Policy Analysis Group – College of Natural Resources

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Fuel Treatments in Idaho's Forests: Effectiveness, Constraints, and Opportunities

by

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About the Policy Analysis Group (PAG)

Role and Mission. The Idaho Legislature created the Policy Analysis Group (or "PAG") in 1989 as a way for the University of Idaho to provide timely, scientific and objective data and analysis, and analytical and information services, on resource and land use questions of general interest to the people of Idaho. The PAG is a unit of the College of Natural Resources Experiment Station, administered by Kurt Pregitzer, Director, and Dean, College of Natural Resources.

PAG Reports. This is the thirty-fifth report of the Policy Analysis Group (see inside cover). The PAG is required by law to report the findings of all its work, whether tentative or conclusive, and make them freely available. PAG reports are primarily policy education documents, as one would expect from a state university program funded by legislative appropriation. The PAG identifies and analyzes scientific and institutional problems associated with natural resource policy issues. In keeping with the PAG's mandate, several alternative policy options are developed and their potential benefits and detrimental effects are analyzed. As an operational policy the PAG does not recommend an alternative.

Advisory Committee. A standing Advisory Committee (see inside cover) has specific functions assigned by the PAG's enabling legislation. The committee's main charge is to review current issues and suggest topics for analysis. Based on those suggestions, the dean of the College of Natural Resources works closely with the PAG director to design analysis projects. The Advisory Committee has a responsibility to suggest the appropriate focus of the analysis. This is done iteratively, until an outline for the project is mutually agreed upon by the committee and the PAG. The outline is usually organized as a series of focus questions, and the PAG's analytical tasks are to develop replies to the questions. The PAG uses the resources of the university and other public and private organizations as needed. When the PAG becomes active on a project, the Advisory Committee receives periodic oral progress reports. This process defines the scope of PAG report content and provides freedom for the PAG to conduct unbiased analysis.

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Executive Summary

Wildfires in Idaho and throughout the western United States have increased in extent and intensity over the past 25 years, resulting in increased severity of adverse effects, including increased risks to firefighters, personal property, and ecosystem services, as well as increased costs for fire suppression and forest rehabilitation. One response to such wildfire problems is to design and implement fuel treatments in an attempt to reduce the severity of effects from wildfires. Fuel treatments lessen the amount of fuel available for burning and/or rearrange fuels to increase the probability that they burn with less intensity.

Researchers have studied fuel treatment effectiveness after wildfires have occurred, and those studies are synthesized herein. In addition, this report examines the risks associated with fuel treatments, summarizes policies that currently affect fuel treatment implementation, and suggests policy options that may increase fuel treatment effectiveness. The following focus questions and brief replies provide the outline of the report.

What factors influence wildfire frequency, intensity and extent in Idaho's forests? Wildfire behavior is influenced by weather, topography, and fuel. Fuel is the only factor that can be affected directly by forest management actions. Differences in amounts of fuels, their types, and their arrangement across the landscape are important factors in determining a fire's characteristics.

What alternative fuel treatments exist? Fuel treatments widely used by forest managers include prescribed fire, mechanical treatments, or a combination of the two. In addition, previous wildfires, timber stand improvements, and commercial timber harvests can functionally serve as fuel treatments although the activities are undertaken for other purposes.

How is effectiveness of fuel treatments measured? The direct goal of treating fuels is to modify potential fire behavior or its effects to achieve a defined purpose, but the reasons for wanting to affect fire behavior can be numerous and varied. Fuel treatments may be implemented to reduce wildfire severity (the effects of a fire's heat, or intensity, on biotic and abiotic ecosystem properties), to aid in fire suppression, to protect human settlements and structures, or a combination of these or other reasons. Measures of the effectiveness of fuel treatments can vary depending on the objectives of treatment and may differ between undeveloped forests and the wildland urban interface.

How effective are fuel treatments during wildfires? Scientists and forest managers generally agree that fuel treatments can be effective, but effectiveness varies according to weather, type of vegetation, type and extent of treatment, time since treatment, and intensity of fire when it encounters a treated area. Fuel treatments have been shown to be effective at reducing wildfire severity at the stand level, and research is beginning to show their effectiveness at the landscape scale. However, research is less clear about how much of the landscape needs to be treated to reduce wildfire severity overall.

What are the risks of implementing fuel treatments? All forest management actions involve risk. Risks can be short term, from the activities themselves, such as an escaped prescribed fire, or manifest themselves in the long term, such as negative effects on site productivity from soil compaction due to mechanical thinning operations. Other risks include increased flammability from activity fuels, negative effects on understory microclimate, favorable conditions for invasive species, negative effects on some wildlife, and adverse effects on water quality and quantity. Reducing risks to an acceptable level of results is challenging.

What policies currently guide implementation of fuel treatments? More than three-fourths of the forests in Idaho are the administrative responsibility of the U.S. Forest Service, an agency in the U.S. Department of Agriculture tasked with managing the National Forest System. The federal Bureau of Land Management, an agency in the U.S. Department of the Interior, also is responsible for some forest lands in Idaho. There is not a single, overarching federal law that guides fuels treatment implementation on federal forests, but rather numerous laws, regulations, and other policy documents provide some guidance. Land use planning laws and regulations guide the agencies' decision processes, in conjunction with the National Environmental Policy Act. Laws protecting air quality play important roles for some fuel treatment methods, particularly prescribed fire. States are responsible for implementing many requirements of federal clean air statutes, and states have primary responsibility for laws that protect state and private forest lands from wildfire.

What policy options might improve fuel treatment effectiveness in Idaho's forests? Numerous policy, financial, and market constraints currently limit the amount of fuel treatments that can be undertaken. Wildfire management and fuel treatment policies are not always congruent and could be improved by better articulating goals and improving the accountability of programs. Enhanced collaboration between levels of government and with communities and stakeholders is needed. An adaptive management approach could potentially improve fuels treatment programs and policies.

