Chapter 12

The Rising Costs of Wildfire Suppression and the Case for Ecological Fire Use

Timothy Ingalsbee[1] **and Urooj Raja**[2]
[1]Firefighters United for Safety, Ethics, and Ecology, Eugene, OR, USA, [2]Department of Sociology, University of Colorado, Boulder, CO, USA

12.1 BURNED AND BUSTED: THE RISING COST OF FIGHTING FIRES

In 1908, just 3 years after the creation of the US Forest Service (USFS), a US Congressional legislative rider established the Forest Fires Emergency Act that gave the fledging federal agency the authority to engage in deficit spending for wildfire suppression operations (Pyne, 1997). This extraordinary power freed up the agency's suppression program from the normal budgetary constraints that affect every other federal agency or program. It was first used during the infamous "Big Blowup" of the 1910 fires when the USFS spent over $1 million that year. A century later, a million dollars is the average daily cost of suppressing large wildfires, and the average annual expenditures exceed one billion tax dollars (Headwaters Economics, 2009). The agency repeatedly overspends its annual appropriated suppression budget, receiving supplemental appropriations from Congress with little oversight of or accountability for how the money is spent (Dombeck et al., 2004). But as suppression expenditures continue to rise, so have the number of hectares burned, the average size of wildfires, and the numbers of homes destroyed and firefighter lives lost. Equally important, accumulating evidence of the adverse ecological impacts of fighting fires raises serious questions about the effects as well as the effectiveness of wildfire suppression. What are the American people getting in return for their annual expenditures of "blood and treasure" in the seemingly endless "war" against wildfire?

Show Me the Money: Poor Data on Suppression Costs

Rising suppression expenditures have been the subject of dozens of peer-reviewed research articles, internal government reports, inspector general

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audits, blue-ribbon commission analyses, and pundit opinion essays, each of them focusing on various "cost drivers." By the mid 1990s these reports had cumulatively offered hundreds of recommendations for changes in policies or practices to contain costs or improve fiscal accountability. Analysis of the economic efficiency of wildfire suppression depends on accurate data, but many reports complained that data were inaccessible, lost, or never recorded; were poorly aggregated; and were inconsistently coded or miscoded, and these defects in the data made accurate economic assessments of individual wildfire events or whole wildfire seasons highly problematic (Schuster et al., 1997; Gebert et al., 2008). Also, cost data from state and local agencies are often not obtainable—a growing problem for economic analysts given the increasing number of large-scale, multijurisdictional wildfires (Taylor et al., 2013). Finally, the USFS and Department of Interior land management agencies use different accounting systems that are highly vulnerable to errors in coding various cost items, especially some high-cost items provided by private contractors (Gebert et al., 2008). Efforts to analyze suppression expenditures, gain more fiscal accountability, and attain more economic efficiency in wildfire operations are undermined by a lack of reliable data.

In the context of current fiscal austerity politics where government spending is closely scrutinized and most agency budgets are getting slashed, the fact that so much taxpayer money is being spent on suppression with such little transparency or accountability raises serious questions about how and why this program persists in its current form. Working with the most recent and reliable cost data available, summaries of some our findings on costs are provided (see Tables 12.1–12.4; see the methodological endnote on our data set). The data focus on the 11 western states in the United States because they generate the bulk of wildfire hectares and firefighting expenditures and illustrate the magnitude of the problem. Analysis focuses on the USFS because it is responsible for over 70% of all federal suppression expenditures. What follows are analyses drawn from the peer-reviewed literature discussing various factors that are driving the rising cost of wildfire suppression for the USFS, with extra emphasis on the "human dimensions" of fire management. These human dimensions not only are a major source of the problem but could also offer potential solutions with the most immediate prospects for containing suppression costs.

Size Matters: Larger Fires Mean Larger Costs

Despite the unreliability of suppression cost data, firefighting expenditures clearly have been rising. According to the National Interagency Fire Center (NIFC) (2014), the official keeper of wildfire statistics, suppression costs since 1985 have totaled more than \$25.4 billion to fight 2.1 million fires that burned across 83,324,774 ha, with the lion's share of these expenses (\$19.2 billion) spent by the USFS. The 10-year average for annual federal suppression expenditures increased from \$620 million in the 1990s to \$1.6 billion in the 2000s (inflated

TABLE 12.1 Total Reported Suppression Costs by Year for Fiscal Years 2000 to 2012

Year	Reported Suppression Costs[a]	All Reported Hectares Burned[b]
2000	$795,438,685	2,129,406
2001	$552,558,849	1,053,848
2002	$1,123,052,397	1,626,718
2003	$944,419,924	1,089,209
2004	$509,178,099	558,149
2005	$471,397,270	1,535,598
2006	$1,110,521,349	2,431,536
2007	$1,094,872,834	2,643,259
2008	$1,257,495,618	1,213,015
2009	$895,966,881	617,883
2010	$448,781,350	640,105
2011	$683,773,629	1,441,411
2012	$1,212,528,811	2,840,003

[a] *Costs are not adjusted for inflation.*
[b] *Conversion from acres to hectares (1 hectare = 2.47 acres); numbers may not match exactly because of rounding.*

to constant 2009 dollars) (Gebert and Black, 2012). The years 2002, 2006-2008, and 2012 all surpassed $1 billion in expenditures (Table 12.1). From 2010 to 2013 these expenditures increased further to nearly $2 billion per year (NIFC, 2014).[1]

Suppression costs began increasing when wildfire activity significantly increased in the late 1980s, measured by the growth in the number of hectares burned, the number of large wildfires, and the average size of large wildfires, continuing into the 2000s (Calkin et al., 2005; see Table 12.1). The average annual area burned from 1970 to 1986 was approximately 115,535 ha, but from 1987 to 2002 this increased to over 404,686 ha per year (Calkin et al., 2005). Along with that increase in burned area came greater suppression expenditures. However, the correlation between area burned and suppression costs is not so simple. From 97% to 99% of all wildfires are aggressively suppressed and contained at a small size (<2023 ha). Holmes et al. (2008) reported that from 1980

1. Figures in Tables 12.1 to 12.4 use data provided by the National Wildfire Coordinating Group (NWCG). Cost figures provided by NIFC are higher than those from NWCG. See Methodological Endnote.

