Congressional Budget Office
Nonpartisan Analysis for the U.S. Congress

Wildfires

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At a Glance

The average annual acreage burned by wildfires in the United States has increased over the past 30 years, affecting both federal and nonfederal lands. In this report, the Congressional Budget Office analyzes trends in wildfire activity; considers the effects of wildfires on the federal budget, the environment, people's health, and the economy; and reviews forest-management practices meant to reduce the likelihood and seriousness of fire-related disasters.

These are the major findings from the analysis:

- About 8 million acres, on average, burned each year in wildfires between 2017 and 2021, more than double the average amount from 1987 to 1991. On average, a fire on federal lands is five times the size of one on nonfederal lands.
- Average annual federal spending on fire suppression totaled $2.5 billion (in 2020 dollars) between 2016 and 2020. Other federal fire-related spending includes disaster assistance (which totaled $5 billion of obligations for disasters declared over those five years) and some indirect costs (such as spending on health care following smoke exposure and the potential loss of revenues from federal timber sales).
- Environmental, health-related, and economic effects of wildfires are felt most acutely in the immediate area. Smoke and air pollution from wildfires spread widely and can exacerbate many health conditions. Wildfires also tend to have negative effects on watersheds.
- Managing forests can reduce the risk and severity of wildfires, according to research. Techniques to do so include setting prescribed fires, managing wildfires in remote areas, and mechanically thinning forests to reduce the density of vegetation and different types of fuel in a forest. The cost to implement those strategies varies by landscape and by treatment required.

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Notes

Unless otherwise indicated, all years referred to are calendar years.

Numbers in the text and figures may not add up to totals because of rounding.

Unless otherwise specified, all dollar amounts are in nominal dollars. Other dollar figures are expressed in 2020 dollars, using the gross domestic product price index from the Bureau of Economic Analysis.

Wildfires

Summary

Fires have always burned on wildlands, and they have important ecological functions in many ecosystems. Over the past 30 years, though, wildfires have burned vegetation on an increasing amount of land in the United States and brought with them environmental, health-related, and economic impacts. Forest-management practices, climate change, and expanding populations in high-risk areas have all contributed to the growth of wildfires and their effects. Wildfires also affect the federal budget through spending on fire suppression, forest management, disaster assistance, and other activities.

How Extensive Are Wildfires in the United States?

The increase in the wildland area burned by fire over the past three decades has occurred both on federal lands and on lands owned by state and local governments and the private sector. From 2017 to 2021, an average of 60,000 wildfires occurred each year, and about one-fifth of them were on federal lands. (Those lands are mostly under the management of the U.S. Forest Service and several agencies in the Department of the Interior, or DOI.) Over that same period, the average annual area burned exceeded 8 million acres. Though fewer in number, federal fires typically affect a larger area than other wildfires; their average size over the 1991–2021 period was more than five times that of fires on nonfederal lands.

Large wildfires are particularly prevalent in western states. In 2021, for example, wildfires larger than 40,000 acres burned more than 2.3 million acres in California, about 500,000 acres in Oregon, and 400,000 acres in Washington. Estimates of wildfires' severity from satellite observations show that, on average, between 2014 and 2018, about one-third of the burned areas that were evaluated experienced high or moderate levels of burn severity, meaning that much of the vegetation was consumed and the effects were expected to be long-lasting. About half of the acres burned at a low level of severity, and an additional 14 percent of the areas evaluated were estimated to have been unburned or to have shown minimal burn severity and were expected to recover quickly.

Why Have Wildfires Increased Over the Past 30 Years?

According to researchers, several factors have contributed to the increase in wildfire activity. To begin with, forest-management practices for much of the past century have allowed vegetation to grow denser, particularly in wildland areas that historically experienced frequent fires. That dense vegetation can fuel fires, especially in times of extreme fire weather, when a combination of conditions—low humidity, strong winds, high temperatures, and drought—makes fires more likely to ignite and burn. In addition, climate change has created hotter, drier conditions that are more conducive to wildfires. Finally, more people are living in and adjacent to wildland areas, which can increase the risk of damage from wildfires to households, businesses, and governments and can complicate efforts to contain fires.

How Do Wildfires Affect the Federal Budget?

Wildfires affect the federal budget both directly and indirectly. Directly, federal spending on fire suppression on federal lands averaged $2.5 billion per fiscal year (in 2020 dollars) between 2016 and 2020. Indirectly, the federal budget is affected through spending on health care following smoke exposure, disruptions to military operations, agricultural assistance, and risks to federal timber sales.

State and local governments and the private sector are responsible for fires that develop on nonfederal lands, although governments at all levels frequently coordinate efforts and share equipment and crews. If a wildfire or its impact exceeds the capacity of state and local governments to respond, the federal government may provide financial assistance through several disaster assistance programs. About $5 billion has been obligated for such assistance for disasters declared during the 2016–2020 period.

How Do Wildfires Affect the Environment, People's Health, and the Economy?

Wildfires are a key ecological process in many ecosystems throughout the United States. The more severe wildfires that have occurred in recent years—as a result of

forest-management practices that have aimed to eliminate fires and climate conditions that are more conducive to fires—have had a broad range of ecological effects, including these:

- Debris and contaminants negatively affect water resources.
- Wildfires increasingly contribute to emissions of carbon dioxide and air pollution, including fine particulate matter.
- Wildfire smoke reaches far beyond burned areas, causing a variety of respiratory and other adverse health effects.
- Wildfires' effects on vegetation varies (both across fires and within the bounds of any individual fire) and can be severe and long-lasting.

The economic impact of wildfires depends on their location, size, duration, and severity and can be extensive. Wildfires can damage and destroy infrastructure, cause business closures, disrupt transportation and supply networks, affect employment, and alter state and local tax revenues. Damage to homes from wildfires is covered under standard homeowners' insurance policies, and insurers have begun to increase rates or exit regions where a large volume of wildfire claims have occurred in recent years.

How Are Forests Managed to Reduce Wildfire Risks?

Dense vegetation, especially when dry, provides fuel for wildfires to spread under certain conditions. Research suggests that fuel treatments, including the use of prescribed fires, mechanical thinning of dense vegetation (using tools or heavy equipment to remove trees), and managed wildfire incidents in remote areas, can reduce the extent and severity of wildfires that encounter those treated areas. Several studies that examined the efficacy of appropriate fuel treatments in specific areas found that they were generally cost-effective; they reduced expected suppression costs or lessened expected risks to local homes and infrastructure.

Those types of fuel treatments are currently used more extensively by nonfederal landowners than by the federal government. In addition to cost, several impediments may hinder policymakers from expanding the use of fuel treatments on federal lands. For prescribed fires, those considerations include air pollution regulations, liability concerns, weather conditions, and the availability of appropriate fire personnel. For mechanical treatments, forest managers would need to evaluate whether sawmills and other wood treatment facilities had sufficient capacity to process treated materials.

Trends in Wildfire Activity

The average annual amount of land affected by wildfires in the United States has increased over the past 30 years. Wildfires are expanding in size, on average, though the number of wildfires started each year has not. Wildfires are larger in western states and tend to be bigger when they occur on land owned by the federal government than on state, local, or privately owned land. A combination of factors—the effects of forest-management practices, climate change, and expansion of urban areas—contributes to determining when and where a fire might ignite, how large it might grow, how it might affect ecosystems and communities, and how successful efforts might be to suppress or contain it.

Wildfires on Federal and Nonfederal Lands

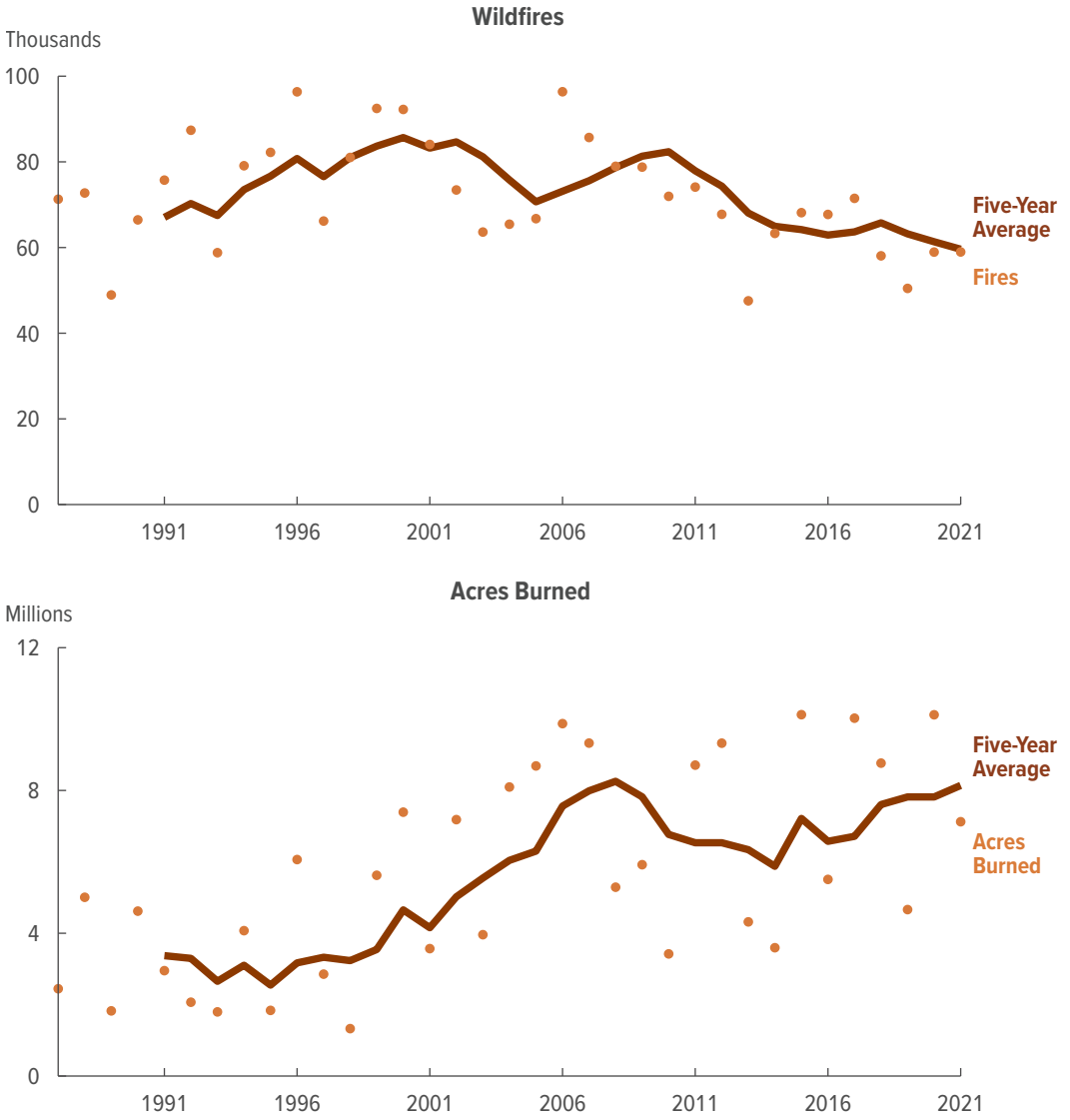
Over the past three decades, the number of wildfires each year has declined somewhat, and the total area affected by those fires has increased substantially. In 2021, nearly 59,000 wildfires occurred in the United States, fewer than the nearly 76,000 that occurred in 1991 (see Figure 1, top panel). The five-year moving average of the number of wildfires has decreased as well, falling from an average of about 82,000 fires per year between 2006 and 2010 to about 60,000 fires per year between 2017 and 2021. (Because the number of fires fluctuates from year to year, five-year moving averages give a clearer picture of the trends than the numbers do in any single year.)

The split between fires begun on federal and nonfederal lands does not vary widely. Each year, between 20 percent and 30 percent of fires begin on federal land, and between 70 percent and 80 percent occur on land owned by state and local governments or the private sector. The decrease in the number of fires over the past decade has been consistent across federal and nonfederal lands: The five-year moving average for fires on federal lands has declined by 23 percent and for fires on nonfederal lands, 26 percent.

