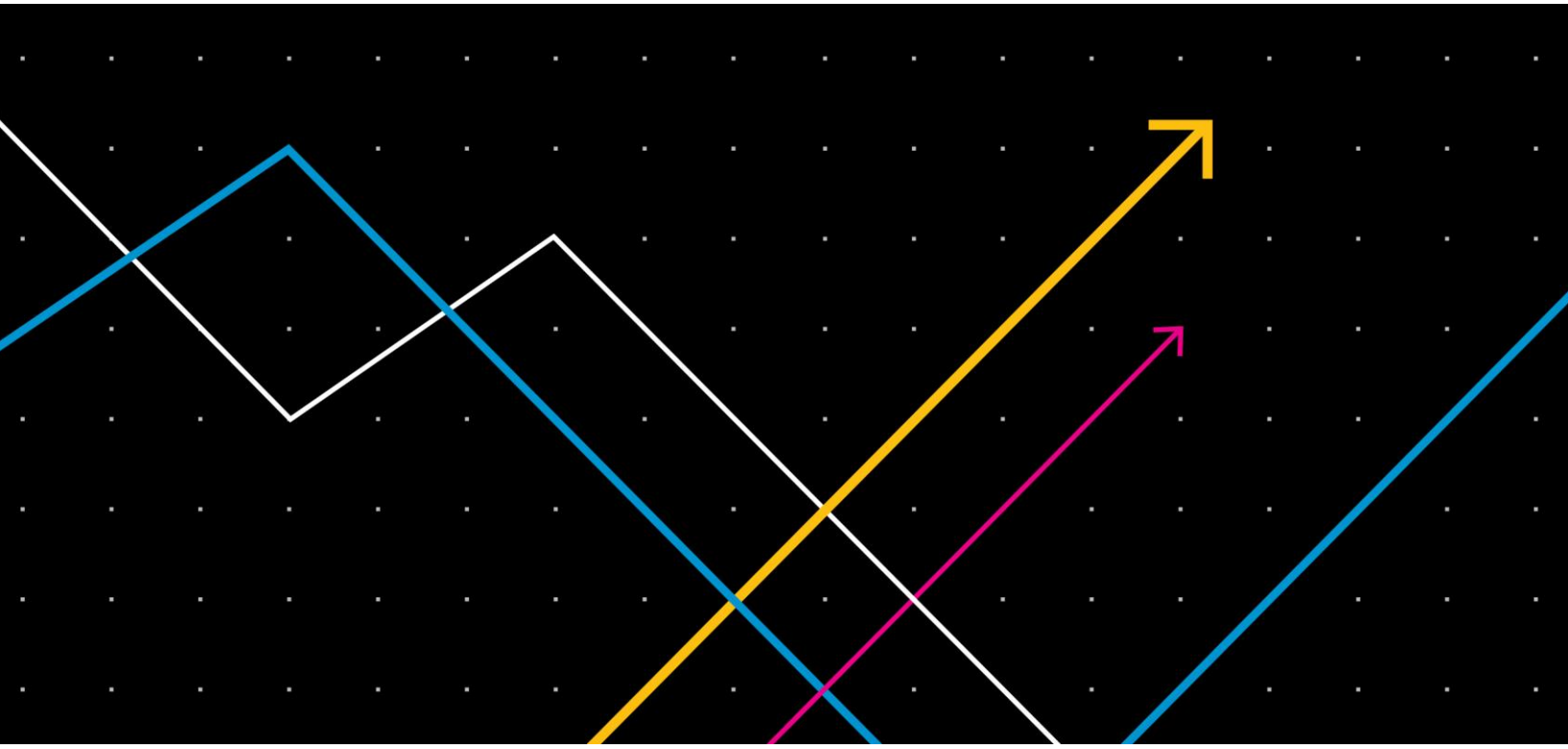

RESEARCH REPORT

Wildfires in the United States

A Primer

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Wildfires in the United States

On August 20, 2015, 93 uncontained large wildfires were burning in the United States including 33 in the Pacific Northwest, 29 in Northern California, and 18 in the northern Rockies, according to a National Interagency Fire Center (NIFC) situation report.[1] A wildfire is defined by the NIFC as the unplanned ignition of a wildland fire (such as fire caused by lightning, volcanoes, unauthorized and accidental human-caused fires) and escaped prescribed fires.[2] As of September 25, 2015, wildfires had burned 9.0 million acres nationwide, far above the annual average of 6.2 million acres. The forecast for the Northwest into the fall is for above-normal temperatures, below-normal precipitation, and continuing drought in many areas. This weather, accompanied by the long-term drought in Southern California and continued periodic acreage growth from established fires in Alaska, is expected to lead to above-normal fire potential throughout the region.

