FIRE THEN AND NOW:

A Look at Wildland Fire in North America in the 21st Century

(Formatted for Southern Rockies Fire Science Network Publication)

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SRFSN Publication 2019-1
July 2019

Abstract

Wildland fire is a global phenomenon that influences ecosystems, cultures, and livelihoods. Humans are only one driver of fire behavior and occurrence, as fires function across dynamic fuel and weather scenarios, yet the human controls of fire are strong and can function through positive or negative feedbacks and direct or indirect forces. For example, humans can influence fire positively and indirectly via fire suppression policies that lead to fuel accumulation and an escalation in future fire behavior, or negatively and directly through fuel manipulation that reduces fuel accumulation and de-escalates fire behavior. Broad anthropogenic changes such as urbanization, development in rural areas, and climatic changes also influence fire. Fire management shapes the ecology of many systems. Human history has largely influenced fire use, and has subsequently induced changes in ecology and human livelihood. Federal expenditure for fire suppression is increasing dramatically and in 2018 exceeded 3 billion USD. Concomitantly, the number of acres burned annually in North America has increased from the years 1985-2018, illustrating our changing relationship with and management of fire.

History of Fire in North America

Wildland fire is a dynamic disturbance that sparks considerable interest, especially in North America, and for good reason. When fires occur in unplanned and uncontrolled scenarios, they can exhibit large, extreme, dangerous, and destructive characteristics (Figure 1) that greatly influence public perceptions and the decisions of resource managers and incident command personnel. Fire is still a greatly misunderstood phenomenon, yet it plays an important ecological role in ecosystems throughout North America and the world. Fire is a dynamic disturbance ecologically, economically, and socially. It is difficult to separate the interaction between humans and fires because historically, Native Americans used fire for multiple reasons including hunting, warfare, and pest control (Gruell 1985). Similar indigenous uses of fire are also evident in Africa (Trollope 1973) and Australia (Bowman et al. 2009). As Europeans settled across North America, the number of human-caused fires declined, in part due to the fear of fire destroying life and property (Pyne 1982; Ryan et al. 2013). Destructive fires in the 1800s and early 1900s, and the loss of life, property, and timber production, led to even more strongly held negative connotations about wildland fire (Dombeck et al. 2004). For example, the Great Hinckley fire of 1984 consumed 200,000 acres and 418 lives (Williams et al. 2013) and the Great Fire of 1910 was the single greatest fire in US history, consuming 3 million acres across Idaho, Montana, and Washington, and taking 87 lives (Pyne 2001).

Figure 1. The Beaver Creek fire of 2016 in Colorado and Wyoming on the Medicine Bow and Routt National Forests. Wildfire in the crown of this high-elevation, mixed conifer forest in the southern Rocky Mountains. Photo Credit to Tyler Campbell.

In spite of and because of these large conflagrations, a debate about the use and management role of fire continued to take place primarily in the southeast and western US during the early twentieth century (Donovan and Brown 2007). Several land managers and scientists argued for the necessity of regular fire in order to reduce fuel loads, to optimize forest stand structure, and to reduce the probability of large, destructive fires. George Hoxie (1910) was one particularly vocal advocate for this viewpoint, describing fires "as necessary as are crematories and cemeteries to our cities and towns." However, this viewpoint was not shared by the majority of professional foresters at the time, who relied on European forestry practices and viewed fires as destructive of trees that ultimately reduced timber production (Donovan and Brown 2007). Interestingly, Aldo Leopold (1920) was one such forester and conservationist that promoted the removal of fires, particularly in ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson) systems.

In 1904, the United States Forest Service (USFS) was established, and the aversion to fire use in forest management was solidified by the 1910 fire season. In 1910, 4.9 million acres of National Forests were consumed by wildfire, and 78 fire fighters lost their lives (Donovan and Brown 2007). Fire was castigated as a destructive force that must be contained and eliminated, leading to the adoption of the 1935 "all fires out by 10AM policy" (Pyne 1982). By 1940, the USFS developed the most effective wildfire fighting capability in the world (Dombeck et al. 2004). The mascot Smokey Bear helped to champion wildfire suppression during this time and established a legacy that for more than 60 years aided in teaching the public to prevent wildfires. The 10AM policy guided Forest Service suppression efforts until the mid-1970s, and was an effective tool to suppress the majority of wildfires (Donovan and Brown 2007).

In the 1970s, official views on fire suppression versus fire management began to shift, beginning with the National Park Service. In the mid-1970s, M. Rupert Cutler, assistant US Secretary of Agriculture announced his intentions to shift USFS policy from fire suppression to fire management (Sampson 1999). However, in the face of the 1988 Yellowstone fires, and the associated media coverage and public perception surrounding the events, fire management rather than fire suppression was not strongly supported as an emerging policy or fire management strategy (Sampson 1999). In 1994, the National Commission on Wildfire Disasters released a report citing increasing fuel loads as the root of the large wildfire damages experienced across the United States (National Commission on Wildland Disasters 1994). Later that year, 14 firefighters lost their lives in Colorado fighting the Storm King fire (Butler et al. 1998). Consequently, the USFS shifted its fire fighting policies to an idea of "Life First" which is an initiative to more strategically fight fires and place high value on the lives of the fire fighting workforce (Figure 2).