The total number of acres burned in wildfires has markedly increased in the past 30 years, though. About 7 million acres burned in 2021, more than double the 3 million acres burned in 1991 (see Figure 1, bottom panel). Fewer acres burned in 2021 than in 2020, when about 10 million acres burned, the second-highest

Figure 1.

Number of Wildfires and Acres Burned, 1987 to 2021



The number of wildfires that occur each year in the United States has fluctuated over the past 30 years. Over the past decade, the five-year moving average of the number of wildfires has decreased. There has been no comparable decrease in the land area affected by wildfires because the average wildfire has grown larger over time. Although the number of acres burned fluctuates from year to year, by 2021 the five-year moving average of acres burned was about double what it had been in the early 1990s.

Data source: National Interagency Fire Center, "Total Wildland Fires and Acres," www.nifc.gov/fire-information/statistics/wildfires. See www.cbo.gov/publication/57970#data.

A five-year moving average replaces the value for each year in an annual data series with an average over five consecutive years. (Here the arithmetic mean of each annual value and the preceding four is used.) A moving average is smoother than the underlying data series and is useful for reducing year-to-year changes unrelated to overall trends in the data.

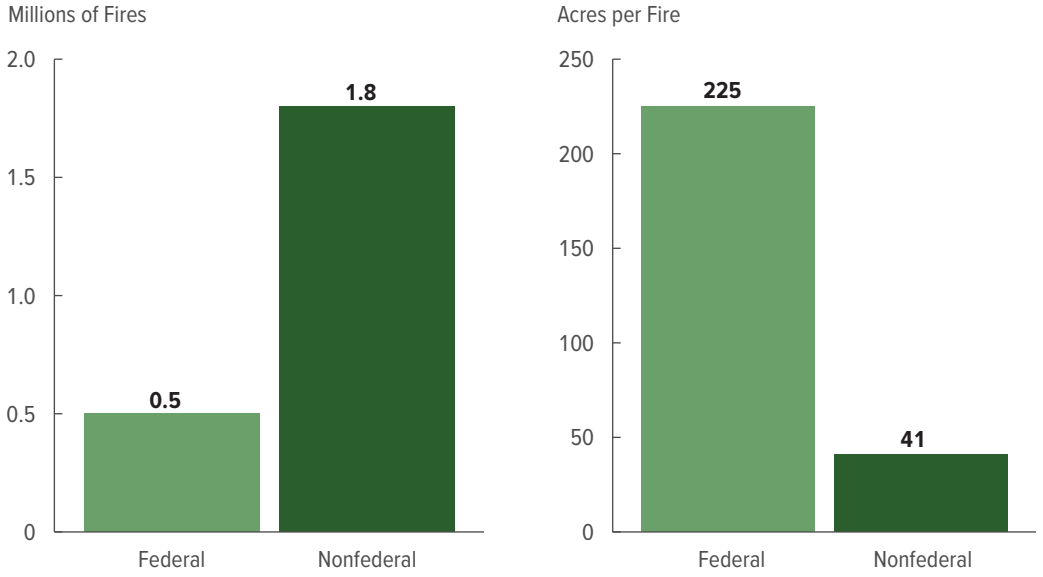
amount recorded in recent years. The five-year moving average of acres burned dipped lower in the 2010s, but by 2021 it had again exceeded 8 million acres per year (an area about the size of Maryland), close to the high reached in 2008.

Fires on federal lands accounted for more than half of the acres burned in wildfires in all but five years between 1991 and 2021. In most years, between 50 percent and 70 percent of the acres burned in wildfires were on federal lands. The combination of fewer fires and more acres burned means that wildfires on federal lands are typically larger than those that occur on land owned by state and local governments or the private sector.

Fires on federal lands are often in more remote or less populated and developed areas, so less effort may be

Figure 2.

Total Number of Wildfires on Federal and Nonfederal Lands and Average Acres per Fire, 1991 to 2021



Although fewer wildfires occur on federal lands than on nonfederal lands, fires that burn on federal lands have been about five times larger, on average, over the past three decades. Wildfires on federal lands are more likely to occur in remote areas and threaten fewer structures and communities, which may reduce the urgency of suppression efforts.

Data source: National Interagency Coordination Center, *Wildland Fire Summary and Statistics Annual Report*, all years from 2000 to 2021, www.predictiveservices.nifc.gov/intelligence/intelligence.htm. See www.cbo.gov/publication/57970#data.

made to suppress or contain them.[1] The average size of the 495,000 fires that burned on federal lands between 1991 and 2021 was 225 acres, more than five times the 41-acre average size of the 1.8 million nonfederal fires (see Figure 2). The average size of both federal and nonfederal fires grew over the period as well: By 2021, federal fires were nearly four times larger than in 1991, on average, and nonfederal fires were about two times larger than those measured in 1991.

Regional Differences in Wildfire Activity

Wildfires are not evenly distributed across the country. Large wildfires—those exceeding 40,000 acres—occur mostly in the western part of the country, particularly in the states along the coast of the Pacific Ocean (Alaska, California, Oregon, and Washington). In most years since 2010, the states in the Plains and Mountain West have seen fewer acres burned in those large wildfires than have the Pacific states (see Figure 3). Large wildfires have been less prevalent in southern states, although more acres burned in fires larger than 40,000 acres in the South in 2011 than in the Pacific and Mountain West states combined. (Conditions in the South that spring were far drier than normal, and numerous large fires burned in Texas at that time.)

Fire Severity and Related Impacts

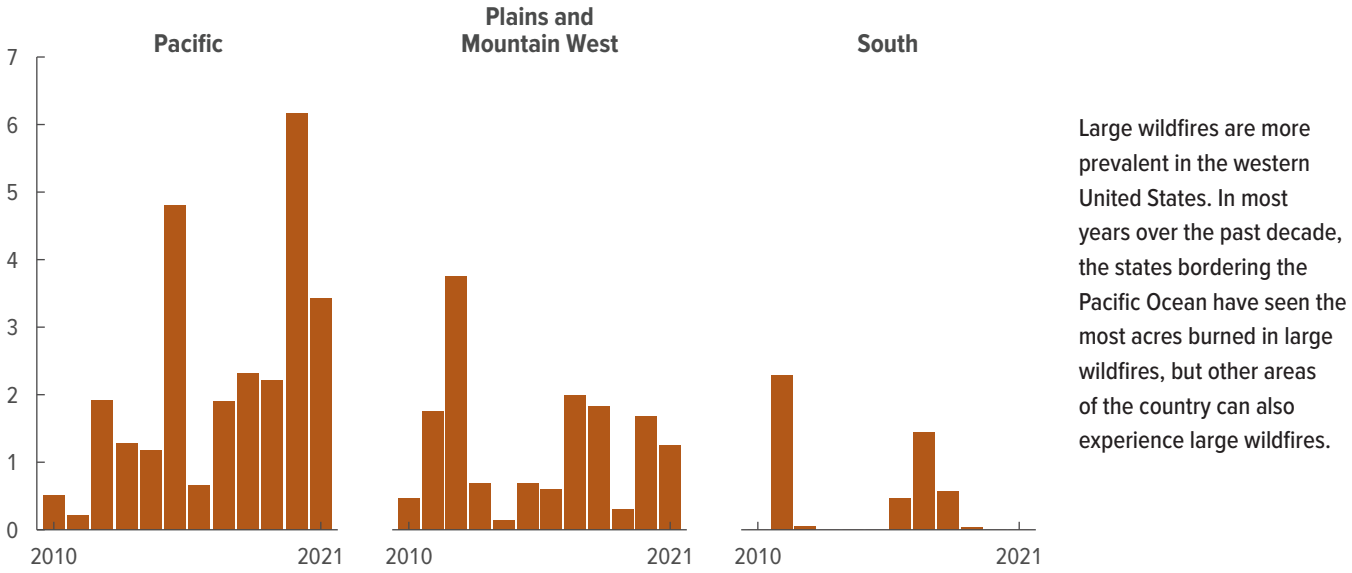
Wildfires produce a range of effects—beneficial, neutral, and harmful—on the vegetation and land they encounter. In some areas they touch, wildfires are beneficial, enhancing growth by consuming dead and live plant material, releasing nutrients into the soil, and allowing certain types of trees to regenerate. Some fires burn with low flame lengths through an area and kill little overstory vegetation, thus having neutral effects. Harmful effects ensue when wildfires kill all frequent-fire-adapted trees and other vegetation over large areas, damaging soils and exposing the land to flooding and erosion, which can have further negative ecological impacts.

An interagency effort between the U.S. Geological Survey and the U.S. Forest Service classifies the burn severity of wildfires that exceed 1,000 acres in western states and 500 acres in eastern states. By comparing satellite images taken before a fire, immediately after a fire, and one growing season later, analysts characterize the severity of a fire's impact on vegetation in the area, classifying it into several categories (see Table 1). In most years

1. Yanjun (Penny) Liao, Resources for the Future, personal communication (February 23, 2022).

Figure 3.

Acres Burned in Fires of More Than 40,000 Acres, by Region



Large wildfires are more prevalent in the western United States. In most years over the past decade, the states bordering the Pacific Ocean have seen the most acres burned in large wildfires, but other areas of the country can also experience large wildfires.

Data source: National Interagency Coordination Center, *Wildland Fire Summary and Statistics Annual Report*, all years from 2000 to 2021, www.predictiveservices.nifc.gov/intelligence/intelligence.htm. See www.cbo.gov/publication/57970#data.

Pacific states are Alaska, California, Oregon, and Washington. Plains and Mountain West states are Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Utah, and Wyoming. Southern states are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

since 1988, close to half of the area within the perimeter of those wildfires was classified as having burned at low severity, and between 10 percent and 20 percent was classified as having burned at high severity (see Figure 4).

Severity is not uniform across the area burned by a wildfire. Any given fire is likely to show varying levels of severity within the perimeter of its burned area. In a study of 10 large fires that affected ponderosa pine and dry mixed-conifer forests in Arizona, Colorado, New Mexico, and Oregon in the early 2000s, high-severity effects were identified in between 7 percent and 43 percent of the burned areas.[2] Within a fire's perimeter, patches known as fire refugia retain some live forest cover and act as seed sources to support a forest's ability to regenerate after a fire. In that same study, researchers found that such patches were smaller and farther apart in areas that burned at a relatively higher severity. In some of those areas, the distance between fire refugias was far enough that it would take several generations for seed sources to reach some locations.

Forest Management, Climate Change, the Wildland-Urban Interface, and Wildfire Risk

Wildfires have grown in reach and severity in recent years, probably owing to several factors. According to researchers, those factors include forest-management practices, climate change, and expansion of the wildland-urban interface.

Most fires are caused by human activity, including negligence, arson, burning debris, and malfunctioning equipment. From 2001 to 2021, human activity sparked 86 percent of wildfires, and lightning accounted for the remaining 14 percent. (Fire authorities identify the ignition source of a wildfire as either human-caused or lightning-caused.) Fires ignited by lightning tend to be larger and in more remote areas, accounting for 59 percent of the acres burned over the 2001–2021 period.[3]

2. Ryan B. Walker and others, "How Much Forest Persists Through a Fire? High-Resolution Mapping of Tree Cover to Characterize the Abundance and Spatial Pattern of Fire Refugia Across Mosaics of Burn Severity," *Forests*, vol. 10, no. 9 (September 2019), doi.org/10.3390/f10090782.

3. National Interagency Fire Center, "Human-Caused Wildfires" and "Lightning-Caused Wildfires" (accessed May 13, 2022), www.nifc.gov/fire-information/statistics.

Table 1.

Burn Severity Classes

Class	Description of Affected Area
Increased Greenness	Site is burned but displays more vegetation cover, density, and productivity, usually within one growing season after a fire.
Unburned to Low	Site is unburned or shows visible effects on a small portion, usually less than 5 percent. Also may include areas that recover quickly after a fire.
Low	More than a small portion of the site is burned, and all levels of vegetation are slightly altered from their condition before the fire.
Moderate	Conditions are transitional between low and high classes.
High	Effects are consistent across a site: Loose debris (such as sticks, twigs, and fallen leaves) is totally consumed, heavier debris is at least partially consumed, and at least 75 percent of overstory trees die. Effects are long lasting; establishment of new trees is possible in one to three years, but forest development may take decades.