Wildfires have always been an integral and natural part of wildland ecosystems. Two main factors, however, are changing these ecosystems. First, climatic conditions are changing the scale of wildfires and the length of the fire season. Second, human development is intensifying in wildfire-prone areas. As more people build homes in and near wildfire-prone areas, individuals and families are exposed to greater risks from wildfires. As a result, fire suppression and recovery costs increase.

Information on the incidence and frequency of wildfires can help stakeholders assess the risk from wildfires and further a discussion of the mitigation and firewise practices landowners can use. It can also help shape the organization of fire suppression in the federal government as well as state and federal funding for wildland fire management.

Statistics on Wildfires

According to statistics published by the NIFC starting in 1960, more than 60,000 wildfires occur in the United States each year. More than 3.0 million acres have burned every year since 1999, and the acreage burned each year is increasing. Wildland acreage nationwide has been relatively constant since 1910: it decreases whenever population growth expands urban development and increases whenever former farmland reverts to wildland.[3] While the annual number of wildfires has not been increasing in recent years, the acres burned per fire have been trending strongly upward since about 1990.

Annual NIFC data show that the United States experienced 5.6 million wildfires between 1960 and 2013.[4] Over these 54 years, the burned area totaled 235.8 million acres, or 362,849 square miles. The cumulative acreage burned between 1960 and 2013 is 9.6 percent of the total land area of the nation (3.8 million square miles).

Each year fires are deliberately set by the various agencies responsible for forest and wildfire management. Federal and state agencies work together through the National Cohesive Wildland Fire Management Strategy. The main federal agencies are the US Department of Agriculture (USDA), specifically the Forest Service, and the US Department of the Interior (DOI).[5] On nonfederal lands, states also manage forests and fight wildfires together with county and local jurisdictions.[6] While state foresters are responsible for managing wildfires, they pay for only a modest share of firefighting costs.

The primary cause of nonprescribed wildfires is human activity: leaving campfires unattended, burning debris, negligently discarding cigarettes, and setting fires intentionally (also called arson).[7] The primary natural cause of wildfires is lightning: it is responsible for 14 percent of the 823,032 wildfires between 2002 and 2012. Lightning-caused fires, however, are much larger on average; they are responsible for 62 percent of total acres burned during the same 11 years.[8] Prescribed fires (also called controlled burns) that escape their boundaries constitute 18 percent of all US wildfires and 25 percent of US acres burned from 2002 to 2012.[9]

Figure 1 displays data from 1960 to 2013 for three indices: the incidence of wildfires, total acres burned, and the average acreage per fire.[10] Each series shows the ratio of annual data to its respective 1960–2013 average.

Three important trends are evident over these 54 years.

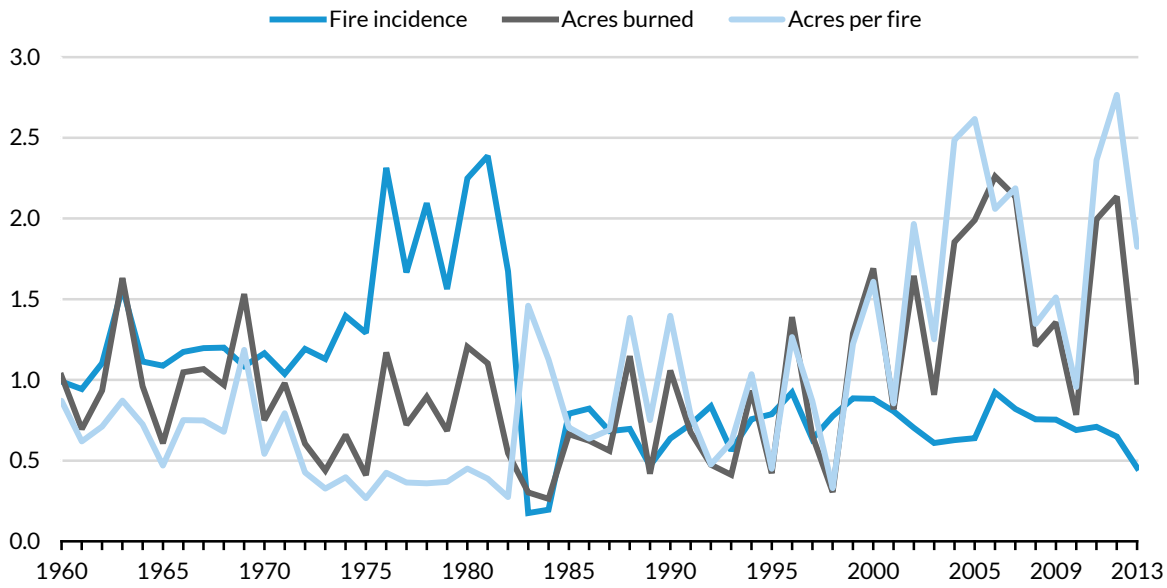
First, the incidence of wildfires has not increased over time. In fact, it is lower from the mid-1980s through 2013 than from the 1960s through the mid-1980s. The index of fire incidence has been below 1.00 since 1983, while all but two pre-1983 indices exceed 1.00. Wildfire occurrences were especially numerous between 1976 and 1982.