In addition, minimum-impact suppression tactics (MIST) are utilized in wilderness, proposed wilderness, and areas with similar management objectives by the USFS and Bureau of Land Management (BLM) to reduce the negative ecological consequences of suppression activities that can lead to issues such as increased soil erosion risk or reduced water quality (Backer et al. 2004). The National Park Service (NPS) also implements MIST tactics (USFS 2001) to reduce suppression activity impacts and the necessity for additional restoration (Mohr and Curtiss 1998). However, wildland fires continue to pose a dilemma for the United States and policy makers due to threats to public safety, massive fire fighting expenditures, commodity damages, compromised ecosystems, air quality, and restoration costs (Busenberg 2004; GAO 1999a, 1999b; USFS 2000). Federal fire fighting has become a difficult balance between protecting values at risk and restoring fire for resource management (Figure 2).

Furthermore, the past century of active fire suppression in the United States has led to vast, large-scale ecological changes through increased fuel loading, vegetation community shifts, and altered fire regimes (Arno and Allison-Bunnell 2002). These factors of human health and safety, federal expenditure, and ecosystem integrity collide to present a complex, multifaceted conundrum for federal land managers and policy makers alike.

Figure 2. Wildland fire management now balances integrated concepts of fire fighter safety, minimizing ecological damage, restoring fire for resource management, and managing costs. Photo Credit to Tyler Campbell.

A Century of Active Fire Suppression

Federal fire policy has shifted from a fire suppression position to a strategic fire use and management stance over the past 100 years. Even though this shift may be optimal for both protecting life/property and managing ecosystems, the past century of active fire suppression in the United States has an enduring legacy that includes vast, large-scale ecological changes through increased fuel loading, vegetation community shifts, and altered fire regimes (Arno and Allison-Bunnell 2002). In the western United States, fire suppression has led to hazardous fuel accumulation including greater canopy fuel loads, more ladder fuels, and greater risk of surface-to-crown fire transitions, all of which increase the potential for catastrophic wildfires (van Wagtendonk 1996). Active fire suppression has resulted in a suite of changes that influence a large variety of fire parameters.

Mean Fire Return Intervals

Mean Fire Return Intervals (MFRIs) are a method to quantify one aspect of fire regimes. MFRIs suggest on average, how frequent fires are present, or were present historically, in a certain area or fuel type (Romme 1980). This concept is useful in tracking change over time from precolonial periods to modern times to better understand anthropogenic influences on fuel models and to determine how to resore fire now and in the future. Fire regimes in the United States are variable as demonstrated by the federal LANDFIRE project which has stratified the US into 5 Fire Regime Groups (Figure 3). These 5 Fire Regime Groups are based on interactions between vegetation, fire behavior, fire effects, and landscape scale context (Figure 3). However, anthropogenic induced changes to fuel types also greatly influence current management needs and actions.