TABLE 12.2 Most Expensive Fire by Year from Fiscal Year 2000 to 2012

Year	Fire	State	Suppression Cost[a]	Hectares[b]
2000	Big Bar Complex	CA	$75,790,000	57,040
2001	Clear Creek Complex	ID	$71,500,000	87,801
2002	Biscuit	OR	$152,658,738	202,169
2003	Grindstone Complex	CA	$46,900,000	81
2004	Old	CA	$42,336,057	36,940
2005	Blossom Complex	OR	$28,742,207	6313
2006	Day	CA	$78,000,000	65,843
2007	Zaca Two	CA	$122,553,385	97,208
2008	Klamath Theater	CA	$126,086,065	77,715
2009	BTU Lightning Complex	CA	$95,000,000	26,303
2010	Station	CA	$95,510,000	64,983
2011	Wallow	AZ	$109,000,000	217,741
2012	Chips	CA	$53,300,000	30,526

[a]*Costs are not adjusted for inflation.*
[b]*Conversion from acres to hectares (1 hectare = 2.47 acres); numbers may not match exactly because of rounding.*

TABLE 12.3 Total Costs Ranked by State from Fiscal Year 2000 to 2012

State	Total Costs for 2000–2012[a]	Total Area Burned during 2000-2012 (Hectares)[b]
California	$4,647,895,621.00	3,265,225
Oregon	$1,362,781,801.00	1,964,984
Montana	$1,128,991,325.00	2,153,954
Idaho	$892,061,813.00	3,350,861
Arizona	$685,668,878.00	1,644,756
Washington	$625,514,507.00	808,961
New Mexico	$444,109,025.00	1,654,984
Colorado	$369,132,917.00	542,788
Nevada	$335,074,723.00	2,697,938
Utah	$331,327,216.00	1,089,920
Wyoming	$277,427,870.00	629,582

[a]*Costs are not adjusted for inflation.*
[b]*Conversion from acres to hectares (1 hectare = 2.47 acres); numbers may not match exactly because of rounding.*

TABLE 12.4 Most Expensive Total Cost Years by State from Fiscal Year 2002 to 2012

State	Year	Suppression Costs[a]	Area Burned (Hectares)[b]
Arizona	2011	$211,014,247	416,017
California	2008	$1,093,083,880	712,724
Colorado	2002	$146,181,060	202,056
Idaho	2007	$241,152,064	1,012,635
Montana	2003	$311,375,413	305,330
Nevada	2006	$61,873,505	591,871
New Mexico	2011	$130,180,833	482,011
Oregon	2002	$372,771,201	426,524
Utah	2002	$68,200,851	109,528
Washington	2006	$114,128,342	110,649
Wyoming	2012	$94,221,798	147,094

[a] *Costs are not adjusted for inflation.*
[b] *Conversion from acres to hectares (1 hectare = 2.47acres); numbers may not match exactly because of rounding.*

to 2002 approximately 94% of fire suppression costs used for fires on national forest lands resulted from a mere 1.4% of all wildfires. In 2006 the 20 biggest wildfires accounted for 11.2% of the nearly 4,046,856 ha burned nationwide, but they cost nearly 30% of the $1.5 billion spent by the USFS (ILWCP, 2007). In 1999 the USFS spent over 30% of its national suppression budget fighting two lightning-caused wilderness fires in northern California (SOLFC, 2000). In fact, the largest costs are associated with the largest wildfires. These so-called megafires (see Chapter 2) function as mega budget-busters (Table 12.2).

Total suppression costs paid by the USFS are rising at an annual rate of 12-15%, and those paid by the National Park Service and Bureau of Land Management are rising by 10% (Gebert et al., 2008). This suggests an inflationary rise in costs per hectare, but a 2005 study found that from 1970 to 2002 suppression costs consistently averaged around $308 per hectare nationally (Calkin et al., 2005). Regardless, per-hectare suppression costs can vary substantially among different vegetation types and geographic regions. Wildfires in forested or slash-covered areas are generally two-thirds more expensive to suppress than fires in shrublands or grass-covered areas (Schuster et al., 1997). The California region averaged the highest costs during the period of 1995-2004, at $1039 per hectare (North et al., 2012). In general, smaller wildfires have higher per-hectare costs than larger wildfires because, for large wildfires (defined as $\geq$2023 ha) (NWCG, 2014), a certain "economy of scale" operates that spreads some fixed suppression costs over a larger landbase (Abt et al., 2008). There can, however, be huge unburned portions of land within the perimeters of large wildfires, and suppression actions mostly occur at the outermost edge of a wildfire. If costs were calculated based on only the specific hectares where suppression actions actually occurred, then the expanse of unburned and unmanaged land inside large wildfires would be irrelevant from a cost standpoint, and per-hectare costs of large wildfires might equal or surpass those of small fires.

Thus suppression expenditures are growing along with the growth in area burned, but the relationship between fire size and suppression costs is not so simple. California (USFS region 5) and Oregon (USFS region 6) have the highest suppression costs compared with all other states and regions but do not necessarily have the most wildfire activity measured either in number of fires or area burned (Table 12.3). Even within the same region, two wildfires with similar conditions of weather, vegetation cover, and terrain can have wide differences in expenditures. In some years the number of fires and burned hectares were below the 10-year averages but suppression costs were above average. So what factors are causing wildfires to grow larger in size in places and suppression costs to increase above the rate of inflation? A host of factors that can be categorized as socioenvironmental, institutional, and operational can affect wildfire activity, firefighting actions, and their subsequent costs. Discussion of these factors follows.