Despite elevated risks from wildfire, fuel treatment policy is inherently about political choices of priorities and programs, and it is unclear where fuel treatments fall in national political priorities. The public must understand that there will be no quick fixes or magic bullets, and undoing the effects of a century of fire exclusion will require patience, cooperation, and tolerance for mistakes.

Chapter 1. Introduction

This report examines fuel treatment effectiveness in the forests of Idaho by summarizing the results of studies that have looked at fuel treatment effects after wildfires in Idaho and comparable forests in other western states. In general, effectiveness means reducing the adverse consequences of wildfire on the landscape as well as in human communities. Researchers have written hundreds of articles about fuel treatment strategies and effectiveness in forests. Many research studies have used predictive simulation models to estimate the effectiveness of fuel treatments under variable, hypothetical wildfire conditions. Models are simplifications of more complex conditions that occur during actual wildfire events. A growing number of studies have examined fuel treatment effectiveness in forests after actual wildfires have occurred; we summarize the findings of those studies herein.

In addition, this report examines the risks associated with fuel treatments, summarizes policies that currently affect fuel treatment implementation, and suggests policy improvements that may increase fuel treatment effectiveness. The following seven focus questions serve as the outline for this report, each within its own chapter:

- What factors influence wildfire frequency, intensity and extent in Idaho's forests?
- What alternative fuel treatments exist?
- How is effectiveness of fuel treatments measured?
- How effective are fuel treatments during wildfires?
- What are the risks of implementing fuel treatments?
- What policies currently guide implementation of fuel treatments?
- What policy options might improve fuel treatment effectiveness in Idaho's forests?

Idaho's forests

Forests cover about 21.4 million (40%) of the 53.5 million acres of land in Idaho (Witt et al. 2012). The forests of Idaho are diverse in both the characteristics of the sites where they exist and the types of trees on those sites. Ecologists have classified Idaho's forests into three broad categories—cold forests, mesic (or wet) forests, and dry forests—based on their "environmental site potential" (ESP), or the type of vegetation an area could support based on biophysical site characteristics such as climate, substrate (soil, water, organic debris, etc.), and topography (Comer et al. 2003, Morgan et al. 2008). Cold forests are often dominated by lodgepole pine, subalpine fir, Engelmann spruce, and other cold-tolerant tree species. Mesic forests are dominated by a mixture of conifer species, including grand fir, Douglas-fir, western larch, western hemlock, and western redcedar. Dry forests are dominated by ponderosa pine and Douglas-fir. In Idaho, cold, mesic, and dry forests occupy 27% (5.8 million acres), 35% (7.5 million acres), and 38% (8.2 million acres) of the forested area, respectively (**Figure 1-1**).

History of fire in Idaho's forests

The forests of Idaho have evolved with fire, but historically, different types of forests developed under different "fire regimes." Fire regime is a term fire ecologists use to generally and broadly describe the nature of fire occurring over long periods and the prominent immediate effects of fire that characterize an ecosystem (Brown 2000). Characteristics used to define a fire regime can include fire frequency, severity, intensity, and extent (Agee 1996, Brown 2000, Lutz et al. 2011). Fire frequency describes how often fires occur. Fire severity refers to the degree to which a site is altered or disrupted by fire, which is loosely determined by fire intensity, fuel consumption, and the amount of time a fire burns on a site (SAF 1998,

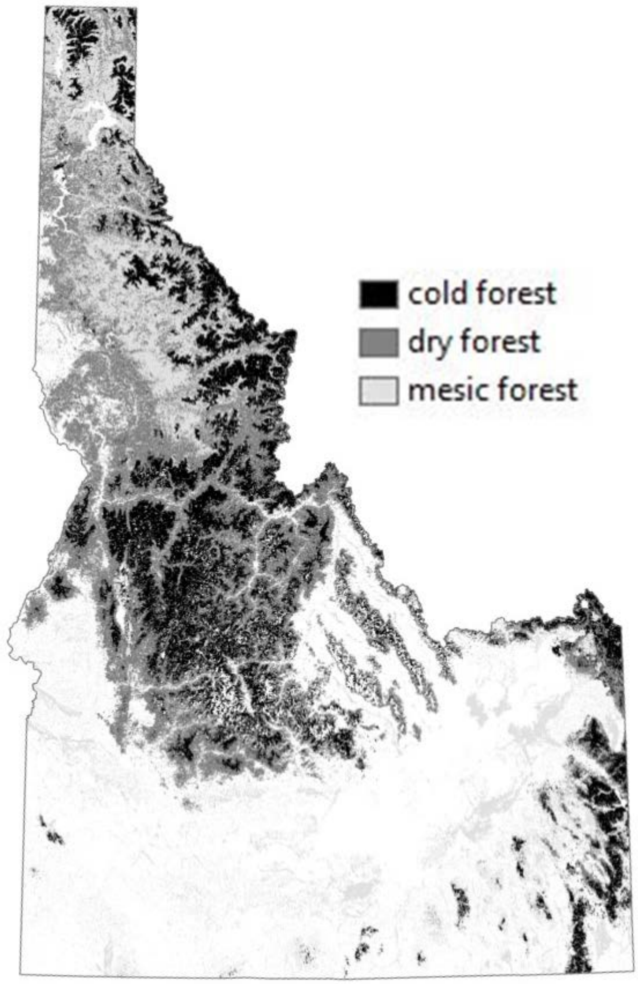

Figure 1-1. Categories of forests in Idaho.
Data source: LANDFIRE 2010a.

Van Wagendonk 2006, NWCG 2011). Fire intensity refers to the rate of heat released by a fire (SAF 1998, Forest Encyclopedia Network 2011). Flame length is a measure of fire intensity (NWCG 2011). Fire extent refers to the size or spatial area of a fire or fires. Numerous fire regime classification systems exist and have been applied to the forests of Idaho (e.g., Quigley and Arbelbide 1997, Arno 2000, Brown 2000, Van Wagendonk 2006).

The federal LANDFIRE (Landscape Fire and Resource Management Planning Tools) program defines five "natural" fire regime groups (**Table 1-1**; Barrett et al. 2010). A natural fire regime is based on the role fire would play across a landscape in the absence of modern human intervention but including the possible influence of aboriginal fire use.