LANDFIRE: Fire Regime Groups

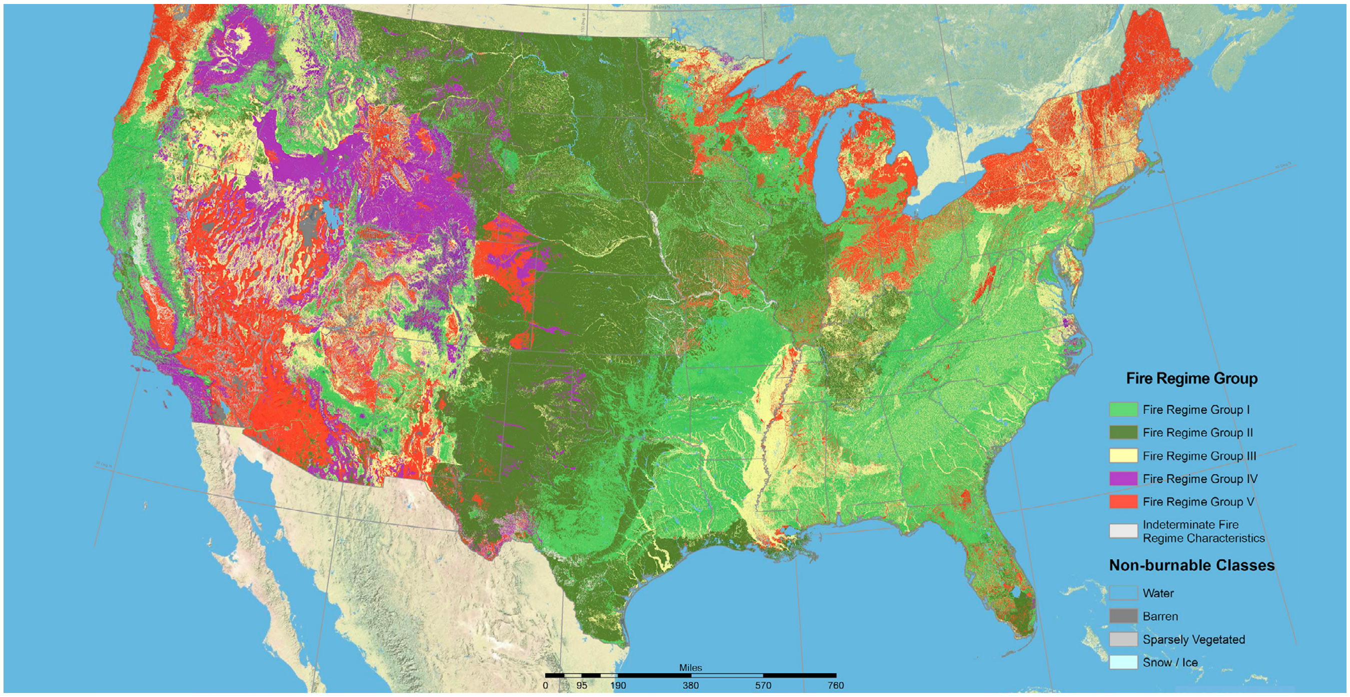


Figure 3. LANDFIRE Fire Regime Groups for the lower 48 US states. Data is publicly available at: https://www.landfire.gov/geoareasmaps/2012/CONUS_FRG_c12.jpg.

For example, research conducted in the Southern and Central Rocky Mountains has found that MFRIs for the modern period (1912-1996; 3.5-4.4 years) increased from the Euro American settlement period (1868-1911; 1.9-2.9 years), suggesting that fire suppression has altered fire regimes in subalpine and montane forests of the Rocky Mountains (Kipfmueller and Baker 2000). This region has then presumably experienced an increase in fuel accumulation due to active fire suppression, which likely affects fire ignition and spread due to a large availability of fuel with greater continuity. Combined with suppression of these wildfire ignitions and increasing MFRIs, more fuel is available for future wildfires to spread (National Commission on Wildland Disasters 1994). Therefore, management of wildland fire is exceedingly complex.

Fire Rotation

Fire rotation is another way to quantify fire regimes. Fire rotation is defined as the time required to burn a land area equal in size to the area being investigated (Romme 1980). In the Routt National Forest in Northern Colorado, fire rotation in Pre-Euro American time periods was found to increase from 127 years to 27,035 years in modern times (Kipfmueller and Baker 2000). In Yellowstone National Park, the fire frequency was found to range from 111-256 years pre-1900, and increased to 3,703 years post-1900 (Barrett 1994). Studies conducted at Mt. Rainer, Washington (Hemstrom and Franklin 1982) and Kootenay National Park, British Columbia (Masters 1990) revealed a similar trend in increasing fire rotations from pre-1900 to post-1900. This research suggests that fires have been actively suppressed in high-elevation forests over the last century, subsequently influencing fire rotation and then ultimately altering fuel structure and loading.

Livestock Grazing and Logging

Livestock grazing has influenced fuel loads of many 1-hour (<0.25 inches in diameter) and 10-hour (0.25-1 inch in diameter) fuels including annual grass cover, perennial grass cover, shrub cover, and the continuity of fuels (Strand et al. 2014). Livestock grazing has the ability to reduce fine fuel loads, thereby reducing probabilities of ignition and rates of spread (Strand et al. 2014; Bruegger et al. 2015). In addition, logging practices throughout the contiguous United States has caused widespread changes in forest vegetation condition (Naficy et al. 2010). Additionally, interactive effects of both logging practices and wildland fire suppression exceed the effects of fire exclusion alone, and historically logged areas might be more prone to severe wildfires and insect outbreaks and should be considered as priority areas for fuel reduction treatments (Naficy et al. 2010).

Global Climate Change And Fire

Global climate change is a current issue influencing ecology generally at a global scale and wildland fire at local, regional, and global scales (Flannigan et al. 2000; Stavros et al. 2014; Jolly et al. 2015). Climate change has begun to induce non-normal climate variations, and these modifications have already led and will continue to lead to altered fire behavior and regimes (Jolly et al. 2015; Westerling et al. 2006).

In general, increased wildland fire activity over recent decades can be largely attributed to sub-regional responses to a changing climate (Westerling et al. 2006). The current forecasts further suggest that global climate change will continue to influence wildfire behavior, management, and effects (Stavros et al. 2014).

Fire Frequency

Fire frequency of very large wildfires (VLWF; defined as greater than 50,000 acres (20,234 ha)) is projected to increase from 2031-2060 as compared to baseline datasets from 1950-2005 (Stavros et al. 2014). Models that predict at least a 30% increase in the probability of VLWF also project an increase in the days and months of extreme weather conditions with high fire danger and low fuel moisture (Stavros et al. 2014). An increase in observed forest wildfire frequency is correlated to the expression of earlier spring-like weather, abnormalities in streamflow, and earlier snowmelt dates (Westerling et al. 2006).