12.2 SOCIOENVIRONMENTAL COST FACTORS

Compounded Interest: Fire Exclusion and Fuel Accumulation

One of the most common assertions in the literature is that large-scale, high-intensity wildfires are burning through unnaturally high fuel loads that have accumulated as a result of fire exclusion from past fire suppression. The ecological impact of past fire suppression varies significantly according to ecosystem and fire regime type. In general, a common view is that many low-elevation dry forest types with a frequent fire regime that have "missed" several fire return cycles (based on average cycles but not variability of cycles) because of past firefighting actions have been the most altered by fire exclusion and may have excess fuels accumulation compared to historical conditions. However, support for this by empirical data is limited or equivocal (see Chapter 1). Both dry and moist mixed-conifer forests and dry ponderosa pine (*Pinus ponderosa*) forests were historically characterized by mixed-severity fire in most, but not all, regions of the western United States, based on dozens of published studies using multiple distinct lines of scientific evidence (Chapter 1). Higher-elevation moist forest types with an infrequent fire regime have been less affected by suppression-caused fire exclusion, and in these systems it is more widely understood that high fuel loads and high-intensity wildfires are natural processes (see Chapter 1). Regardless, large-scale, high-intensity wildfires often are blamed on alleged excess accumulation of fuels.

One of the main claims by proponents of fuels reduction are that "treatments" will compensate for past fire exclusion, reduce the risk of high-severity wildfire, and the costs of fire suppression. Most fuel treatments are designed not to eliminate the need for suppression actions but to facilitate them (Thompson et al., 2013b). When severe fire weather conditions exist, however, high-intensity wildfire can burn over or breach most fuel treatments and make firefighting unsafe or ineffective (Reinhardt et al., 2008; Mercer et al., 2008). Indeed, though there is anecdotal evidence and some modeling exercises that demonstrate that some fuel treatments can reduce fire severity within treated stands, piecemeal fuels reduction projects at the landscape level have not had an appreciable effect on wildfire activity (Williamson, 2007). In recent years the Office of Management and Budget has been cutting funds for fuels reduction, particularly in the National Park Service, because it claims there is no evidence that the millions of dollars invested in treatments to date have actually reduced suppression costs. Thus, although legitimate scientific debate continues over the legacy of past fire suppression and fire exclusion and their effects on current fuels accumulations or wildfire activity (as discussed throughout this book), there is little debate about the fact that recent fuels reduction treatments have not had any real impact on reducing suppression costs (Table 12.4).

Sprawling Suburbs: Wildfire in the Wildland-Urban Interface

Along with excess fuel loads, expansion of the wildland-urban interface (WUI) has been widely blamed for the rapid increase in suppression costs (Gorte, 2013; Liang et al., 2008; Gebert et al., 2007). Public expectations and politics often pressure fire managers to do whatever they can to save homes threatened by wildfire, even if private property protection is not within the scope of federal responsibility, and even if suppression costs surpass the monetary value of the structures being protected (Hesseln, 2001). Despite the billions of dollars spent firefighting, hundreds of homes are burned by wildfires each year. For example, from 1999 to 2010, over $16 billion in federal funds were spent fighting wildfires, yet an annual average of 1179 homes were destroyed from wildfires during this same period (Gude et al., 2013). In the 2010s this more than doubled to an average of 2970 homes burned each year, with over 5000 homes burned in 2007, 2011, and 2012 (Stockmann et al., 2010; Headwaters Economics, 2014).

Several studies have attempted to calculate the influence of WUI protection on suppression costs. A study commissioned by the USFS estimated that approximately one-third of its suppression expenditures went towards WUI protection (SIPFSC, 1994). Based on interviews with USFS managers, estimates from 50% to 95% of total firefighting expenditures on National Forest lands were related to WUI protection (OIG, 2006). However, interviewees based their claims on beliefs that all wildfires can or will eventually threaten private property and homes. Gebert et al. (2007) determined that suppression costs can increase by an average of $1 million for each additional 125 homes near a fire, but their definition of "nearness" included homes up to 32 km away from wildfires, far outside conventional definitions of the WUI.

In some of the most rigorous research assessing the costs of WUI protection, the nonprofit organization Headwaters Economics (2009, 2014) determined that, within the state of Montana alone, the annual cost of WUI protection averaged $28 million, but it estimated that this figure could grow to $40 million by 2025 if rural housing development continues unabated and could explode to between $61 and $113 million under the effects of climate change. Applied nationally, private property protection currently ranges from $630 million to $1.2 billion annually, but a 50% growth in new housing development could increase annual suppression costs up to $2-4 billion.

The post-World War II expansion of logging roads is often an explanation for the alleged increased effectiveness of fire suppression because large amounts of crews and equipment can be transported at relatively low cost. Ironically, however, the presence of roads is associated with higher suppression costs compared with areas with no roads because roads enable managers to order more expensive resources like engines and bulldozers (Gude et al., 2013). Roads also are more often located near high-value assets like homes, private property, or commercial timber stands, so generally more suppression resources are used in areas with roads than in areas without them.

Calkin et al. (2005) pointed out that although the WUI has been expanding since the 1950s, and firefighting agencies are focusing more resources on structure protection, the steady growth of the WUI does not account for the rapid surge in firefighting expenditures that began in the late 1980s. To understand that shift, attention must turn to the effects of weather and climate on the growing frequency of large-scale fires.