Idaho's forests are classified in a variety of fire regime groups (FRG; **Table 1-2**). Most (61%) of Idaho's dry forests historically experienced a low-frequency, low- or mixed-severity fire regime (FRG I), with most of the remaining dry forest (33%) experiencing a longer fire return interval and low or mixed fire severity (FRG III). Most (60%) of Idaho's cold forests experienced high-severity, stand replacement fires every 35 to 200 years (FRG IV). Mesic forests are classified primarily in FRG III (54%) and FRG IV (35%).

Table 1-1. Fire regime groups.

Group	Frequency	Severity	Severity description
I	0-35 years	Low/mixed	Generally low-severity fires replacing less than 25% of the dominant overstory vegetation; can include mixed-severity fires that replace up to 75% of the overstory.
II	0-35 years	Replacement	High-severity fires replacing greater than 75% of the dominant overstory vegetation.
III	35-200 years	Mixed/low	Generally mixed-severity; can also include low-severity fires.
IV	35-200 years	Replacement	High-severity fires.
V	200+ years	Replacement/ any severity	Generally replacement severity; can include any severity type in this frequency range.

Source: Barrett et al. 2010.

Alterations to historical fire regimes and vegetation dynamics have occurred across many landscapes in the U.S., including Idaho's forests. Fire regimes have changed for numerous reasons including land management practices, fire exclusion, livestock grazing, insect and disease outbreaks, invasion of non-native plant species, and climate change (Brown 2000, Fulé et al. 2012, Jain et al. 2012). Fire scientists describe these departures from historical conditions in terms of "fire regime condition class" (FRCC), also called "vegetation condition class."

FRCC reflects the degree of departure of current conditions from reference conditions in terms of two main ecosystem components: fire regime and associated vegetation (Hann et al. 2008). Three FRCCs are defined based on the following criteria: FRCC 1 represents ecosystems with low (<33%) departure from reference conditions and that are still within the estimated historical range of variation of a specifically defined reference period; FRCC 2 indicates ecosystems with moderate (33% to 66%) departure; and FRCC 3 indicates ecosystems with high (>66%) departure.

Most of Idaho's forests are in conditions different from their historical fire regime and associated vegetation (**Table 1-3**). Departures from historic conditions are particularly evident in Idaho's dry forests where 81% are in FRCC 2 and 6% are in FRCC 3.

Departures from historical fire regimes in western U.S. forests, including those in Idaho, have been primarily from low-severity regimes to high-severity regimes (Quigley and Arbelbite 1997). These increases in fire severity have been driven, in part, by increases in fuel, or the amount of vegetation, both alive and dead, in the forests (Brown 2000, Peterson et al. 2005, IDL 2010).

Table 1-2. Fire regime group (FRG) by forest category in Idaho, millions (M) of acres.

Category	FRG I	FRG II	FRG III	FRG IV	FRG V	Total
Cold forest	0.2M	<0.1M	1.5M	3.4M	0.6M	5.8M
(% of category)	4%	<1%	26%	60%	10%	100%
Dry forest	5.0M	0.2M	2.7M	0.3M	<0.1M	8.2M
(% of category)	61%	2%	33%	4%	<1%	100%
Mesic forest	0.4M	<0.1M	4.0M	2.6M	0.4M	7.5M
(% of category)	6%	<1%	54%	35%	5%	100%
Total	5.6M	0.2M	8.3M	6.4M	0.9M	21.4M
(% of category)	26%	1%	39%	30%	4%	100%

Data sources: LANDFIRE 2010a and 2010b.

Table 1-3. Fire regime condition class (FRCC) by forest category in Idaho, millions (M) of acres.

Category	FRCC 1	FRCC 2	FRCC 3	Total
Cold forest	1.8M	3.9M	0.1M	5.8M
(% of category)	30%	68%	1%	100%
Dry forest	1.1M	6.6M	0.5M	8.2M
(% of category)	14%	81%	6%	100%
Mesic forest	3.1M	4.0M	0.4M	7.5M
(% of category)	41%	54%	5%	100%
Total	5.9M	14.5M	0.9M	21.4M
(% of category)	27%	69%	4%	100%

Data sources: LANDFIRE 2008 and 2010a.

The area burned, or extent of wildfires, in Idaho also has changed over the last century. The last century's wildfire extent history can be divided into three periods: 1900-1934, 1935-1973, and 1973-present (Morgan et al. 2014; **Figure 1-2**). The extent of wildfires during the early period is comparatively large because the ability of forest managers to suppress wildfires was limited. The extent of wildfires during the middle period is comparatively small, in part, because of aggressive and effective wildfire suppression and a cooler, wetter climate. The most recent period shows an increase in fire extent from the previous period. Among the reasons for the recent increase in wildfire extent are: less aggressive fire suppression policies (Morgan et al. 2014), a warmer and drier climate (Westerling et al. 2006), and increased fuel loads in forests (Brown 2000, Graham et al. 2004).

Because Idaho's forests historically developed with wildfire, fire is ecologically important and beneficial to forests if it occurs with the frequency and severity that it historically did (Smith 2000, Brown and Smith 2000, Neary et al. 2005a, Keane and Parsons 2010, Hood et al. 2012). The ecological benefits of fire include increased nutrients and productivity in soil systems when burned material decomposes, improved conditions for surviving trees during