Fire Size

Observed inter-annual changes in mean fire weather season length have been significantly correlated to variation in annual area burned (Jolly et al. 2015), both of which are projected to increase. Additionally, the amount of global burnable area affected by long fire weather seasons has doubled during the last 3+ decades (1979-2013; Jolly et al. 2015). Flannigan and VanWagner (1991) discovered an average projected increase of 50% in total area burned across Canada with climate change models. Also, in particular, mixed fire regime forests may undergo increases in lightning-ignited fires, area burned, and proportion of area burned at higher severities (Lutz et al. 2009). These results are echoed by Price and Rind (1994) who projected a 44% increase in lightning caused-fires in the United States by the end of the 21st century and a subsequent 80% increase in associated area burned. Flannigan et al. (2005) developed project models parameterized with historical weather, fire danger, and area burned data to estimate a 74-118% increase in the area burned in Canada by the end of the next century. Westerling et al. (2006) observed increases in the incidences of large wildfires (defined in the study as fires >988 acres [>400ha]) in the western United States forests from 1980-2003, which was correlated with wildfire sensitivity and snowmelt timing. Large-scale studies indicate recent increases in both annual area burned and fuel size in North America (McKenzie et al. 2004; Flannigan et al. 2005; Westerling et al. 2006). These projected changes are not just a function of increased fuel loads or changing fire seasons, but are also a function of fuel moisture as Abatzoglou and Williams (2016) attributed global climate change and fire trends with increased fire-season fuel aridity.

Fire Seasonality

Global wildland fire season length increased by 18.7% from 1979 to 2013 and the frequency of abnormally long fire weather seasons also increased 53.4% worldwide during the same time period (Jolly et al. 2015). Westerling et al. (2006) also observed an increase in the length of wildfire season of 78 days from 1970-1986 to 1987-2003 in the western United States. Half of this increase was attributed to earlier ignitions in the wildfire season, and was moderately correlated with regional spring and summer temperatures (Westerling et al 2006). In addition, Westerling et al. (2006) discovered a substantial increase in the length of time wildfires burned. For example, the average number of days between discovery of fires and control of fires increased from 7.5 days during 1970-1986 to 37.1 days during 1987-2003 (Westerling et al. 2006). Moreover, global climate change models project even longer seasons of high fire potential (Stavros et al. 2014; Liu et al. 2013) in addition to longer fire seasons. With continued snow water equivalent decreases congruent with decreased snowpack, landscape flammability could increase and become more variable (Lutz et al. 2009). Furthermore, changes in relative humidity, as a result of global climate change, are projected to increase the number of high fire danger days in the western United States, particularly in the northern Rockies, Great Basin, and the Southwest (Brown et al. 2004). Additionally, Energy Release Component values (ERC), an indication of both fire severity and fire activity (Brown et al. 2004), for nearly the entire western United States is expected to experience increases in the number of days to weeks that the

ERC threshold index is 60 or greater. ERC values are a composite of live and dead fuel moistures, and this threshold corresponds to watch-out conditions. These watch-out conditions have produced a large majority of the largest and most expensive fires experienced in the United States (Brown et al. 2004).

Fire Weather

Studies have suggested that temperature is the most important variable influencing wildland fire activity. This positive relationship affects fire weather by increasing evapotranspiration in the atmosphere, lowering the water table position, and decreasing fuel moisture in the absence of large precipitation events (Flannigan et al. 2013). Vapor pressure deficit (VPD), an absolute measure of the moisture deficit in the atmosphere (Seager et al. 2015), has exhibited trends toward higher VPD values since 1961, which are consistent with identified trends in wildland fires (Dennison et al. 2014; Seager et al. 2015). VPD is closely related to water stress on vegetation, and subsequent fuels (Seager et al. 2015), which drives probability of ignition. Fire weather is influenced by temperature, precipitation, humidity, and wind, all variables that are predicted to change as a result of climate change throughout the world. Even though global fire weather changes will be spatially variable, these changes in fire weather have the potential to be extreme (Flannigan et al. 2009).

Beetle Kill-Induced Mortality of Conifers

The Beetle Kill Epidemic

Of particular concern in western North America forests is the increase of bark beetles. While there are hundreds of species of bark beetles that live in dead or dying trees, mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreaks have escalated in the last several decades, and combined with wildfire, present two disturbance processes that are both interactive and influenced by climate (Westerling et al. 2006; Bentz et al. 2010). In recent decades, wildland fires have burned millions of acres in western North America (Littell et al. 2009) and bark beetle epidemics have affected tens of millions acres since 1990 (Raffa et al. 2008). As a partial consequence, and in addition, both fire and bark beetle outbreaks have increased in both severity and extent in western North America (Simard et al. 2011) (Figure 4). Similarly, both disturbances are projected to increase with forecasted climatic changes (Bentz et al. 2010; Pechony and Shindell 2010). Over the past century, the beetle epidemic in forests of the western United States has been unprecedented in extent, severity, and duration (Raffa et al. 2008). In southern Wyoming and northern Colorado alone, over 3.7 million acres of forest have been affected by the mountain pine beetle resulting in extensive mortality of lodgepole pine (*Pinus contorta* Douglas ex Loudon). Bark beetle epidemics have caused a substantial shift in species composition and induced alterations in fuel structures; however, bark beetles and their interactive effects with fuel accumulation and fire behavior continue to be poorly understood (Jenkins et al. 2008).

Figure 4: Bark beetle and wildfire patterns from the Beaver Creek wildfire of 2016 in Colorado and Wyoming on the Medicine Bow and Routt National Forests. Photo credit to Bryn Marah.