The Heat Is On: Global Warming and Wildfires

The increase in suppression costs are highly correlated with the growth in area burned, especially by large wildfires, and large wildfires are primarily driven by weather and climate conditions (Gebert et al., 2008; see also Chapters 1 and 2). Prolonged droughts, high temperatures, and high-wind events all are associated with high wildfire activity in terms of ease of ignition, rapid spread, and high-fireline intensity. Westerling et al. (2006) demonstrated that a significant shift in wildfire activity began in 1987, when wildfire seasons lengthened an extra 2 months because of earlier spring snowmelt and later autumn snowfall at higher elevations, an effect attributed to climate change more than fuels accumulation from past fire exclusion. Contrary to widespread popular belief, the larger size of wildfires since the 1980s has not necessarily resulted in higher severity of wildfires in most forested regions of the western United States (see Chapters 1, 2, 9). The effects of climate change on wildfire activity vary among and within different regions because of complex interactions between temperature, precipitation, relative humidity, and their effects on soil moisture and vegetation cover (see Chapter 9). Some areas experience more frequent severe fire weather conditions and lightning storms, but others have more precipitation throughout the typical fire season. Nationwide, federal agencies predict that climate change will result in wildfires burning 4-5 million hectares annually (USDA-FS et al., 2009) with a predictable rise in suppression costs absent any changes in current policies or practices.

12.3 THE HUMAN DIMENSIONS OF WILDFIRE SUPPRESSION COSTS

The three above-mentioned socioenvironmental factors are the most cited factors fueling increased suppression expenditures (Hand et al., 2014), but Canton-Thompson et al. (2008) argue that the biophysical features that affect fire behavior (e.g., vegetation, weather, and terrain) can explain only half of the variation in suppression costs. Among wildfires that share similar physical characteristics but have significant differences in suppression expenditures, the "human dimensions" of fire management, especially the attitudes and choices of fire managers, play a significant role in cost differences. These human dimensions can be categorized in terms of "external" sociocultural factors and "internal" institutional and operational factors that often pressure fire managers to opt for aggressive suppression actions instead of modified suppression or fire use strategies.

12.4 EXTERNAL SOCIOCULTURAL COST FACTORS

The Smokey Bear Syndrome: Public Pressure for Suppression

"External" influences on suppression costs come from outside federal agencies. A century of anti-wildfire propaganda and pro-suppression policies has created what some fire managers have dubbed the "Smokey Bear syndrome" in American culture. It causes many people to demand that firefighters put out all wildfires. There are strong public expectations that all wildfires should be prevented and/or suppressed, that firefighters will always be effective in their actions, and that no expense should be spared in efforts to protect human life or private property (also see Chapter 13). In the false belief that firefighters actually extinguish large wildfires, extreme public pressure is put on fire managers to use costly and extraordinary suppression methods, even when managers suspect that these efforts will have no meaningful effect on the wildfire and will likely be an economic waste.

Residents of the WUI in particular often demand full suppression of wildfires but do not understand the risks or complexities of firefighting, nor the ecological impacts of fire exclusion (Calkin et al., 2011). Black et al. (2010)

discovered that even citizens who support the use of fire in land management lose their tolerance for wildfires after enduring a few weeks of disruption to their everyday routines while breathing lots of smoke. In addition, there is often pressure on federal managers to hire local private contractors for suppression crews, equipment, or supplies, and fire managers often complain that these private resources are more expensive and require more oversight than public agency resources (Canton-Thompson et al., 2008). Related to this, significant pressure for aggressive suppression can come from state and local cooperators working on multijurisdictional wildfires (i.e., fires burning on federal, state, and private lands). Most state forestry agencies have mandates for full suppression and total fire exclusion and suspect that fire use strategies on federal lands are intended to pass suppression costs onto the states. The legacy of Smokey Bear's anti-wildfire message thus afflicts not only the lay public but also fire management professionals who believe the only good fire is a dead-out fire.

Hot Air: Politicians and the Press

Another form of external pressure pushing fire managers to select costly suppression strategies or tactics comes from local, state, or national politicians. Politicians continually intervene in federal fire management, creating laws or policies that ignore the professional expertise of agency fire scientists and managers and undermine science-based fire management (Fifer and Orr, 2013). Politicians also are prone to public grandstanding in the media during wildfire events, pressuring agencies to aggressively fight fires. Firefighters call their actions "political shows" or "political smokes" to describe situations when, under pressure from politicians or local communities to put out a wildfire, managers select resources, strategies, or tactics that will likely be economically inefficient or ineffective but demonstrate to external audiences that aggressive actions are being undertaken (Cart and Boxall, 2008). Examples include the use of aerial retardant drops that have no chance of success during fire behavior conditions or suppressing interior hotspots that have no chance of escaping the wildfire perimeter just to reduce the public's fear of fire spread. Donovan et al. (2011) were able to quantify the cost of external political or media pressure on fire managers. Increasingly, managers are feeling whipsawed between two opposing political pressures: while wildfires are burning there is intense pressure from local politicians to suppress fires at all costs, but then after fire season is over national politicians criticize agencies for failing to contain costs. In the current politicocultural environment, pressures for managers to aggressively fight wildfires are prevailing over pressures to avoid excessive spending of taxpayer dollars (also see Chapter 13).

12.5 INTERNAL INSTITUTIONAL COST FACTORS

Red Ink: Skewed Budgets and Perverse Incentives

One of the most oft-cited "internal" institutional drivers of rising suppression costs is the system for Congressional appropriations for the USFS that authorizes deficit spending for firefighting. The usual practice is that when the agency's annual appropriation for suppression is exhausted, the agency starts "borrowing" funds from accounts in nonsuppression programs to keep money flowing to firefighting efforts then later asks Congress for supplemental appropriations to replenish the transferred funds. Even when those funds for nonfire programs are fully reimbursed (and sometimes this has not occurred), the disruption caused by the budget transfers causes problems for planning and implementing many research and restoration projects. Relying on emergency funds and supplemental appropriations provides little incentive for cost containment and is a significant human factor in increasing suppression expenditures (Donovan et al., 2008; Donovan and Brown, 2005).

Rising suppression costs and increases in annual and supplemental Congressional appropriations have combined to create an extreme imbalance in the USFS budget that some critics charge is changing the focus of the agency's mission away from managing forests toward fighting fires (the Preface refers to the Forest Service becoming the de facto Fire Service). While funding for fire management has been rapidly growing, the budgets for almost all other nonfire programs in forest management, restoration, research, and recreation have been shrinking. For example, the proportion of the agency's budget devoted to fire management was only 16% in 1995 but swelled to 42% in fiscal year 2014 (USDA-FS, 2014). The numbers of wildfires and acres burned were, surprisingly, below the 10-year average in the 2014 fire season, but regardless, the USFS spent over 50% of its total appropriated budget on firefighting—the first time it passed this threshold, but probably not the last.