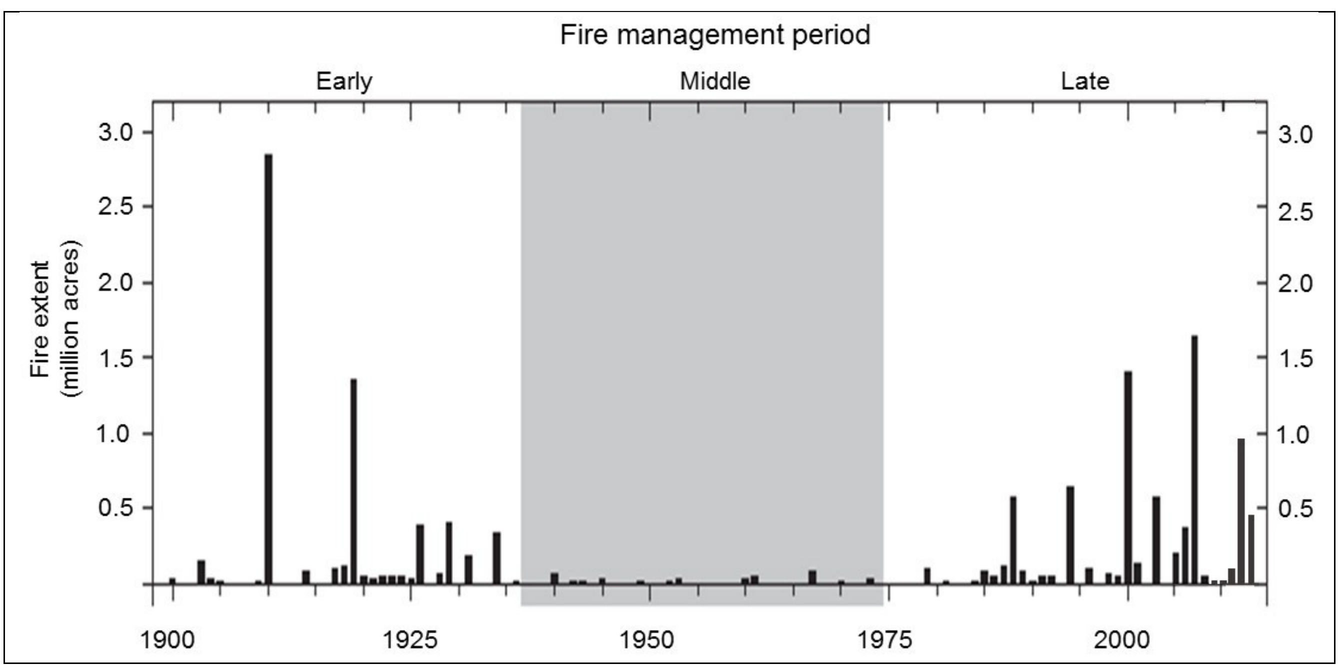

Figure 1-2. Extent of wildfires in forests of Idaho and northwestern Montana, 1900-2013. Source: Adapted from Morgan et al. (2014). Years 1900-2008 from Morgan et al. (2014); years 2009-2013 estimated by authors based on data from NIFC (2014) and USGS (2014).

subsequent fires, improved regeneration of some fire dependent trees (e.g., lodgepole pine), control of some diseases, and improved habitat for some species of wildlife.

However, recent changes toward larger and more intense wildfires have negatively affected many ecosystem components and services that people value (Smith 2000, Brown and Smith 2000, Neary et al. 2005a, Hunter et al. 2007, IDL 2010). For example, wildfires that result in sudden and significant reductions in vegetative cover can lead to increased water runoff and erosion (DeBano et al. 2005, Neary et al. 2005b). Non-native, undesirable plant species are often well-adapted to rapidly invading severely burned sites (Omi et al. 2006). High intensity fires can damage overstory trees making them more susceptible to bark beetle attack (Jenkins et al. 2008). Intense wildfires also can negatively impact biodiversity (Smith 2000).

People and their communities also are negatively affected by larger and more intense wildfires. These conditions make fires more difficult to suppress. They result in increased risk to firefighters and personal property, as well as increased costs for fire suppression and post-fire rehabilitation.

As part of its assessment of forest resources, the Idaho Department of Lands characterized the relative risk to communities and ecosystems from uncharacteristic wildfire (**Figure 1-3**). Most undeveloped forest lands are at moderate risk, but many human habitations and communities at the wildland-urban interface (WUI) are at higher levels of risk.

Managing fuels

Wildfire behavior is influenced by weather, topography, and fuel (see **Chapter 2**). Fuel is the only factor that can be affected directly by management actions. In response to increased wildfire problems, forest resource managers design and implement fuel treatments in an attempt to lessen the effects of wildfires when they burn. Fuel treatments lessen the amount of fuel available for burning and/or rearrange fuels to increase the probability that they burn with less intensity.

Scientists and forest managers generally agree that fuel treatments can be effective. This report reviews studies that have led to that conclusion and examines factors that can affect effectiveness including the type of vegetation, type and extent of treatment, weather, topography, intensity of fire when it encounters a treated area, and time since treatment.

The general objective of modifying wildfire behavior via fuel treatments is to reduce risks to resources valued by people. Fuels therefore present a hazard if the ignition of a wildfire would cause unacceptable adverse effects to resources. However, reducing the quantity of fuels, or changing the quality and distribution of fuels on the landscape, also can pose risks to the same resources managers are trying to protect. For example, in some locations establishing fuel breaks to disrupt the continuity of fuels in order to slow or halt wildfires may increase the opportunity for undesirable invasive species. This report examines some of the risks of implementing fuel treatments.

Government policies influence forest managers' ability to treat fuels. Although some recent policy changes have enhanced the opportunities to implement fuel treatments on forest lands in Idaho, improvements are always possible. Policies affecting fuel treatment implementation on Idaho's forests are examined herein, and policy options that may further enhance the feasibility of fuel treatments are suggested.