Beetle Kill and Fire

Beetle killed stands often exhibit changes in fuel structure, displaying both live and dead standing biomass and subsequent crown fuels that transition to ladder fuels and coarse woody fuels (Jenkins et al. 2008). Alterations in fuel structure hold the potential to change the types and intensities of wildland fires. Increased heat release, more active burning and increased burn duration are important factors that result from increased accumulations of large-diameter fuels and their promotion of long-term smoldering and slow-spreading surface fires (Page and Jenkins 2007). These types of changes; however, are dependent on factors such as time since outbreak and fuel and fire characteristics of interest (Hicke et al. 2012). Overall, bark beetle epidemics have induced changes in fuel structure that cause more extreme crown behavior, increased down woody debris, altered fuel moisture, and increased probabilities of ignition (Hicke et al. 2012). In addition, large diameter fuels accumulate on the forest floor as a result of beetle kill-induced mortality. These large diameter fuels contribute to heat retention, soil heating, fire brands, and spot fires (Monsanto and Agee 2008; Koo et al. 2010).

Fire In The 21St Century

Wildland Fire

Federal fire fighting costs for suppression activities have steadily increased from 1985 to 2018. The total cost of federal suppression efforts was estimated at $3,143,256,000 for the 2018 wildfire season – the first year in our history to surpass the 3 billion dollar level. Of the total suppression costs in 2018, 83.2% was paid by the U.S. Forest Service, while the Department of the Interior provided 16.8% (NIFC 2018; Figure 5).

Based on projections from wildfire expenditure data from 1985-2018, total federal expenditure for wildfires are projected to exceed 3 billion USD every year in the near future (Figure 6).

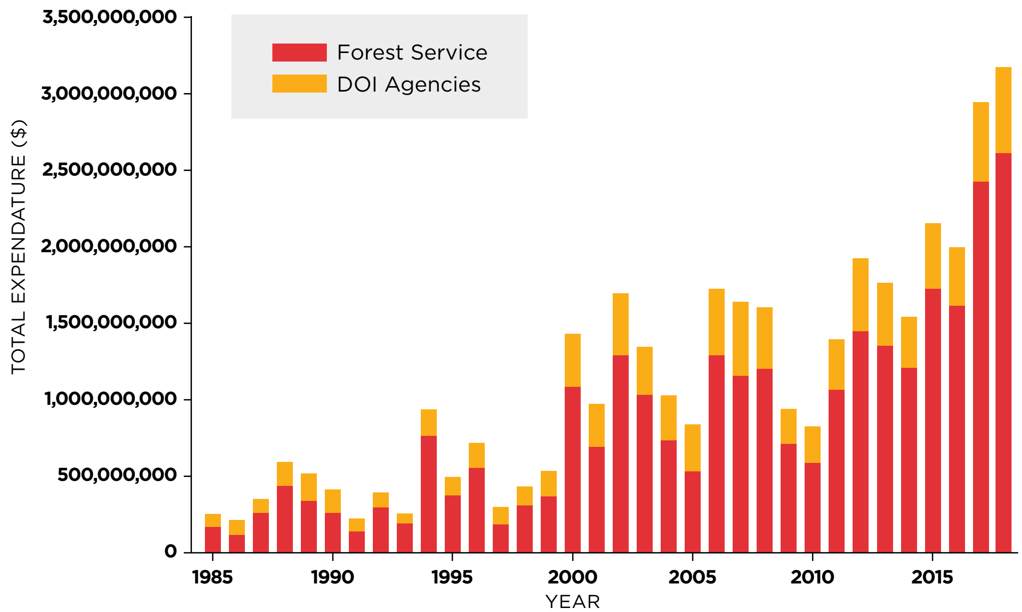


Figure 5. Total federal expenditure ($) for wildland fire suppression from 1985-2018 for the USA by respective federal agencies. Data publicly available from the National Interagency Fire Center.