Data source: Monitoring Trends in Burn Severity, "Frequently Asked Questions (FAQ)," accessed March 15, 2022, www.mtbs.gov/faqs.

Forest-Management Practices. For most of the 20th century, federal fire policy emphasized suppression and prevention. During the decades when strong fire suppression practices prevailed, forests changed. Fires that did occur were quickly suppressed, so forests no longer experienced frequent fires of low or moderate severity that would have reduced or removed vegetation and accumulated fuels.[4] In the late 1960s and early 1970s, federal land management agencies permitted some use of prescribed fires and managed wildfires for ecological objectives, but fire suppression remained the prevailing policy in many agencies.[5] As a result, the fuel buildup and other changes in certain forested areas went unaddressed in many places, creating risky fire conditions. Those elevated fuel levels, especially when accompanied by climate change–related higher temperatures and drought, contribute to fires that burn with greater severity, spread more rapidly, and unleash more harmful impacts.

Climate Change. Climate change has created hotter and drier conditions that are more conducive to longer and more severe wildfire seasons.[6] In every year since 1997, average annual temperatures in North America have exceeded the 1910–2000 average (see Figure 5, top panel). Droughts have grown more frequent as well, particularly in the western part of the United States (see Figure 5, bottom panel). In 15 of the past 31 years, the portion of the country from the Rocky Mountains westward has been categorized as abnormally dry or in drought for all 12 months of the year. Researchers have found that climate change–induced increases in temperatures leave vegetation and other fuels drier, increasing the potential for fires to ignite.[7] Those climate trends have also been linked to higher-severity fires.[8] In addition to creating favorable conditions for wildfires, climate change may induce more ignitions, as lightning occurs more frequently with higher temperatures.[9]

Expansion of the Wildland-Urban Interface. Expansion of the areas where homes and wildland areas meet

4. Jan W. van Wagtendonk, "The History and Evolution of Wildland Fire Use," *Fire Ecology*, vol. 3, no. 2 (December 2007), doi.org/10.4996/fireecology.0302003.

5. Scott L. Stephens and Lawrence W. Ruth, "Federal Forest-Fire Policy in the United States," *Ecological Applications*, vol. 15, no. 2 (April 2005), pp. 532–542, doi.org/10.1890/04-0545.

6. Congressional Budget Office, *Potential Impacts of Climate Change in the United States* (May 2009), www.cbo.gov/publication/41180.

7. John T. Abatzoglou and A. Park Williams, "Impact of Anthropogenic Climate Change on Wildfire Across Western U.S. Forests," *Proceedings of the National Academy of Sciences*, vol. 113, no. 42 (October 2016), doi.org/10.1073/pnas.1607171113.

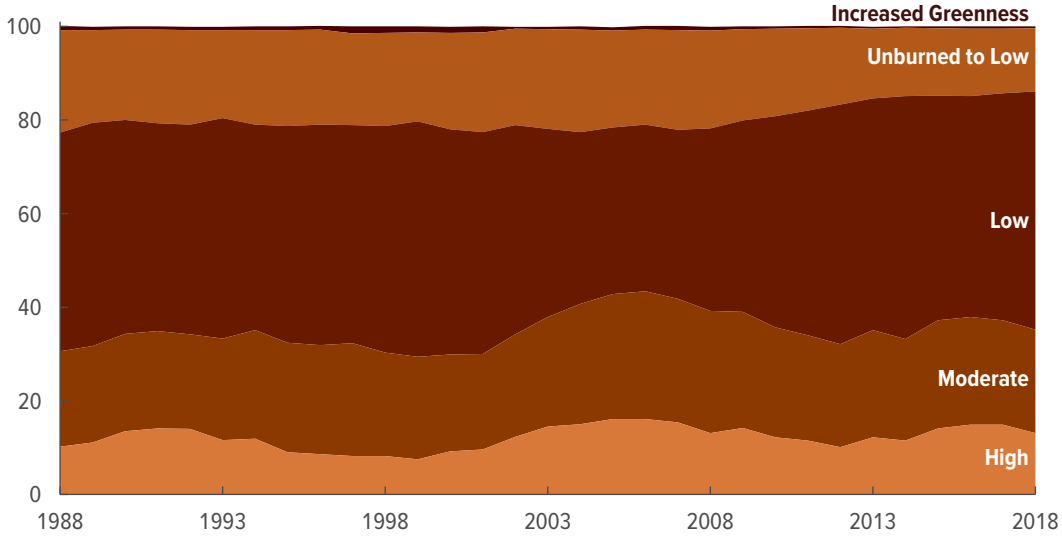
8. S.A. Parks and J.T. Abatzoglou, "Warmer and Drier Fire Seasons Contribute to Increases in Area Burned at High Severity in Western U.S. Forests From 1985 to 2017," *Geophysical Research Letters*, vol. 47, no. 22 (November 2020), doi.org/10.1029/2020GL089858.

9. David M. Romps and others, "Projected Increase in Lightning Strikes in the United States Due to Global Warming," *Science*, vol. 346, no. 6211 (November 2014), doi.org/10.1126/science.1259100.

Figure 4.

Share of Acres Burned in Wildfires, by Burn Severity Class

Percent, Five-Year Average



Wildfires' effects on the vegetation they encounter vary. Fires can enhance growth in areas where they burn at lower severity by consuming dead materials and releasing nutrients into the soil. Where fires burn at high severity, they can cause extensive damage to trees and soils.

Data source: Monitoring Trends in Burn Severity, accessed through "Climate Change Indicators: Wildfires," Figure 3, www.epa.gov/climate-indicators/climate-change-indicators-wildfires. See www.cbo.gov/publication/57970#data.

A five-year moving average replaces the value for each year in an annual data series with an average over five consecutive years. (Here the arithmetic mean of each annual value and the preceding four is used.) A moving average is smoother than the underlying data series and is useful for reducing year-to-year changes unrelated to overall trends in the data.

increases the potential for more human-caused fires and more complicated fire suppression efforts. Between 1990 and 2010, the land area of the wildland-urban interface grew by one-third, to nearly 300,000 square miles, and the number of homes in that area increased from 31 million to 43 million.[10] (A 2020 estimate places 49 million homes in the wildland-urban interface.)[11] Human-caused wildfires also have lengthened the wildfire season: Researchers found that wildfires ignited by lightning were concentrated in the summer months, and human-ignited fires occurred both earlier in the spring and later in the fall than those ignited by lightning.[12]

10. Volker C. Radeloff and others, "Rapid Growth of the U.S. Wildland-Urban Interface Raises Wildfire Risk," *Proceedings of the National Academy of Sciences*, vol. 115, no. 13 (March 2018), doi.org/10.1073/pnas.1718850115.

11. Marshall Burke and others, "The Changing Risk and Burden of Wildfire in the United States," *Proceedings of the National Academy of Sciences*, vol. 118, no. 2 (January 2021), doi.org/10.1073/pnas.2011048118.

12. Jennifer K. Balch and others, "Human-Started Wildfires Expand the Fire Niche Across the United States," *Proceedings of the National Academy of Sciences*, vol. 114, no. 11 (March 2017), doi.org/10.1073/pnas.1617394114.

Federal Spending Arising From Wildfires

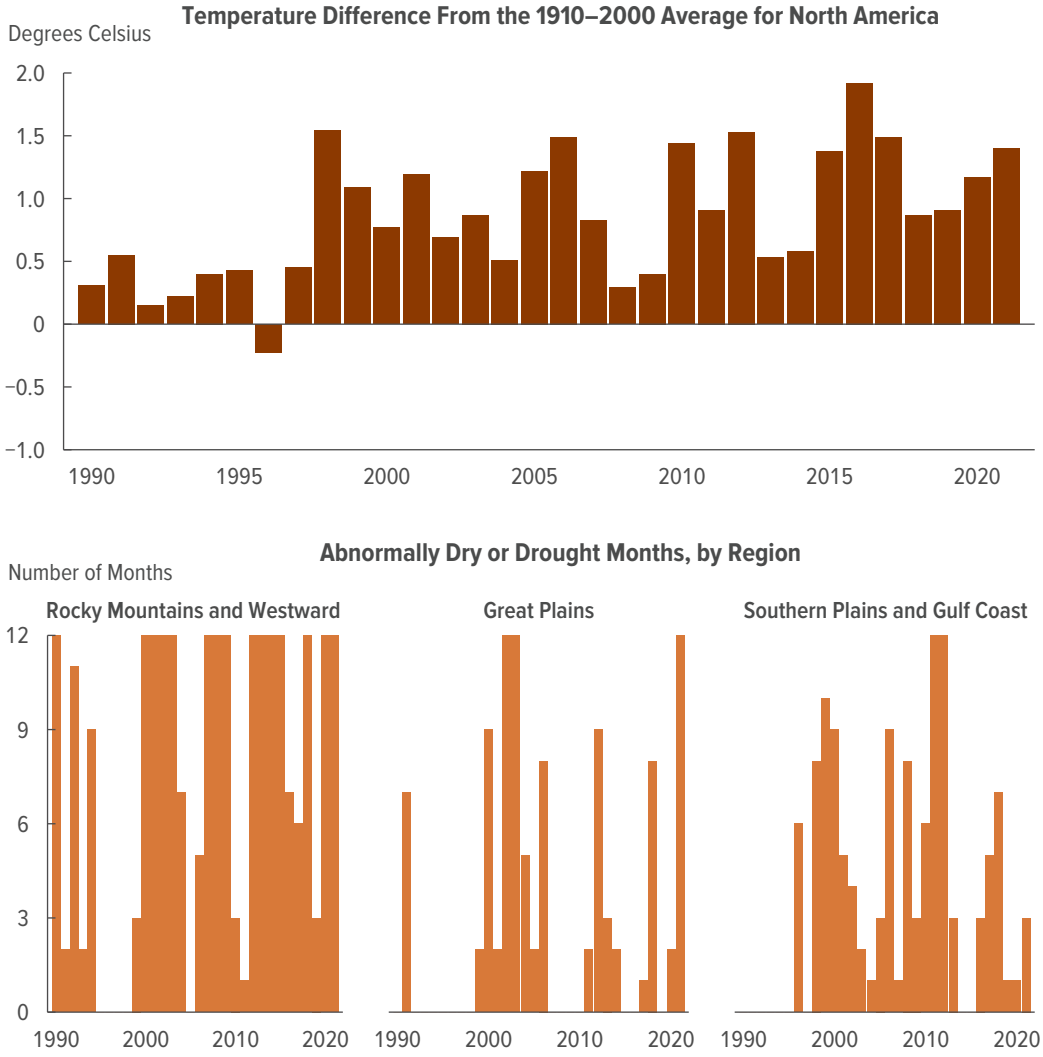
Wildfires prompt federal spending for a range of purposes: to suppress fires that originate on federal lands, to coordinate and assist with efforts between federal agencies and state fire and forestry agencies, to aid individuals and state and local governments affected by wildfires, and for other purposes.

Fire Suppression

The federal government bears responsibility for responding to wildfires that occur on federal lands. Those lands are managed primarily by the U.S. Forest Service, which is part of the Department of Agriculture, and several agencies in the Department of the Interior (the Bureau of Indian Affairs, the Bureau of Land Management, or BLM, the U.S. Fish and Wildlife Service, and the National Park Service). For fires that cross jurisdictional boundaries and burn land managed by more than one federal agency or by some combination of federal, state, or local governments or the private sector, firefighting efforts are typically coordinated across agencies, and each one is responsible for executing those efforts on its own land.

Figure 5.

Climate Trends That Contribute to Wildfires



Hotter, drier weather creates conditions that are more favorable to wildfires by leaving vegetation and plant debris drier and easier to ignite. Temperatures have exceeded historical averages across North America in almost all years since 1990. From the Rocky Mountains westward, drought or abnormally dry conditions have persisted throughout much or all of the year for most of the past two decades. Other regions have also experienced many months of abnormally dry or drought conditions.