Congress almost always delivers on agency requests for supplemental appropriations for firefighting expenditures with almost no questions asked. This has nurtured an "open checkbook" mentality by fire managers, leading them to choose aggressive suppression strategies and order expensive firefighting resources knowing that Congress will eventually pay all of their firefighting bills (Ingalsbee, 2000). This attitude is one of the reasons getting managers to contain costs has been difficult (Snider et al., 2006; Donovan and Brown, 2007; Donovan et al., 2008). Worse, the agency's skewed budget and deficit spending authority has set up a system of "perverse incentives" that encourages the USFS to focus on reactive fire suppression rather than proactive ecosystem restoration or recreation programs (Ingalsbee, 2010). Such programs must be funded by fixed budgets and involve more legal requirements (e.g., environmental analysis and public involvement), but firefighting actions have almost no budgetary limits or legal constraints because of their "emergency" status.

This ongoing practice of Congress failing to appropriate sufficient funds for suppression and then the USFS transferring money from nonfire programs to pay for firefighting expenditures sets up a self-reinforcing system in which the agency keeps reacting to wildfire activity (even in below-average years, as in 2014) while avoiding root problems (e.g., the historic fire deficit, and risks of fire exclusion on rare and imperiled fire-dependent species; see

Chapters 1–5) or the implementation of long-term effective solutions (e.g., wildland fire use to restore mixed-severity fire to ecosystems). In the business management literature this is a classic dilemma known as the "firefighting trap." De Neufville et al. (2013) demonstrated that this emphasis on fire suppression in the short term and neglect of fire restoration over the long term inevitably leads to higher costs over time. Avoiding the vicious cycle of the firefighting trap will be possible only if resources are shifted away from suppression and toward wildland fire use (or "managed wildfire"), ecological restoration projects, and education—but that will be difficult given entrenched mind-sets and vested political and economic interests devoted to fighting fires (Chapter 13). As long as Congress continues allowing deficit spending for firefighting, the USFS will continue to focus on attacking nearly every fire rather than working on root causes or real solutions to rising suppression expenditures.

Tears for Fears: Risk-Averse Managers

External social and political pressures combine with internal agency dynamics to create another suppression cost driver: risk-averse managers. Managing wildfires is inherently risky, hazardous work, and these risks and hazards can be mitigated but never completely eliminated. Current fire management policies are predicated upon "sound risk management," with firefighter safety the highest priority; this involves assessing the exposure of firefighters to safety risks versus the potential effects of wildfire on social and ecological values at risk. New tools for assessing risk are emerging; however, there are several challenges in getting managers to use these new tools in decision-making. First, most managers focus on the immediate or short-term risks of what they perceive as wildfire "damage" rather than the long-term risks of continued fire exclusion to, for example, rare and declining fire-dependent wildlife that benefit from mixed- and high-severity fire effects (see Chapters 2–5). Likewise, managers may try to limit firefighting costs and firefighter exposure by attempting to keep fires small, but this ignores the opportunity costs of failing to get more hectares burned when conditions favor beneficial fire effects. Managers almost always opt to assume short-term risks and costs while externalizing long-term risks and costs to future managers and firefighters.

Second, among managers is a widespread belief that a double standard exists in terms of the risks and consequences of managing wildfires with aggressive suppression versus fire use strategies. Managers believe that if they adhere to approved policies and procedures, then all will be forgiven if the fires they aggressively fight unfortunately result in accidents. If wildfires managed with fire use strategies exceed their desired size, have high-severity effects, or—worse—result in firefighter fatalities or property destruction, then many managers fear that that their agency would not support them, they could lose their careers, and they could be held personally liable for those accidents

(Canton-Thompson et al., 2008). This fear is not entirely unfounded, and it is another source of risk aversion by managers.

There is also a misperception among many managers that increasing firefighter safety and reducing suppression costs are contradictory goals. Consequently, risk-averse managers will order excessive amounts of suppression resources or select more expensive capital-intensive resources like air tankers and engines rather than rely on less expensive labor resources like handcrews to contain and control wildfires quickly and thereby limit firefighter exposure (Calkin et al., 2005). Moreover, managers do not often recognize that foregoing backcountry firefighting reduces unnecessary risks to firefighters. Ironically, much firefighter exposure to hazards occurs during "mop up" (extinguishing all visible smoke and heat sources) that begins after a wildfire has been contained and is no longer spreading. Managers' aversion to the risk of fire escaping containment lines often leads them to order intensive and extensive mop-up activity in which firefighters face increased safety risks from falling snags and health hazards from inhaling large amounts of smoke, ash, and dust. Prolonged mop-up raises total suppression expenditures and can cost several times what other fuels reduction treatments would cost (Gonzalez-Caban, 1984). Allowing more wildfires to burn themselves out over time would raise risks of potential escape but could also result in more fire restoration with less soil disturbance and less risk to firefighters.

Risk aversion extends beyond individual managers' fear of accidental outcomes, but it also includes the agencies' generalized fear of negative publicity. Donovan et al. (2011) demonstrated that managers increase suppression spending in response to media coverage that heightens public fears of wildfire or generates citizen criticisms over alleged government incompetence in fighting fire. The tremendous flexibility in strategies and tactics that federal fire management policy allows is consistently underutilized because much of the public cares only that wildfires are "put out" as quickly as possible. Fire use strategies that achieve management objectives and avoid all accidents can still face public condemnation while smoke plumes stoke people's fear of fire. This causes risk-averse agency officials to avoid potentially negative public reactions by aggressively fighting nearly all fires. Again, this essentially passes on extra risk to future managers, firefighters, and ultimately the ecosystems and species that are negatively affected by fire exclusion.