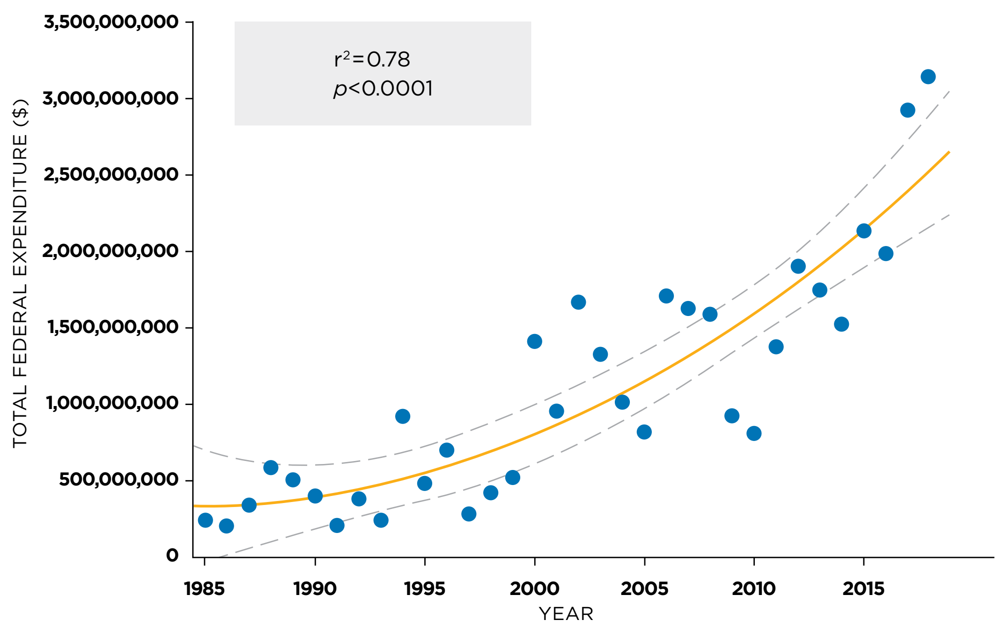
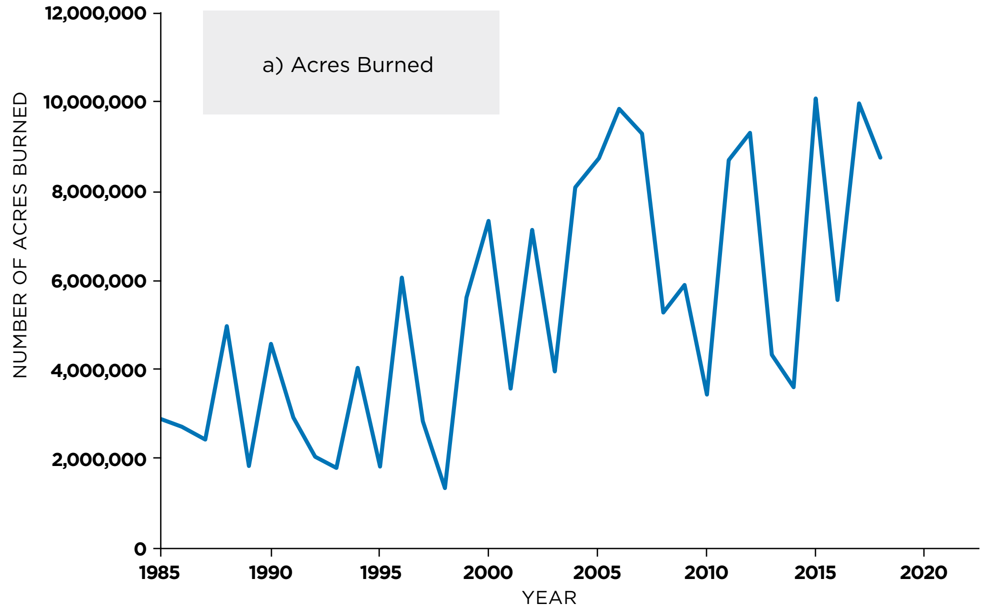


Figure 6. National total federal expenditure ($) for wildland fire suppression from 1985-2018 for the USA. The fit linear trendline in this analysis is significant ($p < 0.0001$) and explains 78% of the variation ($r^2 = 0.78$) of the variation between year and total federal expenditure. Data is publicly available from the National Interagency Fire Center.

In 2018, federal expenditure for fire suppression exceeded 3 billion USD for the first time in history. Part of the explanation for the increase in the cost of combatting wildfires is attributed to an increase in the number of acres burned annually (from 2,896,147 acres in 1985 to 10,026,086 acres in 2018, a 3.5-fold increase) (Figure 7a), while the number of wildfires from 1985-2018 has slightly increased, on average (ranging from 47,579 to 58,083 fires) (Figure 7b).



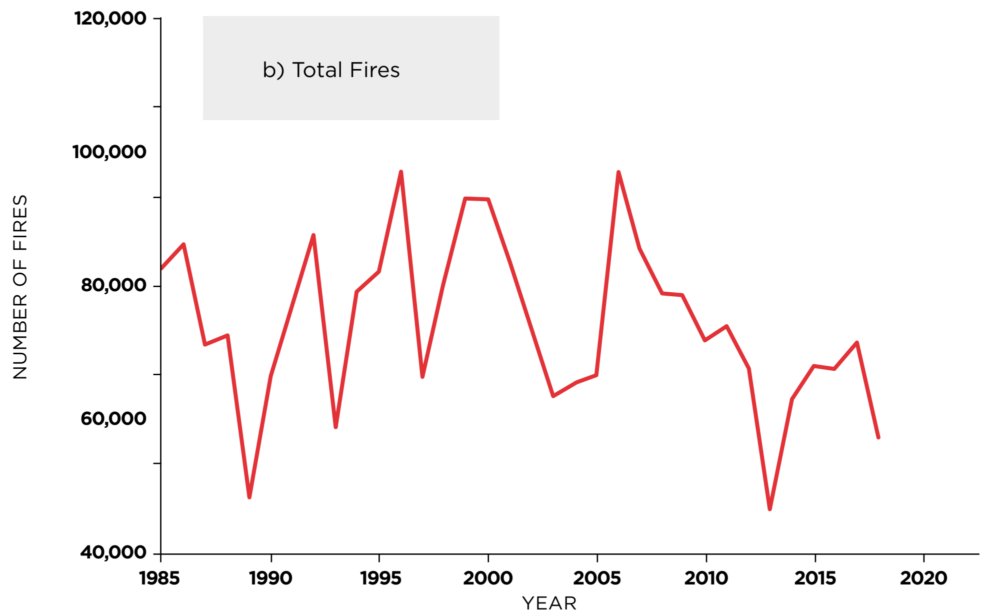


Figure 7. (a) The total number of acres burned annually from 1987-2018 and (b) the total number of wildfires and total number of acres burned from 1987-2018 for the USA. Data gathered from the National Interagency Fire Center.