Data source: National Oceanic and Atmospheric Administration, National Centers for Environmental Information, "Climate at a Glance: Global Time Series," published January 2022 and accessed February 2, 2022, and "Climate at a Glance: Regional Time Series," published March 2022 and accessed April 6, 2022, www.ncdc.noaa.gov/cag/. See www.cbo.gov/publication/57970#data.

Droughts are classified according to the Palmer drought severity index. Areas with an index value of less than -1 are classified as abnormally dry, and those with less than -2 are experiencing drought.

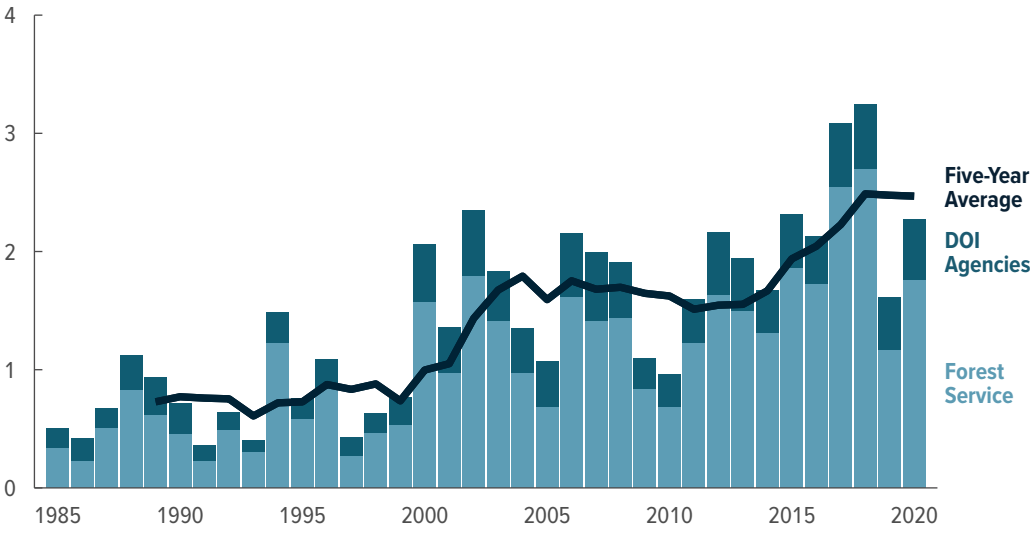
Rocky Mountains and Westward encompasses Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, and portions of Colorado, Montana, New Mexico, and Wyoming. The Great Plains region is Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and portions of Colorado, Montana, New Mexico, and Wyoming. The Southern Plains and Gulf Coast region comprises Florida, Louisiana, Texas, and portions of Alabama, Arkansas, Georgia, Mississippi, New Mexico, and Oklahoma.

In line with fire activity, spending on fire suppression by federal agencies varies from year to year. Over time, trends show a clear increase in federal spending on fire suppression. Over the five fiscal years ending in 1989, average annual spending on fire suppression by federal agencies totaled $728 million (in 2020 dollars), an amount that more than tripled—to about $2.5 billion—for the five years ending in 2020.

Spending on fire suppression by the Forest Service has typically exceeded spending by DOI agencies, and the gap has grown over time. In the late 1980s and early 1990s, spending by the Forest Service on fire suppression accounted for between two-thirds and three-fourths of total federal spending for that purpose (see Figure 6). Since then, spending by the Forest Service has increased more rapidly than spending by DOI agencies. By fiscal

Figure 6.

Spending on Wildfire Suppression by the U.S. Forest Service and Department of the Interior



The Forest Service and several DOI agencies are responsible for managing wildfires on federal lands. In 2020, those lands accounted for 70 percent of the acres burned in wildfires. Between 1989 and 2020, the five-year moving average for federal spending on wildfire suppression more than tripled in inflation-adjusted terms.

Data source: National Interagency Fire Center, "Suppression Costs," www.nifc.gov/fire-information/statistics/suppression-costs. See www.cbo.gov/publication/57970#data.

DOI = Department of the Interior.

A five-year moving average replaces the value for each year in an annual data series with an average over five consecutive years. (Here the arithmetic mean of each annual value and the preceding four is used.) A moving average is smoother than the underlying data series and is useful for reducing year-to-year changes unrelated to overall trends in the data.

year 2020, the five-year moving average of Forest Service spending was nearly four times larger (after removing the effects of inflation) than its corresponding measure in 1989. Over the same period, spending by DOI agencies on fire suppression more than doubled. On average over the five years leading up to 2020, more than 80 percent of federal spending to suppress wildfires originated in the Forest Service.

Coordination of Efforts

The federal agencies involved in managing wildland fires that occur on federal lands also coordinate firefighting efforts with state agencies and other federal agencies through the National Interagency Fire Center (NIFC). Through the NIFC, the Forest Service and DOI agencies share firefighting supplies, equipment, and crews; establish firefighting standards and best practices; and set priorities if the demand for firefighting resources exceeds their availability.

In addition to coordinating responses to fires, the NIFC and regional groups produce short- and long-term outlooks for fire risks, fuel moisture, weather conditions, and other factors that may affect how likely wildfires are to ignite, how quickly they spread, and how intensely they burn. The NIFC also collects and publishes data on current and past fire incidents, including the ownership of the land on which a fire occurs, the size and number of fires, and the equipment and crews requested and employed to suppress or contain fires.

Disaster and Recovery Assistance

The federal government assists communities that have experienced wildfire disasters in two ways. First, through disaster relief programs operated by the Federal Emergency Management Agency (FEMA), it provides funding to state and local governments to help control fires on nonfederal lands, and it offers financial assistance to people and businesses that have suffered losses and to state and local governments responding to those disasters. Second, DOI and the Forest Service administer programs to stabilize and rehabilitate burned areas on federal lands.

For wildfire-related disasters declared during the 2016–2020 period, FEMA obligated about $5 billion for that assistance (see Table 2). Fire-related disaster assistance has been concentrated in western states; California alone

Table 2.

Disaster Declarations for Wildfires and Assistance Obligated as of April 8, 2022

	Fire Management Assistance Declarations		Emergency Declarations		Major Disaster Declarations		
	Number of Declarations	Total Public Assistance and Hazard-Mitigation Assistance Obligated (Millions of dollars)	Number of Declarations	Total Public Assistance Obligated (Millions of dollars)	Number of Declarations	Total Individual and Household Assistance Approved (Millions of dollars)	Total Public Assistance and Hazard-Mitigation Assistance Obligated (Millions of dollars)
2001 to 2005	243	340	0	0	5	34	130
2006 to 2010	264	348	4	249	5	25	292
2011 to 2015	258	562	2	0	12	34	523
2016 to 2020	266	830	4	0	9	193	3,544

Data source: Federal Emergency Management Agency, OpenFEMA Data Sets, "Disaster Declarations Summaries" and "FEMA Web Disaster Summaries," both accessed April 8, 2022, www.fema.gov/about/openfema/data-sets. See www.cbo.gov/publication/57970#data.

accounted for nearly one-quarter of all wildfire-related disaster declarations between 2001 and 2020.

Communities experiencing wildfires may qualify for assistance provided through several types of federal disaster declarations: fire management assistance declarations, emergency declarations, and major disaster declarations. Each type of declaration unlocks different types of assistance.

Fire management assistance grants (FMAGs) are provided to state and local governments to mitigate, manage, and control fires on both public and private lands. They are the most common wildfire-related type of disaster assistance provided, and they have the smallest average obligations per disaster. For the 266 fire management assistance declarations made from 2016 to 2020, the average amount of federal funds obligated totaled $3 million. States seek assistance through FMAGs when a wildfire is burning under such conditions that it threatens to become a major disaster and when eligible firefighting costs exceed a predetermined threshold.

Each state has two separate cost thresholds for wildfires—one for an individual fire and one for cumulative wildfire suppression costs in a calendar year. Individual wildfire thresholds are the greater of $100,000 or 5 percent multiplied by a per capita indicator (which is adjusted for inflation each year) multiplied by the state's population. Cumulative thresholds are the greater of $500,000 or three times the individual wildfire threshold. In either case, the federal government's share of the cost is set at 75 percent.

If a fire causes damage that exceeds the capacity of state and local governments to respond, affected communities may request that the President issue an emergency declaration. (Emergency declarations are not limited to wildfires or other natural disasters, such as earthquakes, floods, or severe storms; they can be made for any instance when the President decides federal assistance is needed.) Four wildfires received emergency declarations from 2016 to 2020. An emergency declaration allows for federal resources to supplement state and local efforts to provide emergency services or to lessen the threat of further disruptions. Those federal funds may be used to assist local public authorities with providing emergency protective measures and removing debris. Assistance to individuals is limited to housing and other immediate needs. Under an emergency declaration, the federal government pays the entire cost of individual housing assistance and 75 percent of the cost of public assistance and other individual needs.

More extensive federal assistance can be provided if the President issues a major disaster declaration. In addition to wildfires, major disaster declarations can be made for any natural event and any type of fire, flood, or explosion if the damage it causes is so severe that it is beyond the capacity of state and local governments to respond. In that case, affected individuals and households may be able to access housing aid as well as crisis counseling, unemployment assistance, legal services, and food assistance. In addition to the assistance for emergency protective services and debris removal allowed under an emergency declaration, state and local governments can

access public assistance to repair and replace damaged infrastructure, including roads and bridges, water and other utilities, and buildings and equipment.

For the nine wildfires designated as major disasters from 2016 to 2020, obligations averaged $394 million for public and hazard-mitigation assistance and $21 million for individual and household assistance (as of April 8, 2022). Those amounts may continue to increase as state and local governments implement required repairs over the coming years.

Following receipt of either an FMAG or a major disaster declaration, communities may be eligible for federal hazard-mitigation assistance. Those federal funds may be spent on certain mitigation measures to reduce losses from future disasters. In the case of wildfires, those projects may include stabilizing soil to prevent erosion, implementing measures to reduce hazardous fuels, expanding defensible space and making structures more resistant to wildfires, repairing and retrofitting water systems that were burned or contaminated, and taking measures to reduce sediment in waterways and prevent flooding.

Other federal programs are in place to rehabilitate burned areas. On federal lands, the Burned Area Emergency Response programs help implement emergency treatments to stabilize burned areas to manage flooding, erosion, and other short-term risks. For nonfederal lands, the Department of Agriculture's Emergency Watershed Protection Program and Emergency Forest Restoration Program provide financial and technical assistance to nonfederal landowners to address damage to streams and restore forestlands harmed by wildfires and other natural disasters.

The loss of vegetation and the increased soil exposure that can follow a wildfire heighten the risk of flooding for up to five years after a fire. That flooding can include rainwater, debris, ash, soil, and sediment. The National Flood Insurance Program offers insurance to homeowners, renters, and businesses to cover claims that arise from flooding, including that following a fire. Those policies have a postwildfire exception to allow coverage to begin without a waiting period when flooding follows a wildfire on federal land and certain other conditions are met.[13]

13. Federal Emergency Management Agency, "Flood Risks Increase After Fires" (fact sheet, November 2020), https://go.usa.gov/xuDGp.

Other Effects on the Federal Budget From Wildfires

In addition to spending on fire suppression and disaster assistance, the federal government incurs costs to address indirect wildfire-related effects. The adverse impacts of wildfires may affect federal spending on health care, agricultural assistance, and military operations. Wildfires may also affect the revenues raised from timber sales on federal forestlands.

Wildfires may affect spending through other federal programs whose spending is not directly connected to suppressing the fires or assisting in the aftermath. For instance, federal spending on Medicare, Medicaid, and other health care programs (which has totaled about 35 percent of national health expenditures in recent years) is likely to increase as a result of treating the adverse health effects from wildfires and wildfire smoke—particularly because older adults face higher health risks from exposure to smoke, and lower-income people may be more exposed to smoke. Farms and ranches that sustain wildfire-related losses may seek compensation through federal agricultural assistance programs. Military operations have also been affected by wildfires, both through disruptions to planned activities from wildfires and smoke and through the assistance they provide (in terms of crews and equipment) to civilian firefighting operations.