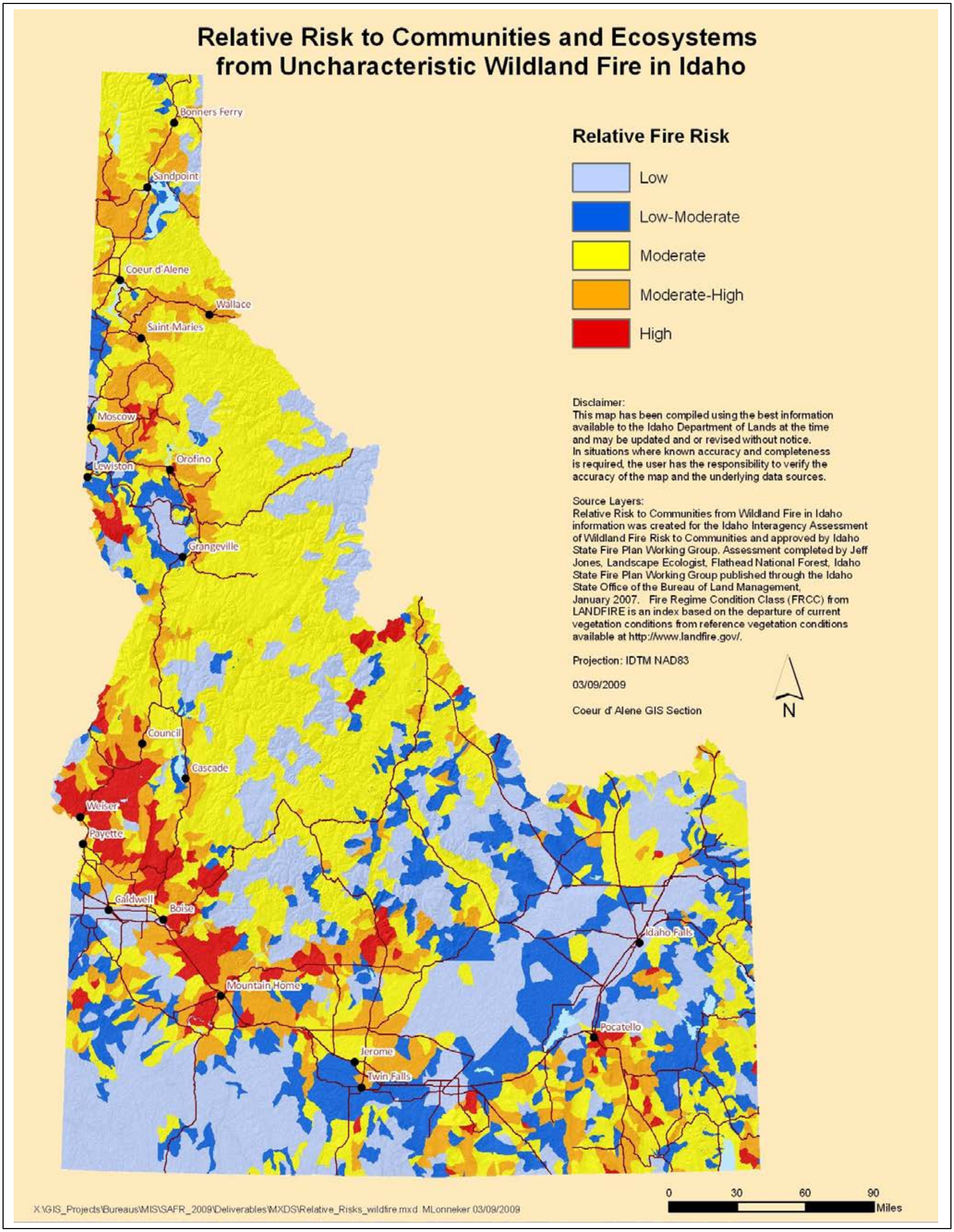

Figure 1-3. Relative risk to communities and ecosystems from uncharacteristic wildfire in Idaho.

Source: IDL (2010).

Chapter 2. What factors influence wildfire frequency, intensity and extent in Idaho's forests?

Wildfire behavior is affected by three factors—weather, topography, and fuel—that comprise the "fire triangle" or, more precisely, the fire behavior triangle (**Figure 2-1**). In this simple model, fuel is the only one of the three factors that land managers can affect in the short term (Carey and Schumann 2003, Graham et al. 2004, Finney 2005).

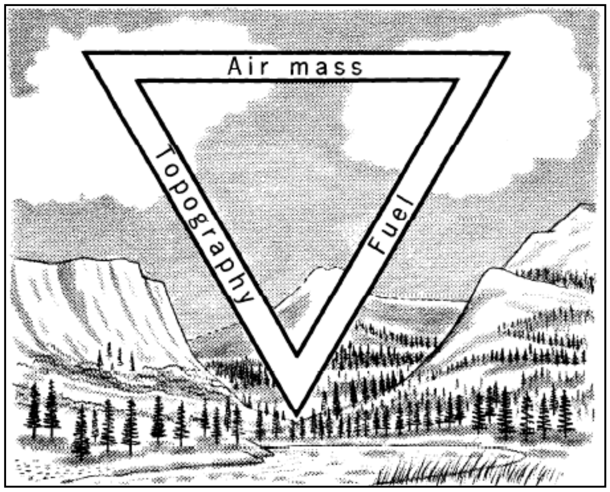

Figure 2-1. Fire behavior triangle.
Source: Countryman (1972).

More complex wildfire models recognize that human factors, including sources of ignition and suppression response, affect fire frequency, extent and intensity (**Figure 2-2**). A common element to all models of wildfire, and the focus of this report, is fuel.