12.6 OPERATIONAL FACTORS: SUPPRESSION STRATEGIES AND TACTICS

Operational factors driving suppression costs are the least discussed issue in the peer-reviewed literature, but the human factors influencing the objectives, strategies, and tactics that fire managers use to respond to wildfires have huge cost implications. According to incident commanders (the leaders of the teams managing wildfire operations), the number 1 driver of suppression costs is the decisions made by line officers (agency administrators such as regional foresters, forest supervisors, or district rangers) (Canton-Thompson et al., 2008). Incident commanders may recommend a certain strategy and set of tactics, but it is the line officers who make the final decisions authorizing suppression objectives and their estimated costs. Unlike some of the big socioenvironmental problems that are driving up suppression costs and will take many years to solve, the operational decisions guiding wildfire responses have the most potential for immediate cost reductions.

Wildfire responses fall into two basic objectives and five strategies. Protection objectives are intended to limit fire spread and exclude it from burning certain areas. Three strategies include (1) direct or full suppression, which is the most aggressive strategy that attempts to contain and control wildfires at their smallest size feasible; (2) modified suppression, which combines some fireline construction with the use of preexisting natural fire barriers (e.g., bodies of water, rocky areas) to confine wildfires to predefined areas but does not necessarily minimize the area burned; and (3) limited suppression, which is the least aggressive strategy that does not build containment lines along a wildfire's entire perimeter but instead attempts "point protection" tactics to keep fire from burning specific high-value places (e.g., structures), while allowing the fire to spread across a larger area. Cost containment goals may influence the selection of modified and limited suppression strategies, but most often they are chosen because of firefighter safety concerns or a lack of sufficient resources for a more aggressive strategy (Black et al., 2010; Gebert and Black, 2012).

Resource benefit or restoration objectives, on the other hand, aim to promote the benefits of fire on specific natural resources, native species, habitats, or landscapes. The two main strategies for managing wildfires for resource benefits include (1) area monitoring, whereby the fire is permitted to burn freely within a defined area but no management actions are attempted beyond observing and mapping; and (2) area management, which includes monitoring plus other minimum-impact management actions designed to delay, direct, or check fire spread in order to keep the fire within a prescribed area or protect specific features within a wildfire's perimeter (Black et al., 2010; Gebert and Black, 2012).

In 2009 the Obama Administration issued new guidance for implementing the Federal Wildland Fire Management Policy that gives managers tremendous flexibility to manage wildfires for both protection and restoration objectives simultaneously using all the strategies and tactics available in modern fire management. Concretely, there might not be much difference in terms of management techniques and environmental effects between modified suppression versus area management strategies, even though they represent fundamentally different objectives. In terms of costs, managing wildfires for restoration objectives or using less aggressive strategies logically should reduce overall expenditures; however, this assumption has rarely been tested because the USFS continues to apply aggressive suppression strategies on roughly 97% of all wildfire ignitions on National Forest lands and boasts that it is successful in controlling wildfire during the initial attack about 98% of the time (Tidwell, 2014). The few studies that have probed the connection between operational strategies and expenditures have come up with some surprising findings, though.

In a pioneering study of the costs of the full range of fire management strategies, Gebert and Black (2012) found that the average costs per hectare of direct suppression ($730) are higher than modified ($404) and limited ($302) suppression strategies, whereas the average costs per hectare of resource benefit strategies is much lower ($127). Measured on a daily basis, the cost variations are similar although not as great, with direct suppression the most expensive at an average $335,000 per day, but this is only 1.2 times the cost of modified suppression. Considering the big picture, modified suppression can be the most expensive strategy because it allows wildfires to grow larger and especially burn longer—nearly twice as long as direct suppression incidents—and this can considerably increase total expenditures. Indeed, the average total cost for modified suppression incidents is $7.3 million, whereas costs for direct suppression are $4.3 million. Surprisingly, the costs for limited suppression strategies or resource benefit objectives were $3.7 million and $3.6 million, respectively. Less-than-full suppression strategies still cost a considerable amount of money! (but see discussion in "Saving Green in the Black" below).

Focusing on average daily costs and total expenditures per suppression incident seems to justify the rationality of fighting fires aggressively to keep them small or of short duration and thereby limit total expenditures. In fact, in 2012 Deputy Forest Service Chief Jim Hubbard suspended fire use on all National Forests for the duration of that wildfire season, claiming that it was a cost containment strategy. Firefighters were dispatched to wildfires even in remote wilderness areas. In one instance, firefighters spent a whopping $425,000 to keep a lightning fire limited to 0.04 ha in size deep inside the Bob Marshall Wilderness Area, a place where wildfires had most often been monitored rather than fully suppressed. The USFS spent $1.3 billion fighting fires during the 2012 fire season, exceeding its suppression budget by $440 million, and forced Congress to provide emergency supplemental appropriations to cover the agency's budget deficit (FUSEE, 2013). Apparently, going all-out on direct suppression does not necessarily contain costs or keep them within budgetary limits, but the question remains: Is adopting less-than-full suppression strategies a viable means of limiting costs or reducing total expenditures in the near or long-term?