Although the effect of wildfires on federal timber sales is uncertain, any changes are not likely to have a large impact on the federal budget because revenues from timber sales are relatively small. Most federal timber sales are administered by the Forest Service and BLM according to rules set in law. About two-thirds of the 145 million acres in the national forest system managed by the Forest Service are timberland, which is defined as land that is capable of growing 20 cubic feet of logs and other round timber not used for energy per acre each year. Of the 38 million acres of forest managed by BLM, 16 percent is considered timberland.[14] Each agency determines which portion of that land to make available for harvesting each year. In fiscal year 2021, commercial timber harvests were completed on 186,000 acres of land managed by the Forest Service and 14,000 acres

14. Sonja N. Oswalt and others, *Forest Resources of the United States, 2017: A Technical Document Supporting the Forest Service 2020 RPA Assessment*, General Technical Report WO-97 (Department of Agriculture, U.S. Forest Service, March 2019), Appendix Tables 2 and 10, doi.org/10.2737/WO-GTR-97.

of BLM-managed land. That year, the cut value of the timber harvested on land managed by the two agencies totaled $152 million and $57 million, respectively.[15]

Environmental, Health-Related, and Economic Effects of Wildfires

The effects of wildfires extend beyond the efforts involved in suppressing them and assisting the affected communities. Wildfires can have an ecological impact on the soil in burned areas and nearby watersheds, and their smoke includes air pollutants. The effects of that smoke on people's health can extend far beyond the burned areas, compounding the effects of wildfires on firefighters and nearby residents. The economic effects of wildfires vary with their location and size and can include employment losses, damage to transportation networks and other infrastructure, business disruptions, and a change in the availability of insurance.

Environmental Effects

Wildfires affect the local ecology of the burned areas and can also have far-ranging ecological impacts through their effects on drinking water sources and their emissions of air pollutants and carbon dioxide. More severe fires are likely to have a larger environmental impact: Crown fires that burn through trees' top layer of foliage in dense forests produce more smoke than fires in grasslands or shrublands, for example.

The localized environmental effects of wildfires center on their impact on soil, water resources, and vegetation. In areas burned by wildfires, the loss of vegetation affects the soil's structure, reducing its productivity, leaving it more vulnerable to erosion, and limiting the vegetation's ability to regrow. The risk of erosion is higher in steep terrain and following high-severity fires.[16] Flooding and debris flows are more likely to occur in those eroded areas, especially after rain or rapid snowmelt. Debris and other contaminants in water runoff negatively affect water quality in and near the burned areas. They also pose difficulties for water utilities because the changes in water quality may require continual adjustments to necessary treatments and filtration. Those effects often persist for four or five years after a fire and may continue longer, especially after large and severe fires.[17]

In addition to their effects on soil, fires that burn at high severity over large areas can alter the types of vegetation in a burned area, eliminating the mature trees that would otherwise serve as seed sources to restore the same types of vegetation that were present before the fire.[18] High-severity fires can also lead to higher levels of severity in future fires in the same area.[19]

Wildfires and the smoke they generate emit air pollutants that can travel far beyond the immediate area of a fire. The Environmental Protection Agency sets air quality standards for several of those air pollutants to protect public health. From 2002 to 2017, these emissions attributed to wildfires all increased by more than 35 percent:

- Particulate matter that is 10 micrometers in diameter or smaller (PM_{10}),
- Particulate matter that is 2.5 micrometers in diameter or smaller ($PM_{2.5}$),
- Volatile organic compounds, and
- Carbon monoxide.

Wildfires burned across fewer acres in 2018 and 2019, so their emissions fell as well (see Figure 7). Because emissions of those same air pollutants from other sources have decreased consistently over the past two decades,

15. Department of Agriculture, U.S. Forest Service, "Harvest Trends on National Forest System Lands: Historic Harvest Records, 1984 to Present" (accessed March 17, 2022), www.fs.fed.us/forestmanagement/reports/index.shtml; Department of Agriculture, U.S. Forest Service, "Forest Products Cut and Sold From the National Forests and Grasslands: Fiscal Year 2021, Quarters 1-4, Servicewide" (November 8, 2021), www.fs.fed.us/forestmanagement/products/cut-sold/index.shtml; and Department of the Interior, Bureau of Land Management, "Bureau Wide Timber Data: Transaction Data, Cumulative Through Fourth Quarter of Fiscal Year 2021" (accessed March 17, 2022), https://go.usa.gov/xuD7V.

16. Daniel G. Neary, Kevin C. Ryan, and Leonard F. DeBano, *Wildland Fire in Ecosystems: Effects of Fire on Soils and Water*, General Technical Report RMRS-GTR-42-vol.4 (Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, September 2005), p. 51, www.fs.fed.us/psw/pubs/20912.

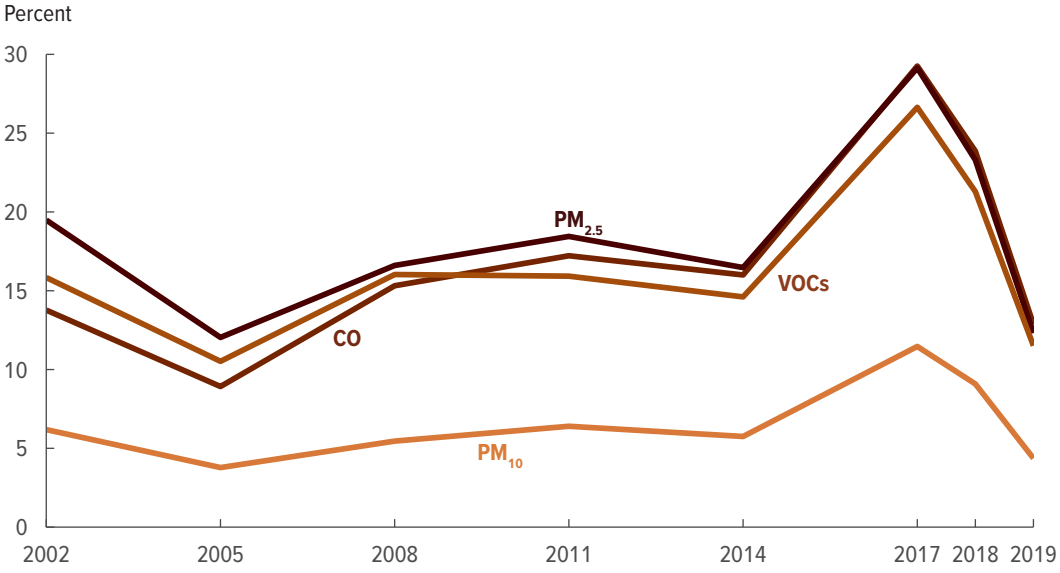
17. Chi Ho Sham and others, *Effects of Wildfire on Drinking Water Utilities and Best Practices for Wildfire Risk Reduction and Mitigation*, Water Research Foundation and Environmental Protection Agency, Web Report No. 4482 (2013), https://tinyurl.com/3rsc8fpa.

18. Jonathan D. Coop and others, "Wildfire-Driven Forest Conversion in Western North American Landscapes," *BioScience*, vol. 70 no. 8 (August 2020), pp. 659–673, doi.org/10.1093/biosci/biaa061.

19. Matthew D. Hurteau and others, "Vegetation-Fire Feedback Reduces Projected Area Burned Under Climate Change," *Scientific Reports*, vol. 9, article 2838 (February 2019), doi.org/10.1038/s41598-019-39284-1.

Figure 7.

Wildfires' Share of National Emissions of Certain Air Pollutants, Selected Years, 2002 to 2019



Smoke from wildfires can reach far beyond the immediate area burned and carry with it air pollutants that have harmful effects on people's health and well-being.

Data source: Environmental Protection Agency, "Air Pollutant Emissions Trends Data, National Tier 1 CAPS Trends," www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data. See www.cbo.gov/publication/57970#data.

CO = carbon monoxide; PM_{10} = particulate matter that is 10 micrometers in diameter or smaller; $PM_{2.5}$ = particulate matter that is 2.5 micrometers in diameter or smaller; VOCs = volatile organic compounds.

wildfires have accounted for a larger share of national emissions over much of that period.[20]

Wildfires also account for an increasing share of net national carbon dioxide emissions. (The carbon stored in trees turns into carbon dioxide when burned.) Over the 2016–2020 period, carbon dioxide emissions from wildfires averaged an estimated 136 million metric tons per year (out of about 5.2 billion metric tons of average annual emissions over that period)—nearly five times the average annual emissions from wildfires estimated for the 1990–1994 period. As a result of that rapid growth, carbon dioxide emissions from wildfires amounted to about 5 percent of gross national carbon dioxide emissions by 2020 (see Figure 8). In areas where fire severity is high, more of the carbon stored in a forest is released during a fire and continues to be released over a longer time as trees killed by the fire decompose in place.[21]

Health-Related Effects

Many of the adverse health-related effects of wildfires occur in and near the areas burned. Firefighters and people in the community suffer fatalities, as well as burns and other injuries, and they face increased risks of mental health problems (like depression and post-traumatic stress disorder) and respiratory problems in the short term. Exposure to wildfire smoke poses heightened risks to individuals whose age or health leaves them vulnerable. Researchers have noted negative impacts in particular for individuals with preexisting respiratory and cardiovascular conditions, older adults, children, pregnant women, and developing fetuses.

Risks are also higher for people with lower income, who may find it difficult to reduce their exposure to wildfire smoke because their work is outdoors or because mitigation options like heating, ventilation, and air conditioning systems with high-efficiency filters are unavailable or unaffordable.[22] In addition, researchers have found links between several diseases and health conditions and exposure to wildfire smoke and the particulate matter it contains:

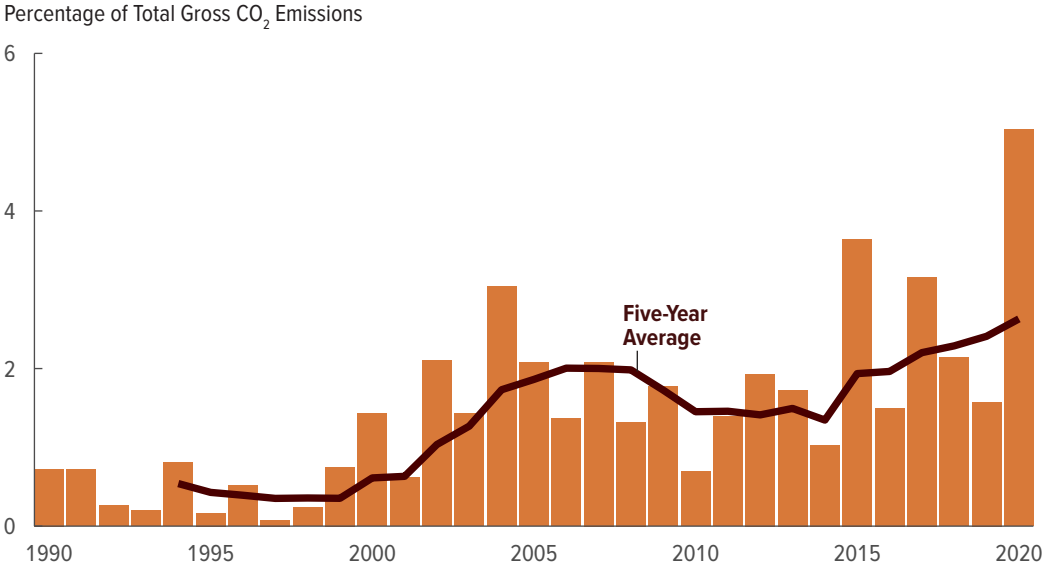
20. Environmental Protection Agency, "Air Pollutants Emissions Trends Data: National Tier 1 CAPS Trends for 1970 to 2020" (updated February 10, 2022), https://go.usa.gov/xuDzn.

21. Garrett W. Meigs and others, "Forest Fire Impacts on Carbon Uptake, Storage, and Emission: The Role of Burn Severity in the Eastern Cascades, Oregon," *Ecosystems*, vol. 12 (October 2009), pp. 1246–1267, doi.org/10.1007/s10021-009-9285-x.