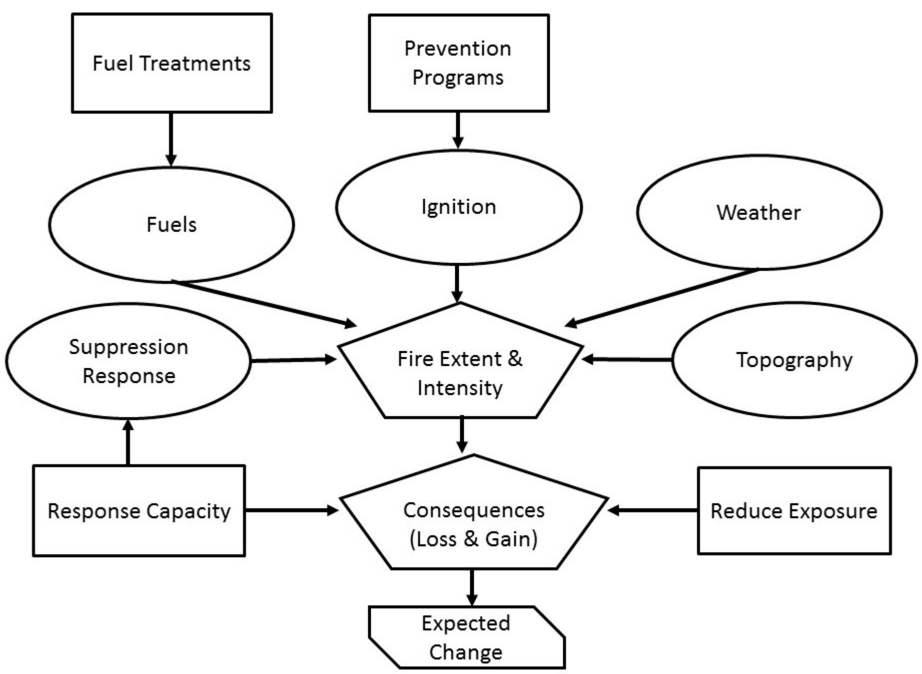

Figure 2-2. A simple conceptual model of wildfire (adapted from Calkin et al. 2011b).
Note: Ovals represent five principal contributing factors, and rectangles represent management options designed to either change wildfire extent and intensity or to alter risk by changing the degree of exposure experienced by valued elements of the landscape.

Fuel

Fuel is essentially vegetation. In addition to quantity, a description of fuel includes elements such as the vertical arrangement of fuels, live/dead fuel mix, fuel moisture, fuel diameter, fuel continuity, whether the fuel is herbaceous or woody, and the fuel's chemical composition which can also affect fire behavior (Cary and Schumann 2003, Graham et al. 2004).

Differences in fuel types and arrangement are important factors in determining a fire's characteristics (**Figure 2-3**; Sandberg et al. 2001). For example, the spatial arrangement of fuels influences the way a fire grows. Patches of vegetation that burn relatively slower than surrounding patches may reduce fire intensity or spread rate (Graham et al. 2004).

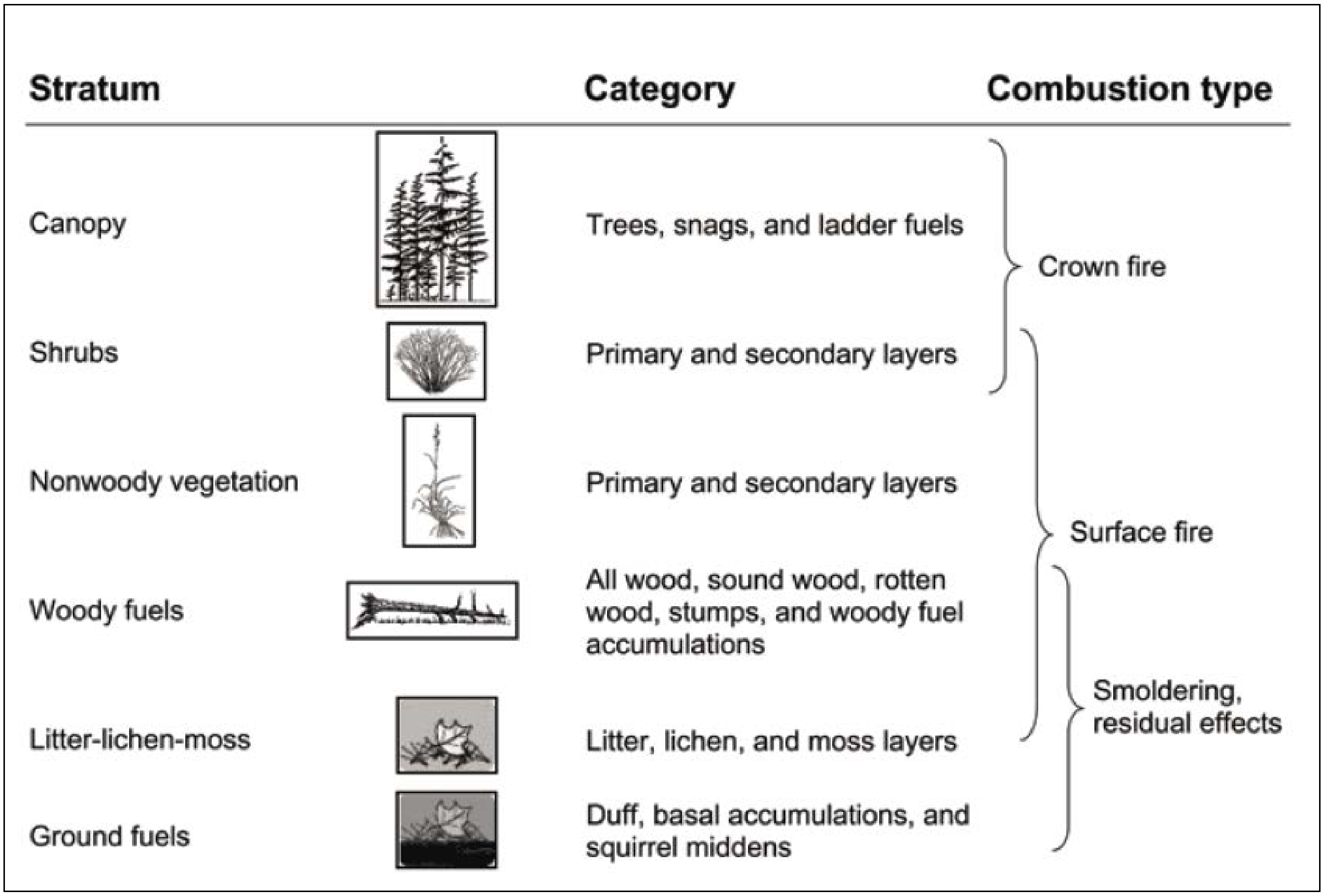

Figure 2-3. Fuel types and arrangement are important factors in determining a fire's characteristics

Source: Ottmar et al. (2007).