Where's the Beef? Questioning the Efficiency and Effectiveness of Aggressive Suppression

Before answering that question, it is important to note some important research that is raising critical questions about the efficiency and effectiveness of wildfire suppression, especially of large wildfires that are the real budget-busters. Butry et al. (2008) stated, "We find no evidence that large wildfires respond to wildland management .... Instead, large fires appear sensitive only to weather and landscape conditions." Indeed, Finney et al. (2009) and Butry et al. (2008) demonstrated what firefighters have long known: aggressive suppression actions are ineffective in containing the spread of large wildfires unless and until the fire encounters moderate weather or low fuel conditions. However, Calkin (2014) disclosed that, on average, 35% of firefighting crews and resources are ordered after a large wildfire has stopped growing and essentially defined its own boundaries. Aviation resources are typically one of the most expensive resources and comprise a major portion of total suppression expenditures. There is a common misperception by people that aerial retardant drops extinguish flames, but in fact, retardant only slows down the rate of spread. Accordingly, air tankers are best suited for the initial attack, but 75% of fires with air tanker drops escape the initial attack and become large wildfires (Calkin, 2014). Air tankers are least effective on large wildfires because the weather conditions that fuel large fires overwhelm the effect of chemical retardants; nevertheless, the majority of air tankers are used on large wildfires (Thompson et al., 2013a). Moreover, the largest percentage of air drops occur in late afternoons on steep slopes in dense timber stands—the times, places, and conditions in which aerial retardant is least effective (Calkin, 2014). Given the emerging research that questions the effectiveness of some of the more expensive suppression resources and methods, and factoring in the ecological costs of fire exclusion, the case for finding alternatives to aggressive suppression becomes stronger.

Saving Green in the Black: The Eco-Nomics of Fire Use

There is an extensive and growing body of research demonstrating various ecological rationales for managing wildfires with restoration objectives and fire use strategies, but only recently has research raised some economic rationales, too. One of the simplest arguments is that wildfire provides nearly "free" fuel reduction (Houtman et al., 2013). Letting wildfires burn avoids both the cost and damage of fighting the fire and the later cost of fuel reduction treatments in the areas in which suppression had prevented the fire from burning (Dale, 2006). Donovan and Brown (2008) used an "cost method" to model the savings in fuel reduction costs from fire use: what would have cost $39 per hectare for a series of prescribed fires or $121 per hectare for mechanical treatments can be avoided by a single wildfire that is simply monitored. Once a wildfire has burned a stand, reduced fuel loads can be inexpensively maintained over time through periodic prescribed burning or simply monitoring future wildfires. The cost savings are highest when wildfires are allowed to burn within dense stands of small trees without first using expensive mechanical pretreatments. Fire managers often assume that wildfire use is too risky in these stands, but by using the best fire management tools, skills, and experience, it is conceivable that conditions might allow wildfire use where relatively low intensity fires can achieve desired fuel reduction at great cost savings.

Few studies have compared the costs of wildland fire use versus full suppression, mostly because fire use is so rarely authorized by the USFS. Dale et al. (2005) calculated that over a 20-year period the USFS spent an average of $236 per hectare for suppression but only $21 per hectare for fire use. This matches a study by Oppenheimer (2013) where aggressive suppression cost an average $216 per hectare but point protection/area management strategies cost only $20 per hectare. Comparing costs of fire use with those of direct suppression has now become impossible given that fire managers can use both strategies on a single wildfire. Accordingly, fire use is no longer a separate kind of fire, that is, what firefighters used to call a "fire use fire;" instead, it is a strategy or tactic available for every wildfire. Most of the economic arguments supporting fire use are thus based on modeling and commonsense assumptions that less use of suppression resources will equate into less costs.

The same economy of scale that drives down per-hectare costs of suppression as wildfires grow larger works even more dramatically with fire use. With full perimeter-control suppression strategies, more crews and equipment are needed to contain and control a fire as it grows larger, resulting in much higher total expenditures even if per-hectare costs seem to decline. With wildfire use strategies, however, as a fire grows there is not the same necessity to keep adding more resources. A relatively small crew can manage large wildfire events with fire use strategies, and an economy of scale makes fire use an extremely economically efficient means of getting fire on the ground for fuels reduction or ecological restoration objectives.

The real cost driver for wildfire use is not the size as much as it is the duration of a wildfire that can engage crews and a district's management staff for an extended period. Thus low daily costs can accumulate to a large total amount over time. Long-duration wildfire events also normally experience changing weather conditions that can cause fires to make occasional "runs" of rapid fire spread. This might necessitate some temporary scaling up of crews and equipment to apply some limited suppression techniques (e.g., holding or checking actions) as part of an area management strategy, but after rapid fire spread subsides, crew and resource levels can be quickly downsized. On the other hand, fire use strategies typically avoid intensive or prolonged mop-up that is often a major cost of full-suppression strategies.

One of the most prevalent economic rationales for fire use (and fuels treatments in general) is the belief that future wildfires will be easier and cheaper to contain and control, but that argument maintains the assumption that firefighting will continue to be the normal or default response to wildfires and misses the real point of restoration objectives: to allow wildfires to burn to restore and maintain natural fire ecology processes. As Reinhardt et al. (2008) advocated, the primary objective of treating fuels is to make wildfire more acceptable rather than to reduce wildfire extent or make it easier to suppress. The assumption that fire use strategies will make wildfires less costly is most logical and likely if managers choose to safely monitor rather than aggressively fight future fires. Applying fire use strategies spares the land from suppression damage, saves taxpayers money, and therefore is the most ecological and economic—or "eco-nomic"—way to manage wildfires and restore mixed-severity fire to the landscape, particularly in forests where it is in deficit (see Chapter 1).

12.7 BANKING ON CHANGE: RECOMMENDATIONS FOR CONTROLLING COSTS AND EXPANDING BENEFITS OF MANAGING WILDFIRES

There is no question that fire suppression of some sort will be needed as long as there are valued human assets (e.g., structures) at risk of unwanted wildfire damage. But the past century of systematic fire suppression across the landscape, including vast backcountry areas, has been a systemic "policy failure" (Busenberg, 2004) that is simply unsustainable on a social, ecological, and economic level. Political leaders, agency managers, the media, and citizens alike must recognize that complete wildfire exclusion is neither possible nor desirable, and maintaining ecosystem integrity and controlling suppression expenditures require extensive areas of wildlands to be burned by mixed-severity wildfire or prescribed fire each year. This means changing the dominant paradigm of federal fire management from protection to restoration objectives and changing default wildfire responses from aggressive suppression to opportunistic fire use (also see Chapter 13). The following are some ideas for solutions to some of the problematic cost drivers that have been highlighted in this chapter.