Second, both total acres burned and average acres per fire have increased since the early to mid-1990s. Recently the indices for both measures have often exceeded 2.00—that is, twice the 54-year average.

Third, the annual data for all three series vary sharply year to year. The coefficient of variation for each series is approximately 0.50 or larger, indicating a high degree of variability from one year to the next.[11]

FIGURE 1

Indices of Wildfires, 1960–2013



Source: National Interagency Fire Center data.
Note: Each series is indexed at 1.00, its respective 1960–2013 average.

The underlying trends in wildfire occurrences and total acres become more obvious when multiyear averages are calculated.[12] Using a regression analysis with an equation that introduces a linear trend starting in 1990, we find that the pre-1990 average acreage per wildland fire was 32.8 acres. The 1990-trend coefficient for the regression is 3.162—that is, an increase of 3.162 acres per fire a year. Based on this linear trend, the projected acreage per wildfire increased from 32.2 acres in 1989 to 108.1 acres in 2013, or more than three times the 1989 level. This single explanatory variable (the 1990 trend) explains more than half the variation in average acreage per wildfire from 1960 to 2013. The implications for societal costs and other consequences of fires are clear.

Wildfires display an obvious geographic pattern (Table 1). Most occur west of the Mississippi River in states with low annual rainfall. On average, these states are larger than their eastern counterparts, accounting for approximately 75 percent of the nation's land area. From 2002 to 2013, 55 percent of wildfires occurred in western states, but those fires accounted for 93 percent of acres burned.

TABLE 1

Wildfires by Census Bureau Division, 2002–13

Census Bureau division	Land area ('000s of square miles)	Fires ('000s)	Fires per 1,000 square miles	Total acres burned ('000s)	Average acres per fire	Average annual precipitation (inches)
New England	72	36.5	0.512	42	1	43
Mid-Atlantic	109	23.5	0.215	114	5	41
South Atlantic	293	209.3	0.714	4,154	20	49
East South Central	183	84.1	0.459	1,516	18	54
West South Central	444	130.0	0.293	9,740	75	35
East North Central	301	38.0	0.126	228	6	35
West North Central	520	67.4	0.129	3,173	47	27
Mountain	864	133.3	0.154	30,781	231	14
Pacific	1,009	143.0	0.142	34,371	240	26
United States	**3,796**	**865.1**	**0.228**	**84,118**	**97**	**29**

Sources: Land area from the Census Bureau; number of wildfires and acres burned from the NIFC; annual precipitation from the National Oceanic and Atmospheric Administration (NOAA).
Notes: Annual precipitation is from 1951 to 2000. Divisional precipitation averages are based on the statewide average weighted by the land area of the state.

In addition to expected relationships, Table 1 displays some unexpected patterns. For example, the four western Census divisions have the largest land areas: the West South Central, West North Central, Mountain, and Pacific regions each exceed 400,000 square miles. The largest number of wildfires (209,259), however, occurs in the South Atlantic, which has a fire incidence rate of 0.714 per thousand square miles—approximately three times the national average of 0.228 per thousand square miles. Especially high fire incidence rates occurred in four of the five largest states of this division (Florida, Georgia, North Carolina, and South Carolina), all 0.50 per thousand square miles. In contrast, both North Central divisions and the Mountain and Pacific divisions have average occurrence rates between 0.126 and 0.154.