22. Wayne E. Cascio, "Wildland Fire Smoke and Human Health," *Science of the Total Environment*, vol. 624 (May 2018), pp. 586–595, doi.org/10.1016/j.scitotenv.2017.12.086.

Figure 8.

Wildfires' Contribution to National Emissions of Carbon Dioxide



Wildfires account for a growing share of national carbon dioxide emissions because wildfire emissions have increased and emissions from other sources have decreased.

Data source: Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020," Tables ES-2 and 6-11, www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020. See www.cbo.gov/publication/57970#data.

CO_2 = carbon dioxide.

A five-year moving average replaces the value for each year in an annual data series with an average over five consecutive years. (Here the arithmetic mean of each annual value and the preceding four is used.) A moving average is smoother than the underlying data series and is useful for reducing year-to-year changes unrelated to overall trends in the data.

- Influenza rates in the winter influenza season were 16 percent to 22 percent higher when average daily exposure to $PM_{2.5}$ during wildfire season increased by 1 microgram per cubic meter.[23]
- A sustained increase of 10 micrograms per cubic meter in exposure to $PM_{2.5}$ over 28 days was associated with an increase of nearly 12 percent in COVID-19 cases and an increase of about 8 percent in COVID-19 deaths.[24] (COVID-19 is the disease caused by the coronavirus.)
- Each additional day of exposure to wildfire smoke during pregnancy was associated with an increase of nearly 0.5 percent in the risk of preterm birth, and the risk was larger from exposure on days when the smoke was more intense. Wildfire smoke accounted for nearly 7,000 preterm births (about 4 percent of all preterm births) in California from 2007 to 2012.[25]

Exposure to wildfire smoke is not limited to the areas burned by wildfires. Researchers have found that plumes of wildfire smoke extend across the United States, and smoke originating in the western United States accounts for more than half the smoke in the rest of the country.[26] Even though smoke is more concentrated in Western states (where wildfires are more prevalent), one study found that about 75 percent of the 1,300 to 5,900 emergency department visits and 300 to 1,400 hospital admissions each year for asthma attributable to wildfire smoke occurred in non-Western states. Although a larger

23. Erin L. Landguth and others, "The Delayed Effect of Wildfire Season Particulate Matter on Subsequent Influenza Season in a Mountain West Region of the USA," *Environment International*, vol. 139 (June 2020), doi.org/10.1016/j.envint.2020.105668.

24. Xiaodan Zhou and others, "Excess of COVID-19 Cases and Deaths Due to Fine Particulate Matter Exposure During the 2020 Wildfires in the United States," *Science Advances*, vol. 7, no. 33 (August 2021), doi.org/10.1126/sciadv.abi8789.

25. Sam Heft-Neal and others, "Associations Between Wildfire Smoke Exposure During Pregnancy and Risk of Preterm Birth in California," *Environmental Research*, vol. 203 (January 2022), doi.org/10.1016/j.envres.2021.111872.

26. Marshall Burke and others, "The Changing Risk and Burden of Wildfire in the United States," *Proceedings of the National Academy of Sciences*, vol. 118, no. 2 (January 2021), doi.org/10.1073/pnas.2011048118.

share of those asthma-related hospital visits in Western states were connected to wildfire smoke, the higher population in the rest of the country accounts for the larger number of cases there.[27]

Economic Effects

Estimates of the effects of wildfires on the broader economy, both locally and nationally, vary widely. Fires that are larger, are more severe, and last longer are likely to have a bigger economic impact. A wildfire's location is also an important factor in determining its impact. Fires that are closer to the wildland-urban interface—and especially those that are closer to populated areas—are likely to have a larger economic impact than fires that occur in remote areas.

Economic Impact Assessments. Decisions about the costs to include when assessing the economic impact of wildfires, together with the specifics of the fires examined, can lead to a wide range of estimates of their economic costs. One study estimated that the annual economic losses generated by wildfires range from $37 billion to $88 billion (in 2020 dollars) nationally.[28] That range, assembled from estimates produced in related literature over different periods, includes the value of structures damaged or destroyed, the lost value of timber, forgone tax revenues, the impact on housing prices, and the costs to evacuate. Other important costs are not included in that range of estimates, such as business interruptions, damage to infrastructure and public utilities, and disruptions to the supply of goods and services.

Case studies of two different series of wildfires in California included some of those infrastructure and business disruptions in their analyses. One study examined the effects of the more than 8,000 fires in 2018 that burned more than 1.8 million acres across the state.[29] Researchers estimated that the economic impact of those fires was $149 billion—a combination of capital losses of $28 billion, health-related costs of $32 billion (primarily from premature deaths caused by air pollution), and indirect losses of $89 billion.[30] Households sustained 17 percent of the capital losses, with more than 17,000 residences destroyed by wildfires.[31] Almost all the health-related costs arose from the more than 3,600 additional deaths estimated to have been caused by air pollution from the fires, although medical costs accounted for $210 million and lost work time for $130 million. More than half of the indirect losses were felt outside of California because wildfires hurt the output of California's businesses and disrupted the shipping and transportation networks that cross the state.

The second study examined the series of wildfires that began in October 2003 in San Diego County, California, in wildlands dominated by chaparral or evergreen shrubs.[32] Those fires burned more than 375,000 acres, destroyed more than 3,200 homes, and had an estimated economic impact of about $2.5 billion. Nearly half of that impact came from the homes, businesses, and property lost in the fires. Other disruptions to the economy were also costly: Unemployment insurance claims reached an estimated $400 million, and lost economic activity from business closures, travel and transportation disruptions, and lost tourism totaled more than $300 million. Many businesses that stayed open also incurred higher costs to maintain equipment affected by smoke and change air filters more often. Assistance provided by FEMA following the fires cost more than $300 million in total, including support the agency gave to local governments and individuals. Furthermore, the local power utility spent $71 million to replace damaged infrastructure, although more than half of that amount was reimbursed by the state.

Researchers have also studied the economic impact of smaller fires, such as the 2010 Schultz Fire in Arizona, which burned more than 15,000 acres and was soon followed by heavy rains and damaging floods.[33] That

27. Katelyn O'Dell and others, "Estimated Mortality and Morbidity Attributable to Smoke Plumes in the United States: Not Just a Western U.S. Problem," *GeoHealth*, vol. 5, no. 9 (September 2021), doi.org/10.1029/2021GH000457.

28. Douglas S. Thomas and others, *The Costs and Losses of Wildfires: A Literature Review*, National Institute of Standards and Technology Special Publication 1215 (November 2017), doi.org/10.6028/NIST.SP.1215.

29. National Interagency Coordination Center, *Wildland Fire Summary and Statistics Annual Report* (2018), https://go.usa.gov/xuWcS.

30. Daoping Wang and others, "Economic Footprint of California Wildfires in 2018," *Nature Sustainability,* vol. 4 (2021), pp. 252–260, doi.org/10.1038/s41893-020-00646-7.

31. National Interagency Coordination Center, *Wildland Fire Summary and Statistics Annual Report* (2018), https://go.usa.gov/xuWcS.

32. Matt Rahn and others, *Economic Impacts of Wildfires: 2003 San Diego Wildfires in Retrospect,* Wildfire Research Report No. 3 (San Diego State University, Wildfire Research Center, Spring 2014), https://tinyurl.com/mr2pfnty.

33. Melanie Colavito and others, *Full-Cost Accounting Remeasurement of the 2010 Schultz Fire: Understanding the Long-Term Socio-Economic Implications of High-Severity Wildfire and Post-Wildfire Flooding* (Northern Arizona University, Ecological Restoration Institute, August 2021), https://tinyurl.com/yckmfhtt.

fire cost about $100 million over 10 years, according to researchers' calculations: $11 million was spent, mostly by the Forest Service, to contain and suppress the fire; $61 million was spent by federal, state, and local government agencies and local utilities to respond to the subsequent flooding and implement floodwater mitigation projects in later years; and households incurred about $18 million in costs. That household estimate includes both monetary costs (including higher insurance premiums) and the value of the time that individuals spent repairing damaged structures, evacuating people, and implementing preventive measures to protect against future losses, as well as the value of damaged possessions.

In recent years, following destructive wildfires in California that were found to have been caused by problems with electric utility equipment, the state developed requirements for electric utilities to implement public safety power-shutoff programs in which utilities cut power to electrical lines in certain weather conditions. In 2021, electric utilities in California proactively shut off power during 17 weather events (for some combination of low humidity levels, high winds, dry vegetation, and warnings from the National Weather Service), affecting 288,000 customers. At those times, power was cut to more than 500 circuits for an average period of 32 hours, although shutoff durations ranged from 3 hours to more than 1 week.[34] Power shutoffs impose costs on affected residents, businesses, and infrastructure services (such as water utilities). A 2020 study estimated that the costs of those power shutoffs generally exceed their benefits, which are calculated as the expected reduction in costs avoided by lessening the likelihood of damage from wildfires.[35]

Effects on Municipalities, Housing, and Insurance. Following a wildfire, local governments typically increase spending on public safety, particularly emphasizing fire and disaster preparedness as well as community development and transportation. Areas that have had a wildfire remain at risk, and such spending can help mitigate the impact of future fires.

In terms of revenues, researchers found that sales tax collections increased in the four years following a wildfire, as few residents left the area and insurance settlements allowed property owners to rebuild. In California, revenues from property taxes also increased following a fire because more property sales occurred and tax assessments were updated as part of the sale. That increase in assessed value would be less likely to occur in states that reassess property values at regular intervals. (California assesses values only when properties are sold.) Overall, wildfires increase the risk of budget deficits for municipalities, and the potential negative impact is greater from more severe wildfires.[36]

Two studies suggest that home prices decrease after nearby wildfires. In a Colorado study, home prices in an unburned community declined by 15 percent following a wildfire that occurred two miles away.[37] A study of home prices in southern California communities that experienced multiple fires showed similar effects; prices fell by about 10 percent after one fire and by about 23 percent after a second fire.[38] In some instances, housing rental prices moved in the opposite direction: Rents increased rapidly in the short term in areas where many homes were damaged or destroyed.[39]

Wildfires also affect homeowners' insurance policies, which usually include coverage for damage from fires (including wildfires). In 2017 and 2018 combined, home insurers' underwriting losses in California reached an estimated $20 billion, more than double their profits from that line of business since the late 1990s.[40] In response to that high number of claims, insurers have raised rates and opted not to issue new policies or renew existing policies in certain areas. Homeowners' insurance is regulated at the state level, and California has at times temporarily prohibited insurance companies from not renewing policies in wildfire-affected areas. The state also

34. California Public Utilities Commission, "CPUC PSPS Event Rollup October 2013 Through December 2021," accessed March 21, 2022, https://tinyurl.com/2p98vdj7.

35. Jonathan A. Lesser and Charles D. Feinstein, *Playing With Fire: California's Approach to Managing Wildfire Risk* (Manhattan Institute, April 2020), https://tinyurl.com/yck6ms8t.

36. Yanjun (Penny) Liao and Carolyn Kousky, "The Fiscal Impacts of Wildfires on California Municipalities," *Journal of the Association of Environmental and Resource Economists*, vol. 9, no. 3 (May 2022), doi.org/10.1086/717492.

37. John Loomis, "Do Nearby Forest Fires Cause a Reduction in Residential Property Values?" *Journal of Forest Economics*, vol. 10, no. 5 (November 2004), doi.org/10.1016/j.jfe.2004.08.001.

38. Julie M. Mueller, John D. Loomis, and Armando González-Cabán, "Do Repeated Wildfires Change Homebuyers' Demand for Homes in High-Risk Areas?" in *Proceedings of the Third International Symposium on Fire Economics, Planning, and Policy: Common Problems and Approaches*, General Technical Report PSW-GTR-227 (Department of Agriculture, U.S. Forest Service, Pacific Southwest Research Station, November 2009) pp. 70–81, doi.org/10.2737/PSW-GTR-227.

39. Selma Hepp, *The Impact of Wildfires on Rent and Home Prices* (CoreLogic, September 2021), https://tinyurl.com/2cdkmuut.