The primary challenge for fire management is dealing with crown fires (Peterson et al. 2005, Graham et al. 2010). In the dry forests that account for 8.2 million acres (38%) of Idaho's forests, crown fires are considered the primary threat to things humans value in such forests. Crown fires are dependent upon the vertical arrangement of available fuels. Fire behavior in dry forest types indicates that crown fires begin with a transition from surface fire to ignition of the canopy. This transition requires fuels in low vegetation or shrub strata, and then ladder fuels, followed by canopy fuels (Graham et al. 2004, Alexander and Cruz 2011).

At the forest stand level, forest structure affects fuels, and therefore wildfire behavior. For example, many ponderosa pine forests today are more densely packed with trees than they were historically. This denser forest structure leads to more ladder fuels that allow fires to move into tree crowns. In addition, some forests also are experiencing stand-type conversion as more shade-tolerant trees out-compete ponderosa pine. These changes have been attributed to effective fire suppression efforts over the past 100 years as well as to logging, reforestation practices, and livestock grazing after European-American settlement, and are making frequent-fire-adapted ecosystems of the western U.S. more susceptible to larger and more severe fires (Pollet and Omi 1999b, Peterson et al. 2005, Strom and Fulé 2007).

Weather and climate

In the short term, weather influences fire behavior primarily through fuel moisture and wind (Rothermel 1983, Finney 2004). Fuels are dried by higher ambient temperatures and lower relative humidity. Higher wind speeds contribute to conditions that can lead to more extreme fire behavior. Over the course of a year, regional weather patterns that affect temperatures and the amount and timing of precipitation (e.g., less winter and spring precipitation) can lead to drought, low snow pack, early melting of snow pack, and other conditions that contribute to more extreme fire conditions. In the western U.S., variation in area burned from year to year is strongly related to patterns in temperature and precipitation, with big fire years more likely to occur in years with warm, dry conditions (Westerling et al. 2006; Morgan et al. 2008 and 2014; Miller et al. 2012).

Climate also affects the characteristics of wildfire (Schoennagel et al. 2004b). Climate is the description of the average weather and its variability over a given time period, commonly at least 30 years (Sommers et al. 2011). A warmer and drier climate in the late 20th century compared to the middle portion of the century, along with increases in fuels, contributed to increased fire activity and area burned in recent decades (Westerling et al. 2006; Morgan et al. 2008 and 2014; Sommers et al. 2011; Miller et al. 2012).

Climate change in the 21st century is projected to affect wildfires in the future (Brown et al. 2004, Blate et al. 2009, Keeley et al. 2009, Sommers et al. 2011, Collins and Skinner 2014). While site-specific forecasts remain uncertain, the fire season in the western U.S. is predicted to become longer with more severe fires because of increased extreme fire weather (Stephens et al. 2013). Vegetation and forest types also are predicted to respond to climate change (Strom and Fulé 2007, Diggins et al. 2010).

Topography

Elements of topography, such as slope, aspect, and elevation, help determine wildfire intensity and extent. Idaho's forests occur on diverse topography, and a full discussion of the complex interactions between topography and wildfire is beyond the scope of this report. In general, the influence of topography on fire behavior is greater on steep slopes, ridge tops, and southerly aspects (Lentile et al. 2006). Complex mountainous topography contributes to variable fuel and burning conditions, which favors non-uniform fire behavior (Arno 2000, Brown 2000).

Conclusions

Although forest managers have a good general understanding of the factors that affect fire behavior, the interactions among these factors and the way in which fire behaves on the landscape are highly complex. Factors such as changing climate, exotic or invasive species, and expansion of human settlement into wildland-urban interface (WUI) areas are expected to increase fire risks and complicate the ability to predict and influence fire behavior (DellaSala et al. 2004). As a result, fire behavior and severity can be understood and predicted in general terms, but exact predictions are not possible (Graham et al. 2004).

Chapter 3. What alternative fuel treatments exist?

In a narrow sense, forest fuel treatments focus on fuel reduction to reduce wildfire hazards, including aiding firefighters with fire suppression activities, protecting human settlements, and reducing the severity of the effects of wildfires. However, more broadly, fuel treatments may be designed not only to reduce hazards but also to accomplish other ecological restoration objectives such as restoring the historical role of fire in forested ecosystems (Omi and Martinson 2004, Strom and Fulé 2007, Reinhardt et al. 2008, Keeley et al. 2009). Ecological restoration seeks to accomplish multiple goals, such as restoring wildlife habitat, natural processes and watershed function, and tree health and vigor in addition to hazardous fuels reduction.

One goal of fuel treatments for decreasing wildfire hazards is to decrease the susceptibility of treated forest stands to crown fire. This is done through a combination of reducing surface fuels, ladder fuels, and/or canopy fuels, actions that either prevent fire from reaching the canopy or lessen its ability to spread once it reaches the canopy (Graham et al. 2004, Peterson et al. 2005, Raymond and Peterson 2005, Strom and Fulé 2007, Graham et al. 2010, Hudak et al. 2011).

Fuel treatments widely used by forest managers include prescribed fire, mechanical treatments, or a combination of the two. In addition, livestock grazing, timber stand improvements, and commercial timber harvests can functionally serve as fuel treatments even though the activities are undertaken for other purposes (Martinson et al. 2003). Previous wildfires may also act as fuel treatments for subsequent wildfires (Parks et al. 2013).

Prescribed fire

Managers can treat fuels by applying fire to the forest in a controlled manner to achieve management objectives (**Figure 3-1**). This is called prescribed fire, or prescribed burning. Prescribed fire is commonly used throughout the western U.S. to reduce surface fuels for fire hazard reduction, as well as for ecosystem restoration in appropriate forest types (Peterson et al. 2005, Graham et al. 2010). Prescribed fire can reduce horizontal fuel continuity on the ground and in lower vegetation strata, and later disrupt the growth of a surface fire, limits its intensity, and reduces the potential of spot fire ignition. In addition, the fuel energy stored on site as fine fuels, duff, large woody fuels, and rotten material is reduced which in turn potentially reduces both fire intensity and burn severity. Prescribed fire can directly consume low ladder fuels—such as shrubs, dead trees, needle drape, and small trees—and scorch and kill the lower branches of overstory trees, effectively raising the live crown above the ground surface and reducing the likelihood of fire spreading into other ladder fuels and tree crowns (Peterson et al. 2005, Graham et al. 2010).