In addition, precipitation among the South Atlantic states averages nearly 50 inches a year, the second highest of the nine Census divisional averages and 70 percent above the national average. This observation raises questions about why an area with so much rainfall has such a high wildfire incidence rate.

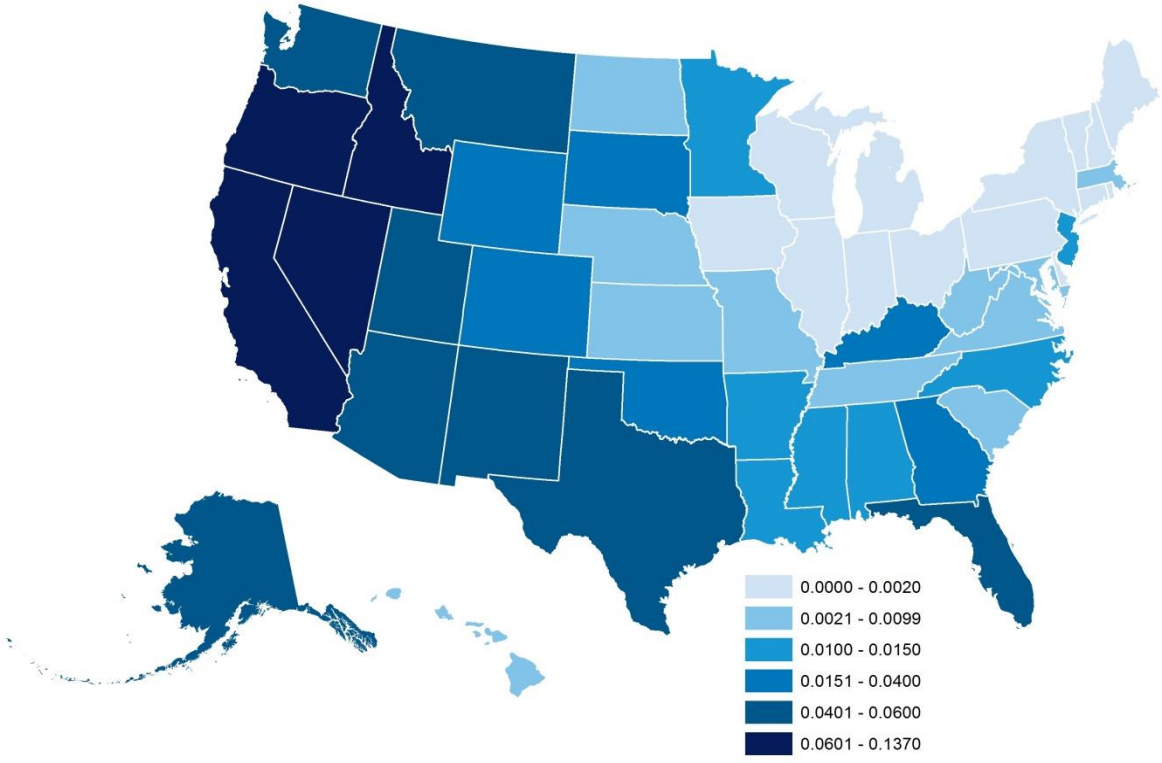
Wildfire severity, as gauged by the average acres burned per fire, shows an expected association with precipitation. Mountain states have the second-highest average acres per fire (231) and the lowest annual rainfall (14 inches, less than half the national average). In contrast, the four divisions where the average annual rainfall is above 40 inches all have average acreage of 20 acres or less per wildfire. In a simple cross-section regression analysis, the association between average acreage burned per fire

(during 2002–13 for the 48 contiguous states) and annual precipitation is negative and statistically significant.[13] At the state level, however, the results are more varied; only about half the interstate variation is associated with differences in annual rainfall.

Figure 2 vividly illustrates the geographic variability of wildfires. Between 2002 and 2013, total acreage burned by wildfires represented 3.5 percent of the total acreage of the 50 states plus the District of Columbia. In 26 states, the acreage burned was less than 1 percent of total acreage; 20 of these 26 states were east of the Mississippi. Acreage burned exceeded 1.5 percent of total acreage in just Kentucky, Georgia, and Florida. In contrast, all four states where burned acreage was above 6.0 percent, and 11 of the 12 where burned acreage was above 4.0 percent, were western states.