Fix the Budget

Congress must end the skewed budgetary structure that authorizes deficit spending, allows budget transfers from nonfire programs, and promotes "emergency" supplemental appropriations exclusively for wildfire suppression. Congress needs to stop signaling to agencies that they will write a "blank check" for wildfire suppression and should consider setting fixed budgets and firm limits for wildfire suppression. A fixed and firm budget for suppression would force managers to be more selective and strategic in their use of suppression resources. Donovan and Brown (2005) proposed that Congress permit budget deficits or surpluses to be carried into the next fiscal year and allow managers who are conservative in suppression spending to use surplus funds for fire planning, fuels reduction, or restoration projects. A fixed budget for suppression might also make managers prioritize aggressive suppression actions near the WUI, where wildfires clearly damage or destroy human assets, while restricting suppression in backcountry wildlands where more often there are net beneficial effects of mixed- and high-severity fire for natural resources and ecosystems

(Calkin et al., 2014). Finally, Congressional appropriations are divided into two programmatic areas called "fire preparedness" and "fire operations." Defining these terms almost exclusively as prevention and suppression has long been a distortion of fire management philosophy. It is time to define fire operations more literally as fire use.

Change the Incentives

Current USFS performance measures focus on fire size rather than fire effects and encourage managers to aggressively fight fires to keep them small rather than wisely manage them to facilitate ecologically appropriate and heterogeneous fire effects across larger areas. The set of "perverse incentives" that reward fire managers for aggressive suppression, fails to recognize their accomplishments in fire use, and harshly penalizes them for any accidents that occur during fire use strategies must be fundamentally changed. The artificial distinction between wildfire and fuels management should be abolished, and managers should be rewarded for accomplishing lower-cost fuels reduction with wildfire use. The agency should fully support managers assuming proper risks for managing wildfires. The current perception of risk should be inverted such that sending firefighters to aggressively attack fires is considered the most risky decision for managers to take, whereas selecting monitoring or fire use strategies with preplanned restoration objectives is the least risky decision from the standpoint of firefighter safety and a manager's professional career.

Convert Costs into Investments

Managing wildfires with less-than-full suppression strategies may actually have higher costs per incident in some cases in the short term than if they had been aggressively attacked and controlled at a small size, though aggressively attacking every small fire creates a cumulatively large expenditure overall. However, the expenditures of fire use strategies should be viewed as investments in forest restoration with long-term payoffs in enhanced biodiversity, ecological integrity, and community security. In addition, fire use strategies involve more labor-intensive than capital-intensive tools and techniques. For the price of one air tanker and its multiple retardant loads, many jobs to manage wildfires for restoration objectives could be funded, providing tangible socioeconomic benefits that better justify the cost to taxpayers. Agencies should thus change their mind-set from viewing large wildfires as costly problems to seeing them as "investment opportunities" yielding multiple social and ecological benefits.

Build a Firewall Against Rural Sprawl

Given that much of the increase in suppression costs has been attributed to the vulnerability of homes in the WUI renovating existing homes with fire-resistant materials, mandating vegetation treatments on private lands adjacent to homes, and preventing new home construction in wildfire-prone wildlands could reduce the need for aggressive suppression and expand fire management options (see Chapter 13). These would require creating local ordinances, land use zoning laws, and other means to regulate or restrict suburbs from sprawling into wildfire-prone rural areas. Another approach would be to charge more of the cost of wildfire protection to those who build homes and the local governments who issue permits for them (Headwaters Economics, 2014). The current system whereby federal and state taxpayers pay most of the costs for firefighting on private lands functions as a de facto subsidy for individual homeowners as well as an incentive for irresponsible new home construction, thereby raising suppression costs for all taxpayers.

Assert the Will to Change

Historically, the USFS has received significant public, political, and fiscal support for its firefighting actions. The current system is not sustainable, however, and it must change given our increased knowledge of fire ecology, understanding of the adverse effects of fire exclusion and the ecological benefits of higher-severity fire effects (e.g., Chapters 2–6), and the evidence of increasing spending but declining effectiveness of suppression on large wildfires. Donovan and Brown (2005) assert that it is not a lack of knowledge that has impeded change in fire management, but a lack of will. The GAO (2007) identified over 300 recommendations for changes in fire management policies and practices to contain or reduce costs, but as Reinhardt et al. (2008) simply stated, the bottom line is that the only sure way to reduce suppression spending is to make a decision to spend less money suppressing fires. In many respects, the USFS has been taking the blame for decisions made by cultural, political, and economic forces outside of its control (Hudson, 2011). Nevertheless, it is time for the USFS to adopt a new philosophy of fire management centered on wildfire use for ecological restoration, or what we call ecological fire use. Working with wildfires rather than fighting against them will ultimately prove to be the safest, surest, most sustainable, most eco-nomical way to control costs while protecting communities and restoring ecosystems in wildfire-adapted areas.

12.8 ENDNOTE ON METHODOLOGY

Suppression costs presented by federal and state agencies reflect a subset of total wildfire costs for which corresponding documentation exists. Here costs are defined as the total expenditures in U.S. dollars spent to suppress a fire, but do not reflect costs incurred due to loss of life and/or property damages that can be much greater than suppression expenditures. The data in Tables 12.1 through 12.4 are based on cost data compiled by the National Wildfire Coordinating Group (NWCG), and from historical incident ICS-209 forms and

SIT-Reports in the FAMWEB database. Each year represents the fire fiscal year (October 1 of the preceding year through September 30). The data reflect all reported wildfires on lands under federal protection that meet federal reporting thresholds (larger than 40 hectares for timber or 121 hectares for shrublands). We acknowledge that these are at best cost estimates that are not complete due to the nature of how these data are tracked and recorded. Wherever possible we have verified much of the information contained in this database via other official sources. Cost figures provided by the NIFC are generally higher because they reflect data from all fires of all sizes on all lands (including state and private lands), but may be subject to more reliability errors from the various reporting sources.

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