40. Eric J. Xu and others, *Trial by Wildfire: Will Efforts to Fix Home Insurance in California Stand the Test of Time?* (Milliman, September 2020), https://tinyurl.com/2yedmh2r.

offers a "last resort" insurance plan to people who cannot get coverage through traditional insurance, though that coverage may be limited.

Wildfire risks are not limited to California. Analysts calculated that in the 15 states with the largest average annual acreage burned by wildfires from 2002 to 2019, the cost to rebuild the roughly 2 million homes that are in areas at elevated risk of wildfires would be an estimated $644 billion.[41] Across the country, an estimated 49 million homes are located in the wildland-urban interface, which is about one-third of the total number of housing units (140 million) in 2020, according to the Census Bureau.[42] One study estimated that the total cost to cover the wildfire peril to single-family homes nationwide would amount to $3.5 billion, or $53 per household per year.[43]

Forest-Management Practices and Wildfire Risk

Various forest-management practices can reduce the density of vegetation and fuels in forests that have adapted over time to frequent fires. Among those tactics are mechanically thinning the forest to better adapt to climate change and wildfires; conducting controlled, prescribed fires in forests; and allowing some wildfires to burn to consume fuels and improve forest resilience. Those practices can be implemented singly or in combination.

By leaving less fuel available to burn, forest-management practices may make it more difficult for wildfires to spread or to cause severe damage. Those reductions in risk may translate into lower fire suppression costs, fewer negative health-related and environmental effects, and economic benefits. Federal land management agencies have identified untreated areas at high risk of wildfires. In addition to the cost of treatments, though, several obstacles may hamper federal and other efforts to expand the forest area on which fuel treatments are implemented.

Effects of Forest-Management Practices

The aim of forest-management practices is to improve forests' resistance to fire. By reducing the density of vegetation and different types of fuel in a forest, those practices ensure that any fires that do arrive in the treated area are easier to control (or are allowed to burn to meet ecological objectives) and have fewer severe impacts. If any fires do arrive, their flames are less likely to reach the tree canopy (where they can spread from tree to tree and become more difficult to contain) because of reduced density.

Researchers have found that forest-management strategies that consider the landscape, vegetation, and treatment types in a particular area can reduce a fire's spread and severity—even in wind-driven fires.[44] The appropriate strategies to use are likely to differ across vegetation types. Certain types of vegetation, such as the evergreen shrubs in chaparral ecosystems in southern California and other areas of the Southwest, cannot be thinned with the mechanical treatments that might be used in other areas, for instance.

In the northern Sierra Nevada mountains of California, researchers established an experiment to compare the effects of four possible treatment options: no active management, prescribed fire, mechanical thinning, and mechanical thinning followed by prescribed fire.[45] All of the treatments reduced fire hazards relative to the option that provided no active management. The time paths of the reductions in wildfire risks differed, though, and the treatments needed to be repeated to maintain their effectiveness over the 20-year period of the study.

The duration of treatments' effects is likely to vary by forest type. In a simulation of various mechanical thinning treatments across 12 million acres of western dry mixed-conifer forest, researchers estimated that the effectiveness of treatments rarely exceeded 20 years and that follow-up treatments would be necessary to maintain fire resistance beyond the initial treatment.[46] In southeastern pine flatwood forests (where regrowth is rapid), prescribed

41. Those states are Alaska, Arizona, California, Colorado, Florida, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington, and Wyoming. See Thomas Jeffery and others, *Wildfire Report* (CoreLogic, September 2020), https://tinyurl.com/4x2rxsvj.

42. Census Bureau, "2020 Population and Housing State Data" (visualization, August 2021), https://go.usa.gov/xuZRQ.

43. Dave Evans and Nancy Watkins, *Catastrophic Risk Premium Subsidization Analysis for National Association of Realtors* (Milliman, November 2020), https://tinyurl.com/2ztnwpps.

44. Susan J. Prichard and others, "Fuel Treatment Effectiveness in the Context of Landform, Vegetation, and Large, Wind-Driven Wildfires," *Ecological Applications*, vol. 30, no. 5 (July 2020), doi.org/10.1002/eap.2104.

45. Scott Stephens, *Sierra Nevada Forest Restoration Works: A Summary of the Fire and Fire Surrogate Study*, (Berkeley Forests, University of California at Berkeley, undated), https://tinyurl.com/2auz8myd.

46. Theresa B. Jain, Jeremy S. Fried, and Sara M. Loreno, "Simulating the Effectiveness of Improvement Cuts and Commercial Thinning to Enhance Fire Resistance in West Coast Dry Mixed Conifer Forests," *Forest Science,* vol. 66, no. 2 (April 2020), pp. 157–177, doi.org/10.1093/forsci/fxz071.

fire treatments would need to be repeated every 3 years to 5 years to maintain their fuel reduction effects.[47]

Other researchers have found that investing in forest management can be cost-effective. In a simulation study, researchers showed that enacting the optimal treatment plan over a 50-year period would cost an average of $65 million for prevention across 500 simulated scenarios and require an average of $42 million in fire suppression spending. Untreated, that same forest would require average fire suppression spending of $236 million.[48] In a different study, researchers compared the costs of forest management in a region of the western Sierra Nevada mountains with the cost of homeowners' insurance in the area. They found that spending $194 million to reduce fuels over 10 years to 15 years would decrease wildfire risks to such an extent that homeowners' insurance premiums could be reduced by $315 million over 15 years. In addition, expected losses from damage to the $23 million in structures at risk that are owned by the local water authority would decrease by 44 percent.[49]

Besides their economic benefits, forest-management practices can lessen some of the adverse health-related and environmental effects of wildfires. Compared with the smoke from wildfires, for example, that generated by prescribed fires is probably less harmful. Prescribed fires typically burn at lower intensity and for a shorter duration—thus reducing the number of people exposed to smoke and the intensity of their exposure.[50] Similarly, mechanical thinning and prescribed fire treatments reduce the carbon stored in a forest in the short term by removing trees and other vegetation. Over time, because those treatments reduce the risk of wildfires, they are expected to decrease carbon dioxide emissions as well.[51] Furthermore, using the wood collected from thinning operations for certain purposes can generate carbon benefits by creating durable products that continue to store the carbon in the thinned materials or by substituting for other sources of energy with higher carbon dioxide emissions.[52] Also, efforts to manage fuels showed a positive return on investment in a watershed by reducing the costs of dredging sediment from the watershed after a severe fire.[53]

Use of Forest-Management Practices

In 2021, the Forest Service used fuel treatments on 3.7 million acres of federal lands, and DOI agencies treated an additional 1.9 million acres. About half of the Forest Service lands were treated with prescribed fire.[54] Those amounts are higher than the 1 million to 2 million acres of federal lands subject to prescribed fires each year for much of the past 20 years.[55] Overall use of prescribed fires has increased in recent years. State forestry agencies report that prescribed fires were used on more than 10 million acres in 2019 by all landowners, both public and private.

Prescribed fires have been used most extensively in the southeastern United States. Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia accounted for 59 percent of all acres subject to prescribed fire in 2019. Use of prescribed fire has expanded most rapidly in the western United States,

47. Patrick Brose and Dale Wade, "Potential Fire Behavior in Pine Flatwood Forests Following Three Different Fuel Reduction Techniques," *Forest Ecology and Management,* vol. 163, nos. 1–3 (June 2002), pp. 71–84, doi.org/10.1016/S0378-1127(01)00528-X.

48. Betsy Heines, Suzanne Lenhart, and Charles Sims, "Assessing the Economic Trade-Offs Between Prevention and Suppression of Forest Fires," *Natural Resource Modeling*, vol. 31 (2018), doi.org/10.1111/nrm.12159.

49. Willis Towers Watson and the Nature Conservancy, *Wildfire Resilience Insurance: Quantifying the Risk Reduction of Ecological Forestry With Insurance* (July 2021), https://tinyurl.com/4beu4ahy.

50. Don Schweizer, Haiganoush K. Preisler, and Ricardo Cisneros, "Assessing Relative Differences in Smoke Exposure From Prescribed, Managed, and Full Suppression Wildland Fire," *Air Quality, Atmosphere, and Health*, vol. 12 (2019), pp. 87–95, https://tinyurl.com/2p9ykpue.

51. Daniel Foster and others, "Potential Wildfire and Carbon Stability in Frequent-Fire Forests in the Sierra Nevada: Trade-Offs From a Long-Term Study," *Ecosphere*, vol. 11, no. 8 (August 2020), doi.org/10.1002/ecs2.3198.

52. Bodie Cabiyo and others, "Innovative Wood Use Can Enable Carbon-Beneficial Forest Management in California," *Proceedings of the National Academy of Sciences*, vol. 118, no. 49 (November 2021), doi.org/10.1073/pnas.2019073118.

53. Kelly W. Jones and others, "Return on Investment From Fuel Treatments to Reduce Severe Wildfire and Erosion in a Watershed Investment Program in Colorado," *Journal of Environmental Management*, vol. 198, part 2 (August 2017), doi.org/10.1016/j.jenvman.2017.05.023.

54. U.S. Forest Service, *Fiscal Year 2023 Budget Justification* (March 2022), www.fs.usda.gov/about-agency/budget-performance, p. 129; and Department of the Interior, Office of Wildland Fire, "Fuels Management," www.doi.gov/wildlandfire/fuels (accessed May 10, 2022).

55. National Interagency Coordination Center, *Wildland Fire Summary and Statistics Annual Report* (2002, 2009, 2018), https://go.usa.gov/xuWcS.

but those increases have still left large swaths of forest untreated.[56] The number of acres subject to prescribed fires more than tripled from 2011 to 2019 in Alaska, Arizona, California, Colorado, Hawaii, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.[57] Researchers identified challenges to accurately tracking the use of prescribed fire and other fuel treatments across jurisdictions and over time, making it more difficult to identify and implement needed treatments.[58]

Between 2009 and 2018, fuel treatments by DOI agencies reached an average of 1.1 million acres per year; an average of 1.4 million acres were treated by the Forest Service in each of those years. Other data suggest that since 2003, 58 percent of federal fuel reduction treatments were used on land in the wildland-urban interface, and 47 percent of acres were treated with prescribed fire.[59] The areas treated each year account for a small share of the land that the agencies reported as being at very high risk of wildfires, though: 54 million acres for the DOI agencies in 2019 and 63 million acres for the Forest Service in 2018.[60]

That treatment deficit has been confirmed by researchers. According to one study, 26 percent of Forest Service lands that historically would have burned each year between 2008 and 2012 were subject to fuel treatment, and 19 percent of those lands experienced wildfires that were about as severe as those they would have experienced historically. At that pace of treatment and wildfire activity, addressing the backlog of treatment that has accrued would be difficult, those researchers suggest. Furthermore, lands at greatest risk of wildfires were treated at an even lower rate—perhaps because high-hazard areas are typically more difficult and costly to treat.[61] (Low-hazard areas received relatively more treatment.)

Another report confirms that the selection of areas to treat is not always based on risk.[62] Funding for fuel treatments is usually allocated to regional agency offices on the basis of the amount they received in previous years, and acreage-treatment targets may be more easily met by treating areas that can be reached at low cost.

Treatment costs depend on many factors, including the terrain of the area to be treated, its elevation and road access, the type of vegetation in the area, the type of treatment, proximity to populated areas, markets for wood products, season of the year, size of the treated area, and time elapsed since the land was last treated. Between 2009 and 2018, average annual appropriations for fuel reduction by the Forest Service and DOI agencies totaled $516 million, or $206 per acre of federal lands treated by those agencies.[63]

Another study reviewed data on fuel treatments used at several sites in western states in 2004 and 2005. Prescribed fires cost from $125 to $489 per acre, whereas mechanical treatments cost from $700 to more than $2,000 per acre. The net cost of mechanical treatments could be smaller than the cost of prescribed fires (or even negative) in some instances, though, depending on the value of the wood harvested in the treatment. Factors

56. See, for example, California Wildfire & Forest Resilience Task Force, *California's Strategic Plan for Expanding the Use of Beneficial Fire* (March 2022), https://tinyurl.com/5yr82ww6.