FIGURE 2

Share of State Area Burned by Wildfires, 2002–13



Source: NIFC data on acres burned by state, 2002–13 measured as a proportion of total state acreage.

The Direct Costs of Wildfires

The many wildfires and the acreage they burn entail substantial costs. Fire management expenditures include the costs associated with preparedness ahead of the fire season, suppression or firefighting during the fire season, measures to reduce vegetation fuel (either through removal or prescribed burns), and post-fire rehabilitation (Bracmort 2013).

The NIFC has published estimates of annual fire suppression costs incurred by federal agencies since 1985. Federal fire suppression costs averaged $371 million a year during 1985–89 but $1,548 million a year during 2009–13. Of the total federal costs in 2013, the Forest Service was responsible for almost 77 percent; the DOI was responsible for the remaining 23 percent.

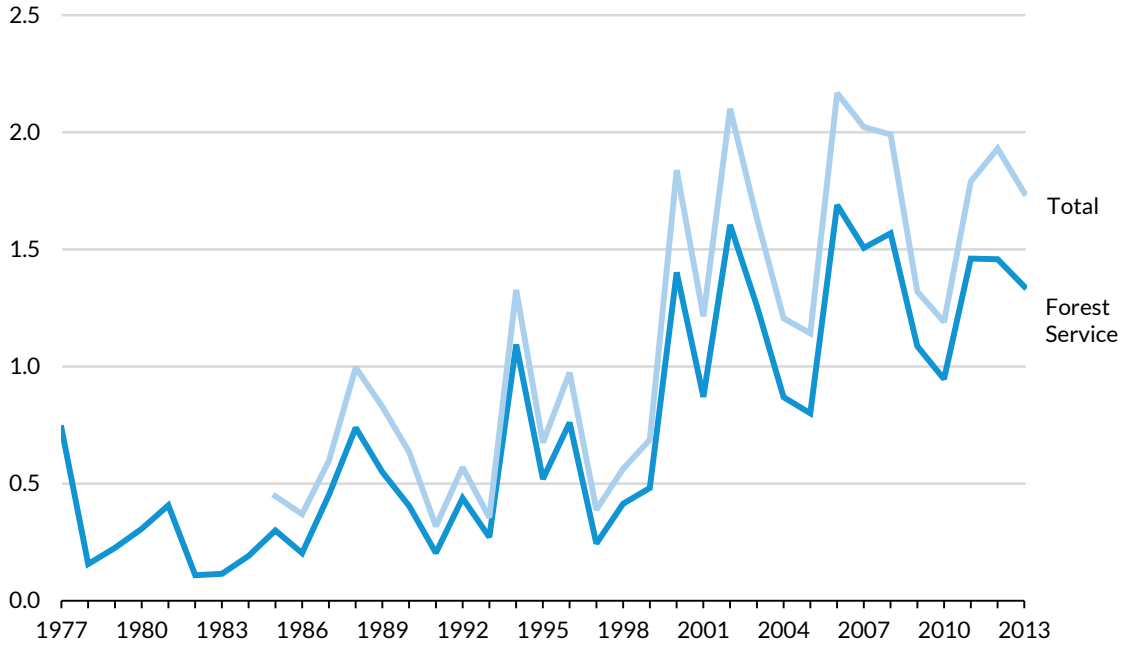
Most of the fourfold cost increase was the result of increased acreage burned and inflation. The real cost per acre in prices of 2009 purchasing power increased 17 percent, from $222 in 1985–89 to $260 in 2009–13. Though federal firefighting costs have increased, the increase in real terms is mainly the result of an increase in acreage burned since the late 1980s.

Figure 3 summarizes the annual costs of fire suppression for the two lead federal agencies in real terms. Fire suppression costs for the Forest Service are displayed from 1977 while the combined costs for DOI and the Forest Service are shown from 1985. Two patterns are obvious: the large increase since 2000 and the wide year-to-year variability. Note also that total federal costs exceeded $1.5 billion in 9 of the 14 years since 2000 but not once in the years before 2000.

FIGURE 3

Federal Fire Suppression Costs, 1977–2013

Billions of 2013 dollars



Sources: NIFC and Bracmort (2013), figure 2.

