the state's fire season. As demonstrated by these two disasters, California's environment is increasingly at risk from wildfire. Scientists predict that the largest changes in property damage will occur in wildland/urban interfaces proximate to major metropolitan areas in coastal southern California, in the San Francisco Bay Area, and in the Sierra foothills northeast of Sacramento (Westerling and Bryant, 2008). By the end of the century, substantial increases in residential wildfire risk are projected to result from rapid, sprawling growth in areas on the periphery of the Sierra Nevada (Bryant and Westerling, 2014).

Wildfires severely impact air quality both locally and in areas downwind of the fire (Luber et al., 2014). Exposures to wildfire smoke, which contains particulate matter (PM), carbon monoxide, nitrogen oxides, and various volatile organic compounds, have been associated with general respiratory illnesses and exacerbations of asthma and

COPD (Reid et al., 2016; Liu et al., 2017). Medical costs in 2007 associated with wildfires in Southern California were estimated to have exceeded $3. 4 million (Kochi et al., 2016). Globally, hundreds of thousands of deaths annually have been attributed to exposures to landscape fire smoke.

Larger and more extreme wildfires could be especially challenging for rural, low-income households residing in fire prone areas. Property loss is more likely to occur in smaller, more isolated housing clusters that are difficult for firefighters to reach and suppress (Syphard, 2012). Rural residents may have a lower capacity to protect themselves and recover from fire impacts than people living in more affluent communities (Collins and Bolin, 2009). Wildfires on or near native lands threaten the health, safety and economy of those tribes, culturally important species, medicinal plants, traditional foods, and cultural sites (Bennett et al., 2014).

The increased number and severity of fires and losses of property, lives, and natural resources has made fire suppression in California an increasingly higher priority for federal, state, and local land management agencies. As large wildfires increase in size and number and the fire season has grown longer, firefighting consumes more of the annual resource management budgets for federal and state lands that otherwise could be spent on sustainable programs for fuel management and forest health. Threats posed by wildfires are expected to rise in the face of changing climate conditions and shifts in land use, especially population growth and housing development (USDA, 2015).

What factors influence this indicator?

California's Mediterranean climate predisposes its landscape to fires. Winter rains lead to abundant vegetation that, following the warm, dry summer months, become potential fuel for fires. Prior to Euro-American settlement, the state's diverse vegetation experienced the periodic recurrence of low-severity fires: more than 40 percent of the state supported high fire frequencies (that is, "fire return intervals" of less than 35 years), and another 15 to 20 percent supported moderate fire frequencies (fire return intervals of 35 to 100 years) (Keeley and Safford, 2016).

Increased spring and summer temperatures and earlier spring snowmelt have been associated with increased large wildfire activity (higher large-wildfire frequency, longer wildfire durations, and longer wildfire seasons) in western US forests beginning in the mid-1980s (Westerling et al., 2006; Westerling, 2016). The earliest third of spring snowmelt years accounted for over 70 percent of the area burned in large forest wildfires and more than 40 percent of the area burned in non-forest wildfires. Another study found that increasing trends in the number of large wildfires and area burned annually in the western US across ecoregions representing a wide range of vegetation types, latitudes and precipitation regimes (Dennison et al., 2014). In ecoregions with the largest increases in fire activity, temperatures trended hotter and precipitation trended drier — coinciding with trends toward increased drought severity — compared to ecoregions without significant changes in fire activity. This study's findings implicate climate as a dominant driver of changing fire activity in the western US.

In western US forests, increases in temperature and vapor pressure deficit linked to anthropogenic climate change significantly enhanced fuel aridity over the past several decades, allowing for a more favorable fire environment (Abatzoglou and Williams, 2016). California has recently experienced extreme drought intensified by unusually warm temperatures, known as a hotter drought. With a hotter drought comes very low precipitation and snowpack, decreased streamflow, dry soils, and large-scale tree deaths. These conditions create increased risk for extreme wildfires that spread rapidly, burn with a severity that damages the ecosystem, and are costly to suppress (Crockett and Westerling, 2017).

Higher altitude forests are buffered against climate change warming effects to some extent by available moisture from colder conditions (more snowpack and abundant spring runoff). The runoff provides moisture to soil and vegetation, reducing the flammability of these forests. Interestingly, researchers have reported an increasing frequency of wildfire at higher elevations in the Sierra Nevada using a 105-year dataset (Schwartz et al., 2015). Several factors are likely contributing to this trend, including warming temperatures (especially nighttime) and earlier snowpack melt; increased fuel loads from increasing tree densities; changes in fire management such as reduced fire suppression at high elevations; and increasing ignition frequencies (both lightning and human-caused). These factors are not mutually exclusive and may have synergistic effects. An analysis of forests in the western US forests found that the number of large wildfires increased exponentially with a measure of moisture deficit (a forest-area weighted moisture deficit index) that incorporates both temperature and precipitation (Westerling, 2016). Forests at elevations with snow-free seasons averaging two to four months and relatively high cumulative warm-season actual evapotransporation have been most affected.

The large differences in wildfire acres burned from year to year in California are primarily due to variable weather conditions and situations in which lightning-ignited fires occur in remote locations that are difficult to access (CalFire, 2010). For example, the size of a fire is influenced by the presence of strong winds, the dryness of vegetation due to lack of rainfall, and the ease of accessibility to firefighters. In Southern California, the influence of Santa Ana (SA) winds on wildfires is evident; a study found that non-Santa Ana fires, which occur mostly in June through August affected higher elevation forests, while SA fires, which occur mostly in September through December, spread three times faster and occurred closer to urban areas (Jin et al., 2015).

Changes in population and land use can have immediate and dramatic effects on the number and sources of ignitions and on the availability and flammability of fuels. For example, the escalation of fire losses at the wildland-urban interface is often attributed to new housing development within or adjacent to wildland vegetation (Syphard et al., 2012). This results in increasing shrubland acreage burned. Over the long term, fire management and land uses that suppress surface fires can lead to changes in the density and structure of the vegetation biomass that fuels wildfires, increasing the likelihood of a large or severe fire occurring.

Technical Considerations

Data Characteristics

Data on statewide annual acres burned (Figure 1) were downloaded from a fire perimeter database made publicly available online through CalFire. CalFire works with the USDA Forest Service (USFS) Region 5 Remote Sensing Lab, the Bureau of Land Management (BLM), and the National Park Service (NPS) to track fires on public and private lands throughout California. The data for the period 1950 to 2001 includes USFS wildland fires 10 acres and greater, and CalFire fires 300 acres and greater. In 2002, BLM and NPS fires 10 acres and greater were added, as were CalFire timber fires 10 acres and greater, brush fires 50 acres and greater, grass fires 300 acres and greater, wildland fires destroying three or more structures, and wildland fires causing $300,000 or more in damage. Further details are available at: http://frap.fire.ca.gov/projects/fire_data/fire_perimeters_methods

Fire data for the western U.S. (Figure 2) are from the U. S. Department of Interior and the U.S. Forest Service, as described in Westerling (2016).

Strengths and Limitations of the Data

The CalFire database contains the most complete digital record of fires in California. However, some fires may be missing for a variety of reasons (e. g., lost historical records, inadequate documentation). In addition, although every attempt is made to remove duplicate fires, some duplicates may still exist. Overgeneralization may also be an issue, in which unburned regions within old, large fires may appear as burned.

Fire records used for Figure 2 were reviewed and obvious duplications and errors corrected, as described in Westerling (2016).

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