The relationship of total wildfires to total acres burned has increased substantially from 1985 to 2018 (NIFC 2018) likely as a function of management and climatic changes. The most notable fires, consuming the most acreage from 1997-2018 include the 2004 Taylor Complex in Alaska (1,305,592 acres), the 2006 East Amarillo Complex in Texas (907,245 acres), the 2017 NW Oklahoma Complex in Oklahoma (779,292 acres), the 2007 Murphy Complex in Idaho (652,016 acres), and the 2009 Rainbelt Complex in Alaska (636,224 acres; NIFC 2017). These five largest historical wildfires on record since 1985 have occurred in the last 13 years – the latter half of this 3+ decade period of record.

Fuel Mitigation

In 2000, the USFS and the Department of the Interior (DOI) developed the National Fire Plan and in 2003, President Bush signed the Healthy Forests Restoration Act. The National Fire Plan and Healthy Forests Restoration Act both emphasize the following actions: modification of forest fuels so that fires will be easier to control causing less damage; ensuring that firefighters have access to resources in the face of wildland fires; and conducting emergency stabilization and rehabilitation after wildland fires to limit further damage and promote recovery in the forest (Donovan and Brown 2007). Land management agencies have responded to this legislation and current fire conditions by employing treatments such as prescribed fire and thinning (both separately and combined) in an attempt to reduce fuel loading and reintegrate natural fire into ecosystems. These treatments substantially reduce the intensity of simulated wildland fires across the Rocky Mountains (Fiedler et al. 2002, 2004) and are the first step in a process to reintegrate natural fire into the ecosystem. Managers must choose between a small suite of fuel mitigation tools to meet objectives while maximizing efficiency, adhering to public perception, and reducing unnecessary expenditure.

Prescribed Fire

Prescribed fire is a fuel mitigation tool that more closely mimics natural fire than other fuel reduction strategies. Prescribed fire also provides more safety for fire fighting personnel and reduces potential transitions into unwanted stable states post-fire as opposed to wildfire response and effects (Battaglia et al. 2009). Prescribed fires are applied with highly trained staff that use a suite of specific ignition techniques and safety protocols to accomplish their objectives. (Figure 8).

Prescribed fires are only ignited within a set of prescription parameters that matches weather criteria and fuel models to maximize safety and control. For example, prescribed fires are typically conducted under higher relative humidity and lower wind speeds than are characteristic of wildfires. Prescribed fire has increased in the United States from 1998-2018 more than seven-fold from the 878,290 acres burned in 1998 to more than 6 million acres in 2018 (NIFC 2017) (Figure 9).

Figure 8. Prescribed fire using very precise ignition techniques, fire types, and safety precautions. Photo Credit to John Derek Scasta.

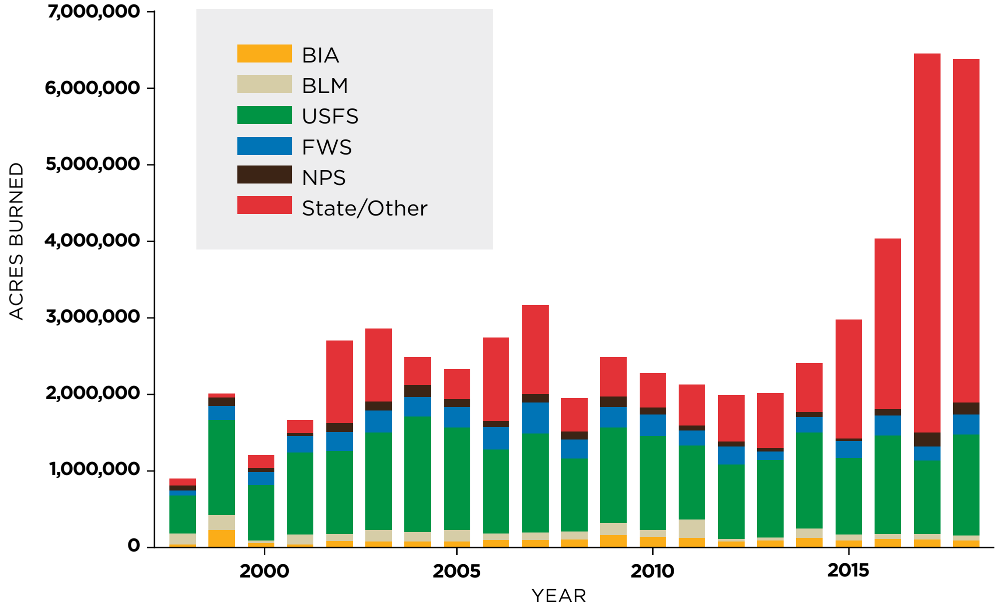


Figure 9. Total number of prescribed fires acres by year and entity for the USA from 1998-2018. Data are publicly available from the National Interagency Fire Center.