A second component of total firefighting costs is those incurred by the state agencies. These costs are less easily estimated because of the large number of state and local agencies with wildfire suppression responsibilities. A recent analysis by the Union of Concerned Scientists, however, shows that state spending on fire management nearly matched federal spending on fire suppression in 1998, 2002, 2004, 2006, and 2008 (the five years covered in the analysis).[14] Because assembling state data is a major undertaking, it is not obvious how state spending compares to federal spending over the long run. Also, since the states receive substantial reimbursements from the federal partner for firefighting costs, estimating net state-financed firefighting costs is challenging. The federal share of total fire suppression costs exceeds 50 percent, but it may or may not reach 60 percent.

The Frequency of Large Wildfires

While there is no universal definition of what constitutes a large wildfire, at least three data series could be useful: one from the Federal Emergency Management Agency (FEMA) and two from the NIFC.

FEMA makes fire management assistance declarations after a state submits a request because a single fire (or a group of fires) is large enough to pose a "threat of major disaster." FEMA responds to these requests expeditiously; a decision is often rendered within hours of the appeal. The fire management assistance grant program provides a federal cost-share of 75 percent of the allowable costs of firefighting. Allowable costs include the costs of field camps; equipment use, repair, and replacement; tools, materials, and supplies; and mobilization and demobilization activities.

The FEMA data on fire management assistance declarations commence in 1970. In the 44 years between 1970 and 2013, FEMA made 1,049 fire management declarations. The declarations fall into two broad periods. Between 1970 and 1993, FEMA consistently made fewer than 10 declarations a year. Starting in 1994, the agency averaged 48 declarations a year. These declarations refer to major fire events that involve large costs of suppression and other factors, such as the value of lost timber and crops. FEMA does not however, estimate the total costs of its fire-related declarations.

On occasions a wildfire grows and becomes large enough to be classified by FEMA as a major disaster. Between 1970 and 2013, FEMA declared 35 wildfires major disasters. In addition, FEMA classified 15 wildfires as emergency declarations. Emergency declarations are smaller than major disasters but of sufficient scale that states are reimbursed for certain fire suppression costs. These declarations can be considered large fires. Note that the 1,099 FEMA declarations between 1970 and 2013 represent 0.025 percent of the 4,443,165 wildfires reported by NIFC over the same period.

Two measures of large wildfires are available from NIFC data. Between 1950 and 2013, there were 52 "historically significant wildland fires." Only four of these fires occurred before 1970. Among historically significant fires, 9 were classified as major disasters and 15 were classified as fire management assistance declarations by FEMA. The NIFC also identified 154 wildfires since 1997 that have burned 100,000 or more acres. Of that group, 58 had burned more than 200,000 acres.

The three groupings of large fires show similar patterns in both their timing and their geographic locus (table 2). The table reinforces points made earlier, but now with specific reference to *large* wildfires as recorded by both FEMA and NIFC.

TABLE 2

Geographic Locus of Large Fires by Decade and Geographic Area, 1970–2013

	Fire management assistance and other declarations	Historically significant fires	Wildfires that burned 100,000+ acres (2000–13)
Major fires by decade			
1970–79	41	4	NA
1980–89	38	5	NA
1990–99	231	16	NA
2000–09	571	11	103
2010–13	218	12	40
Major fires by Census Division			
East	115	4	5
West North Central	38	2	1
West South Central	332	2	12
Mountain	310	25	59
Pacific	304	15	66

Sources: Fire management and other declarations data from FEMA; other data from NIFC.
Note: NA = not available.

Two patterns, both discussed earlier, are obvious in Table 2. One, large wildfires became more frequent after 1989. There were from three to six times as many large wildfires during 1990–99 than during 1980–89. In addition, there were more large wildfires from 2010 to 2013 than during the 1970s and 1980s combined. More than likely, drought conditions will only add to the frequency of wildfires and increase the associated costs of fire suppression and recovery.

Two, wildfires are mainly a western phenomenon; the incidence of large fires is higher in both the Mountain and Pacific divisions. This pattern is related to the low precipitation received by sizable areas of the states in these divisions, increasing the risk of large acreage burned per fire.

More people have built or are building homes in and near wildfire-prone areas, exposing them to greater risks from fires and greater recovery costs. In the past 50 years, development near wildland areas has expanded significantly (Radeloff et al. 2005; Theobald and Romme 2007). Population growth, housing preferences, and the increasing number of vacation homes are contributing to these development trends. The intersection of wildlands and urban environments is known as the wildland-urban interface (WUI). In 2008, approximately 40 percent of the 115 million single-family homes in the United States were in the WUI (Botts et al. 2013; Cleetus and Mulik 2014, table 1). Housing development in and near wildfire-prone forested areas raises the exposure to both the risks of wildfires and their costs, and it requires spending more resources on fire suppression.