57. Data on the use of prescribed fires in various regions of the United States come from Coalition of Prescribed Fire Councils and National Association of State Foresters, *2012 National Prescribed Fire Use Survey Report* (https://go.usa.gov/xuBRm), *2015 National Prescribed Fire Use Survey Report* (https://tinyurl.com/2p8rt7bh), *2018 National Prescribed Fire Use Survey Report* (https://tinyurl.com/bdfu5m3m), and *2020 National Prescribed Fire Use Report* (https://tinyurl.com/ym66ztp7).

58. Clarke A. Knight and others, "Accurate Tracking of Forest Activity Key to Multi-Jurisdictional Management Goals: A Case Study in California," *Journal of Environmental Management*, vol. 302, part B (January 2022), doi.org/10.1016/j.jenvman.2021.114083.

59. Forests and Rangelands, "Hazardous Fuels Reduction and Landscape Restoration Accomplishments, Fiscal Years (FY) 2003–2021" (accessed June 1, 2022), https://tinyurl.com/57b2f93v. Forests and Rangelands is a cooperative effort of the U.S. Forest Service, the Department of the Interior, and several other agencies.

60. Government Accountability Office, *Wildland Fire: Federal Agencies' Efforts to Reduce Wildland Fuels and Lower Risk to Communities and Ecosystems*, GAO-20-52 (December 2019), www.gao.gov/products/gao-20-52.

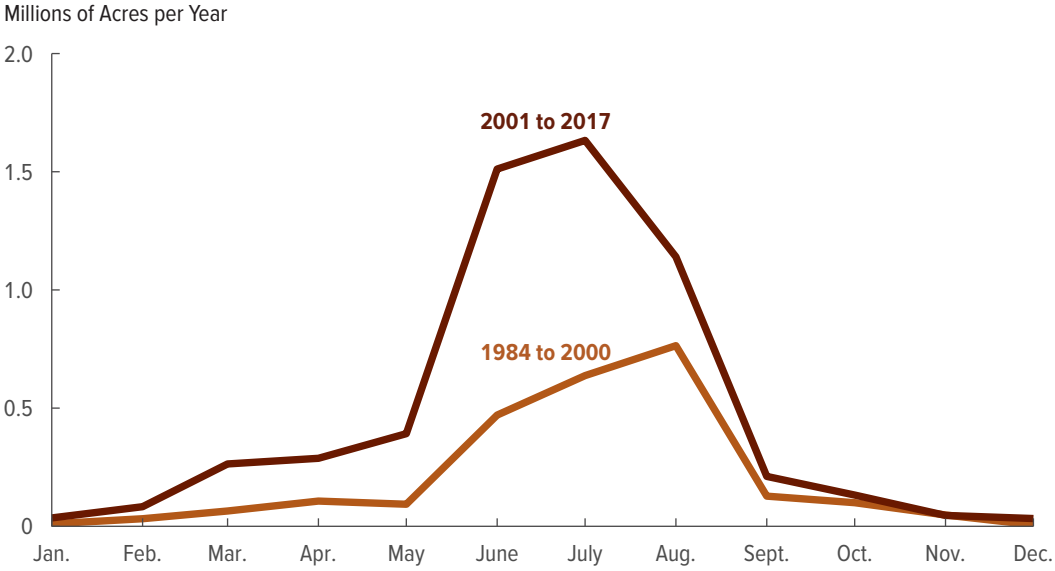
61. Nicole M. Vaillant and Elizabeth D. Reinhardt, "An Evaluation of the Forest Service Hazardous Fuels Treatment Program—Are We Treating Enough to Promote Resiliency or Reduce Hazard?" *Journal of Forestry*, vol. 115, no. 4 (July 2017), pp. 300–308, doi.org/10.5849/jof.16-067.

62. Government Accountability Office, *Wildland Fire: Federal Agencies' Efforts to Reduce Wildland Fuels and Lower Risk to Communities and Ecosystems*, GAO-20-52 (December 2019), www.gao.gov/products/gao-20-52.

63. Ibid.

Figure 9.

Acres Burned Each Month as a Result of Wildfires



Wildfires have traditionally peaked in the summer months. Increases in the number of acres burned have not been confined to those summer months, however, but have expanded earlier into the spring.

Data source: Monitoring Trends in Burn Severity, accessed through "Climate Change Indicators: Wildfires," Figure 6, www.epa.gov/climate-indicators/climate-change-indicators-wildfires. See www.cbo.gov/publication/57970#data.

that affect that value include the type of wood, the size of the trees removed, current prices, and mill capacity.[64]

Over the next decade, the Forest Service plans to treat 20 million acres of its lands and assist in treating an additional 30 million acres of federal, state, tribal, and private lands.[65] Those efforts would be focused on western states, and priority would be given to high-risk areas. Funding would come in part from the Infrastructure Investment and Jobs Act (enacted in November 2021), which authorized $5.5 billion for fire management efforts on federal wildlands over five years.

Obstacles to Use of Fuel Treatments

Efforts to implement fuel treatments for forest management face several obstacles in addition to cost.[66] First, the fire season has expanded in recent years, shrinking the time in which prescribed fires are safe to conduct. More than twice as many acres burned, on average, each month from December through May between 2001 and 2017 as between 1984 and 2000 (see Figure 9). The longer fire season keeps year-round firefighters engaged in suppression activities for more of the year, limiting their availability to manage prescribed fire operations. In addition, seasonal fire crews are not usually employed through the winter and spring months, when weather conditions are more likely to permit prescribed fires. Furthermore, if conditions are favorable for wildfires to burn, there may be greater potential for a prescribed fire to escape and become an uncontrolled wildfire. Those conditions may also make mechanical thinning treatments unsafe because operating the necessary equipment creates a risk of igniting a fire.

Second, air quality concerns pose an obstacle to greater implementation of prescribed fires. Like wildfires, prescribed fires release smoke that contains air pollutants. Wildfire smoke is exempt from Clean Air Act requirements as an "exceptional event," but smoke from prescribed fires is not.[67] Because the pollutants released

64. Bruce R. Hartsough and others, "The Economics of Alternative Fuel Reduction Treatments in Western United States Dry Forests: Financial and Policy Implications From the National Fire and Fire Surrogate Study," *Forest Policy and Economics*, vol. 10, no. 6 (August 2008), pp. 344–354, doi.org/10.1016/j.forpol.2008.02.001.

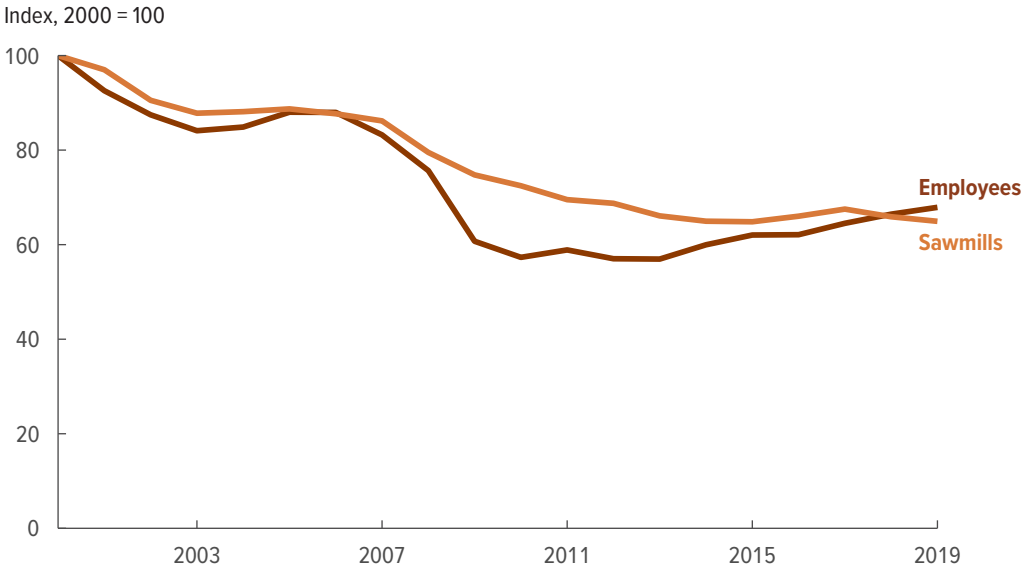
65. Department of Agriculture, U.S. Forest Service, *Confronting the Wildfire Crisis* (January 2022), https://tinyurl.com/bdcvuwje.

66. For a discussion focused on prescribed fire treatments and policy actions specific to California, see Rebecca K. Miller, Christopher B. Field, and Katharine J. Mach, "Barriers and Enablers for Prescribed Burns for Wildfire Management in California," *Nature Sustainability*, vol. 3, no. 2 (January 2020), doi.org/10.1038/s41893-019-0451-7.

67. Kirsten H. Engle, "Perverse Incentives: The Case of Wildfire Smoke Regulation," *Ecology Law Quarterly*, vol. 40, no. 3 (2013), dx.doi.org/10.15779/Z38PG4W.

Figure 10.

Changes in the Number of Sawmills and Employees Since 2000



With fewer sawmills available to process the vegetation removed from mechanical thinning operations or recovered from areas burned in wildfires, it is more difficult to capture the value of those materials in ways that might offset fuel treatment costs.

Data source: Census Bureau, "Statistics of U.S. Businesses, Annual Data Tables by Establishment Industry," all years from 2000 to 2019, www.census.gov/programs-surveys/susb/data/tables.html. See www.cbo.gov/publication/57970#data.

in the smoke from a prescribed fire would factor into whether an area met air quality standards, states typically regulate prescribed fires, requiring them to be preapproved by air quality regulators. (States adopt smoke management programs in compliance with Clean Air Act requirements.) Prescribed fires may also require a study of their environmental impact under the National Environmental Policy Act.

Third, liability concerns may limit the expansion of fuel treatment efforts. State laws govern liability rules for prescribed fires, and states may set different standards of negligence in case of damage from escaped fires. Some states provide an insurance pool to cover costs from fires that are planned and executed properly but still cause damage. For prescribed fires carried out by federal employees on federal lands, any that escape and cause damage could lead to claims against the federal government under the Federal Tort Claims Act.

Fourth, a decline in the number of sawmills since 2000 may make it more difficult to capture the value of harvested wood and use sales of those materials to offset some of the cost of expanded treatments (see Figure 10). The number of sawmills in the United States fell by one-third between 2000 and 2019, leaving 1,500 fewer sawmills in operation, and the number of employees decreased at a similar rate. Those closures make it more difficult for materials harvested from mechanical treatments and recovered from areas burned in wildfires to be processed because they compete with the timber industry for mill capacity.

Furthermore, federal agencies that conduct mechanical thinning operations for forest management may face further challenges in processing harvested materials. In the western United States, many recent wildfires have burned on private timberlands. When the owners of those lands also own local processing facilities, they prioritize salvage logging from their own lands to capture the remaining commercial value over processing other materials. In addition, materials harvested from federal lands may not be processed outside the United States because federal law generally prohibits the export of unprocessed logs harvested from federal lands in the western United States.[68] Backlogs may render harvested materials worthless because the market value of those thinned and recovered materials diminishes over two to four years.[69]

68. Government Accountability Office, *Federal Timber Sales: Forest Service and BLM Should Review Their Regulations and Policies Related to Timber Export and Substitution*, GAO-18-593 (August 2018), www.gao.gov/products/gao-18-593.

69. Scott Stephens, University of California at Berkeley, personal communication (September 10, 2021).

List of Tables and Figures

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About This Document

This report was prepared at the request of the Chairman of the Senate Committee on the Budget. In keeping with the Congressional Budget Office's mandate to provide objective, impartial analysis, the report makes no recommendations.

Sheila Campbell prepared the report with guidance from Joseph Kile. Sebastien Gay, Ben Hopkins, Edward G. Keating, Janani Shankaran, Jon Sperl, Natalie Tawil, and Chapin White offered comments. Pranav Bhandarkar fact-checked the report.

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CBO seeks feedback to make its work as useful as possible. Please send comments to communications@cbo.gov.

Phillip L. Swagel
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