Figure 10. Federal application of prescribed fire in mixed forest-shrub-grassland systems in Wyoming. Photo credit to Tom Gonnoud.

The USFS leads in area burned by prescribed fire based on the 10-year average (NIFC 2018; Figure 10). However, public perception surrounding prescribed fire does not always allow for its implementation. In a study by Brunson and Schindler (2004) examining acceptability for fuels treatment options in Arizona, Colorado, Oregon, and Utah, researchers found the highest acceptability of 56% for prescribed fire in Oregon. Acceptability ratings for prescribed fire as a "legitimate tool to be used anywhere" were lower for Colorado, Arizona, and Utah at 48%, 46%, and 37% respectively. On average, 43.3% of residents in the study among all four states provided a response that prescribed fire should be used infrequently in selected areas. In areas where the social license does not exist to use prescribed fire as a fuel mitigation tactic, public land managers often resort to 'non-fire' tools. These tools are often more expensive to implement, and often do not possess an ecological proxy.

Mechanical Removal

Mechanical treatments can include mastication, thinning, and logging. Mastication is a fuel mitigation treatment that allows for precise manipulation of overstory fuels through mulching, chipping, shredding, or mowing (Kreye et al. 2014) (Figure 11). This method reduces vertical fuel continuity and redistributes the fuel particles to the forest floor (Kreye et al. 2014).

This tactic is more expensive than prescribed fire, and the accumulation of woody debris on the forest floor can influence understory vegetative community responses (Schwilk et al. 2009; Kreye et al. 2014; Clyatt 2017).

In addition, there is a general lack of knowledge quantifying the probability of ignition, fire behavior, long-term smoldering, and ecological effects on the ecosystem in masticated systems (Knapp et al. 2012; Kreye 2012; Brewer et al 2013; Kreye et al 2013). However, mastication can be utilized as a stand-alone treatment, or combined with other treatments such as prescribed burning to meet objectives and more closely mimic ideal fuel structure and composition (Battaglia et al. 2010; Reiner et al. 2009). Public perception regarding mechanical removal as a fuels treatment in Arizona, Colorado, Oregon, and Utah had on average a 56.5% acceptance (Brunson and Shindler 2010).

Figure 11. Mastication to manage conifer stand density in mixed forest-shrub-grassland systems. Photo Credit to Daron Reynolds.

Livestock Grazing

Livestock grazing is a fuel mitigation treatment that targets understory vegetation that can include herbaceous plants and shrubs, but generally not forest overstory fuel features (Figure 12). This tactic can be especially useful in areas with difficult terrain such as steep slopes. In southern Arizona, light cattle grazing (26% utilization) reduced fire rates of spread by greater than 60% in grass communities, and by greater than 50% in grass/shrub communities. Grazing also significantly reduced flame lengths in these same fuel types (Bruegger et al. 2015). In addition, public perception towards using livestock grazing as a fuel mitigation tool to reduce fine fuels in Arizona, Colorado, Oregon, and Utah resulted in an average 66.3% acceptability, the highest in the study (Brunson and Shindler 2004). Livestock grazing can be utilized independently, or in combination with other fuel mitigation tools, to meet fuel reduction objectives.

Viability of Fuel Mitigation Treatments

Despite the increased implementation of fuel mitigation treatments, these treatments alone are not enough to combat anticipated increases in wildland fire intensity, frequency, and area burned. Despite progress in fuel reduction by land management agencies, fire weather and fuel conditions enhanced by global climate change may create intense fires with a broad suite of both positive and negative effects. Flannigan et al. (2000) suggests that fuel reduction strategies can be implemented at local levels to protect areas at risk, yet at the larger, national scale, fuel management is not possible. Therefore, it is necessary to explore the impacts and effects of wildland fire in different spatial settings to begin to understand the variability of wildland fire and respond accordingly to enhance post-fire recovery.

Figure 12. Cattle grazing in the Medicine Bow National Forest of Wyoming. Photo credit to John Derek Scasta.

Figure 13. Varying burn severity patterns after a wildfire near the Wyoming-Colorado border. Photo Credit to Bryn Marah.

Moving Forward and Planning for Ecological Effects Post-Wildfire

With projected increases in annual wildfire area burned and fuel size in North America (McKenzie et al. 2004; Flannigan et al. 2005; Westerling et al. 2006), in combination with projections for longer wildfire seasons (Westerling et al. 2006) and increased landscape flammability (Lutz et al. 2009), much is uncertain about subsequent fuel structures, fire behaviors, and ecological effects post-fire. Altered fuel structures and the subsequent release of heat to the forest floor from increased large diameter fuels may influence the response of vegetation post-fire as well as soil and site stability and hydrologic function. The ecological effects from the projected new generation of wildland fires in the Rocky Mountains is unknown. Quantifying short-term recovery and site stability after heterogeneous and complex fires is needed to effectively make forest restoration and management decisions (Westerling et al. 2006) (Figure 13).

Modern fire responders and ecologists must embrace a “new normal” to enhance protection and restoration post-fire. To accomplish this goal, more seamless interaction between both parties must ensue, and new, advanced technologies should be adopted to maximize efficiency and effectiveness.

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