Nearly 90 percent of the developed areas located in or near forests are privately owned; nearly two-thirds of that private land is at high risk of wildfires (Theobald and Romme 2007). Development in and near the WUI increases the costs for federal agencies that help provide financial and technical assistance to state and local agencies for wildfire protection.

The costs associated with wildfires are substantial. Two main factors affect those costs: the size of a wildfire and how much private property is damaged. Direct fire suppression costs, however, significantly underestimate the total costs of a wildfire. Other costs, such as pre-suppression costs, disaster relief expenditures, timber losses, tourism-related losses, human health effects, and damage to ecosystems can greatly exceed the direct costs of fire suppression. In some cases, these other categories of costs may not be fully evident until years after the suppression of a fire (Butry et al. 2001).

Wildfire protection efforts are weighted toward fire suppression, which takes up a major share of agency budgets. While the protection of natural resources and property is important, the overarching priority in wildfire management is human safety. According to the Office of the Inspector General, an audit of Forest Service expenditures found that the majority of the costs of putting out large fires are "directly linked to protecting private property in the WUI" (2006, ii). Moreover, one response to the worsening wildfire situation has been a shift of financial resources from investment in long-term forest management and forest health that would lower the risk of future wildfires to fire suppression. With the cost of fire suppression often exceeding actual budget allocations in recent severe wildfire seasons, the Forest Service has borrowed from nonsuppression or even non–fire management budget lines (Tidwell 2013). In addition, budget constraints have delayed the acquisition of lands for conservation and reduced the expenditure on other maintenance programs. The reallocation of resources to fire suppression activities from other intended uses is commonly termed "fire borrowing."

Another response to the worsening wildfire situation has been an increased reliance on supplemental emergency appropriations from Congress. In 2012 and 2013, the Obama administration removed more than $1 billion from other program accounts and transferred the funds to fire suppression (Cleetus and Mulik 2014). Recent legislative proposals, as well as the Obama administration's 2014 budget, would change how federal wildfire costs are funded and create a separate emergency fund for fire suppression. Senators Ron Wyden and Mike Crapo proposed legislation in 2013 to increase funding for fire suppression (S. 1875, or the Wildfire Disaster Funding Act of 2013) and Senators John McCain, John Barrasso, and Jeff Flake proposed similar legislation in 2014 (S. 2593, or the FLAME Act Amendments of 2014). In an environment of tight budgets, however, rising wildfire costs will continue to pose a major fiscal challenge.

Wildfire Management in the Federal Budget

Table 3 summarizes federal appropriations for wildfire management spanning fiscal years 2008 to 2013. The table displays activities divided into five subaccounts. The data are derived from a recent report by the Congressional Research Service that separates details for both Forest Service and DOI wildfire activities (Bracmort 2013, table 5).

The subaccounts for Preparedness and Hazardous fuels encompass various activities designed to prevent and limit the scope of wildfires, such as firefighter training, equipment acquisition, reduction of fuel loads in fire-prone areas, and rehabilitation of fire-damaged areas. Their combined appropriations exceeded that for the suppression subaccount ($9.436 billion versus $6.860 billion) over the six years examined. Emergency and other ad hoc budget increments for fire suppression during these years, however, totaled fully half the original amounts budgeted for suppression costs.

TABLE 3

Federal Wildfire Management Appropriations, Fiscal Years 2008–13

	Total appropriations ($billions)	Budget shares
Preparedness	6.394	0.308
Hazardous fuels	3.043	0.147
Suppression	6.860	0.330
Emergency and other suppression costs[a]	3.453	0.166
All other costs	1.009	0.049
Total	**20.759**	**1.000**

Source: Bracmort (2013), table 5.

[a] Emergency appropriations and Federal Land Assistance, Management and Enhancement (FLAME) Wildfire Suppression Reserve Fund appropriations net of recessions and use of prior year funds.

"Fire borrowing" transfers financial resources from the Preparedness and Hazardous fuels sub-accounts for use in fire suppression. This practice effectively reduces activities related to forest management, forest restoration, and land acquisition. The 2013 Wyden-Crapo proposal (S. 1875) and the 2014 McCain-Barrosso-Flake proposal FLAME Act Amendments (S. 2593) would provide explicit and enhanced funds for fire suppression, protect the other subaccounts, and end fire borrowing. Neither bill has been enacted.

Conclusion

Private local development complicates decisions about how to manage our wildland in many ways. Urban development not only eliminates some trees and forests, it also increases population density, human activities, and urban infrastructure. State and local zoning policies continue to allow development in the WUI. The fact that most firefighting costs are borne by the federal government, while local authorities and developers decide where and how much to build in wildfire-prone areas, creates a misalignment of incentives. Indeed, local zoning policies may encourage development in high-risk areas, reduce the incentive for homeowners to fireproof their homes and properties, increase firefighting costs, and exacerbate the physical risk to firefighters. As a result, federal taxpayer funds are not being used to manage wildlands and build resilience to wildfires because they are heavily directed at fire suppression.

Risk is defined as the probability of an adverse event (or hazard) occurring that causes physical harm or monetary losses. In the context of wildfires, risk is increasing in part because of climate change. The risk is compounded by a moral hazard problem: local decisionmakers (governments and homeowners) may make choices that result in a greater exposure to risk because they do not pay the full costs of those choices.

Mitigating the risks from wildfires requires a combination of active measures. A key element in reducing threats to the WUI and restoring fire to its natural role in the environment is community education and involvement. Active measures include actions that reduce the risk itself (such as limiting the chances of wildfire damage through fuels management or fireproofing measures in homes and communities), limit exposure to risk (such as limiting development in wildfire-prone areas or buying insurance protection), or providing financial resources to help people recover from fires (such as disaster assistance or insurance payouts; see Bracmort 2013, table 5).

Homeowners share responsibility for protecting themselves and their property. In many states, however, this responsibility is voluntary and not enforced by statewide law or insurance company practices. California is one of the few states in the nation with strict statewide building regulations and fire codes that apply to communities in wildfire-prone areas.

Why encourage mitigation in building regulations? Adherence to model building codes can mean the difference between life and death or whether homes remain standing or are completely destroyed by fire. The evidence that mitigation can saves lives and reduce costs is more than anecdotal. Model building codes can offer enhanced protection against the threats of natural disasters and terrorism to

make communities more resilient, sustainable, and livable for generations to come (Vaughan and Turner 2013). Such codes lower the price of mitigation for building owners. Other states, particularly western states, should follow California's lead.

Notes

1. "Incident Situation Management Report," National Interagency Fire Center, http://www.nifc.gov/nicc/sitreprt.pdf.
2. A wildland is defined as land that is not cultivated or not suitable for cultivation. Wildlands include forests, shrublands, grasslands, and other types of natural ecosystems. A prescribed fire is a wildland fire originating from a planned ignition to meet the objectives specified in a preapproved, written prescribed fire plan.
3. Forest area has been relatively stable since 1910, although the population has more than tripled since then (Oswalt and Smith 2014).
4. "Total Wildland Fires and Acres" (1960–2014), NIFC, accessed September 18, 2015, http://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html.
5. To be specific, five federal agencies manage and have primary fire program responsibilities: the Bureau of Land Management, the National Park Service, the US Fish and Wildlife Service, and the Bureau of Indian Affairs in the Department of the Interior; and the Forest Service in the Department of Agriculture.
6. The US Fire Administration works with county and local fire departments; the National Association of State Foresters represents the states. The state, county, and local jurisdictions provide primary fire protection on nonfederal public and private lands across all 50 states.
7. See Theobald and Romme (2007).
8. The NIFC recently changed its nomenclature. What was previously termed *human-caused fires* is now *nonlightning fires*.
9. Statistical information from the NIFC on prescribed fires in the United States has only been published since 2002.
10. The National Interagency Coordination Center at NIFC compiles annual wildland fire statistics for federal and state agencies. As the statistics before 1983 were not derived from the current reporting process, information before 1983 should not be compared to subsequent data.
11. The coefficient of variation is the ratio of the standard deviation to the mean.
12. For example, acres per wildland fire averaged 39.8 during 1980–89 but 96.6 during 2002–13.
13. Alaska, the District of Columbia, and Hawaii are not included in the analysis because of the lack of long-term average precipitation data.
14. Expressed in 2013 dollars, state spending totaled $7.7 billion, while federal spending totaled $8.0 billion. See Cleetus and Mulik (2014), figure 7.

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