Although prescribed fire generally refers to fires started intentionally by forest managers, wildfires that start unintentionally via lightning strikes or human causes sometimes can be managed for resource objectives including fuels management. In federal wildfire management jargon, “use of wildland fire” to meet resource objectives can include fires resulting from “unplanned ignition” as long as the objectives are specified in the appropriate land or resource management plan and fire management plan (see **Chapter 8**; USDA and USDI 2009).

Figure 3-1. Prescribed fire being set to reduce fuels near a residence. Photo courtesy of USDA Forest Service.

Prescriptions for applying prescribed fire in low-severity fire regimes, such as ponderosa pine forests, are fairly well established (Pollet and Omi 2002). Burn prescriptions are written in ways that keep fire intensities and flame lengths to minimum levels required to achieve management objectives while minimizing negative impacts (Graham et al. 2010). Prescribed fires are implemented only in very narrow windows of weather conditions, and require expertise in personnel to plan and implement. The primary constraints to the use of prescribed fire are human, not ecological, concerns, including smoke that decreases air quality, risk of escape, and damage to property (Cook and O'Laughlin 2004, Graham et al. 2010, Palmer 2012).

Prescribed fire is most likely to be used in forest stands that:

- have moderate or low tree densities, so the prescribed fire does not become too intense and burn unwanted areas or kill residual trees;
- lack ladder fuels, so the prescribed fire does not become a crown fire; and/or
- have moderate to steep slopes, which preclude mechanical treatment (Pollet and Omi 2002).

The effectiveness of prescribed fire depends on weather, initial fuel conditions, and skill of fire managers (Graham et al. 2010). The results of prescribed fire fuel treatments are likely to vary across a stand and result in less predictable stand structure changes than mechanical treatments (Pollet and Omi 2002, Arkle et al. 2012). Prescribed fire has a long history as a tool for managing fuels and is applied successfully in many parts of the U.S. and world (Ryan et al. 2013).

Mechanical treatments

Mechanical treatments use machinery to rearrange or remove vegetation in the forest (**Figure 3-2**). Thinning, or removing trees to lessen the number of tree stems per acre, is the primary mechanical treatment used for reducing ladder and canopy fuels. Thinning increases spacing between the residual tree crowns (i.e., decreases canopy bulk density) and removes small understory trees, low branches, and tall shrubs (ladder fuels) that create vertical continuity between surface fuels and the forest canopy (i.e., increases canopy base height). As a result of these actions, potential crown fire behavior may be reduced, especially in forest types that historically burned in low-severity fire regimes (Raymond and Peterson 2005, Reinhardt et al. 2008, Graham et al. 2010).

Prescriptions for mechanical thinning vary. Low thinning removes trees from the lower canopy, leaving large trees to occupy the site. It mimics mortality caused by inter-tree competition or surface fires, and primarily removes small and suppressed trees that would otherwise serve as ladder fuels. Crown and selection thinnings reduce canopy density and continuity within the main forest canopy and alter forest composition. Thinnings can remove varying proportions of trees on a site and leave residual trees in a variety of spatial configurations. As such, thinnings can precisely create targeted stand structures and compositions that will influence both fire intensity and burn severity (Graham et al. 2010).

Mechanical thinning may be preferred in forests that are too densely packed with trees to allow prescribed fire, that have nearby markets for small-diameter trees, and/or in areas where expertise and personnel are not available for prescribed fire programs. Mechanical fuel treatments can be labor intensive, especially on steep slopes and in remote areas, and may not be economically attractive due to the low economic value of small diameter trees that are removed (Pollett and Omi 2002).

Figure 3-2. Machines such as feller bunchers or chainsaws are used to remove unwanted vegetation during mechanical fuel treatments.

Photo courtesy of Chris Schnepf, University of Idaho.

Mechanical treatments to reduce ladder and canopy fuels create surface fuels in the form of branches, needles, and other slash leftover from tree removal. These are also known as activity fuels. They can be treated by mechanical piling, chipping, and/or mastication. Such treatments can change fire hazard without reducing fuel loads, but in many cases, activity fuels are then prescribed burned in order to reduce the amount of fuel available for subsequent wildfires (Graham et al. 2010, Hudak et al. 2011). The states of Idaho and Montana, for example, require treatment of surface fuels following tree removal (see **Chapter 7**).

Mastication, also known as mulching, is an increasingly common mechanical fuel treatment that chips shrubs, small trees, and down woody debris with a rotary cutting or shredding head mounted on an excavator, depositing the woody material in a layer of shredded irregularly shaped particles on the ground. It can be applied as a stand-alone treatment, but may also be applied following understory thinning or prior to prescribed burning (Kreye et al. 2014). Mastication treatments change fuel arrangement by lowering the vertical height of fuels.

Compared to prescribed fire, the advantages of mechanical fuel treatments include increased precision, lower air pollution emissions, lower risk of treatments leaving prescribed boundaries, and sometimes the production of woody materials that can be converted to wood products or energy. For these reasons, mechanical fuel treatments are often relied on more heavily in the WUI (Reinhardt et al. 2008, Schoennagel et al. 2009). However, mechanical treatments do not replicate the ecological processes of burning including nutrient cycling, creating a patchy mosaic, and removing fine fuels (Omi and Martinson 2004, Reinhardt et al. 2008).

Fuel breaks

Although not the focus of this report, fuel breaks that remove almost all vegetation and are intended to reinforce an existing defensible location (e.g., road, ridgetop, human settlement) can be used by firefighters to stop fire spread. The influence of roads acting as fuel breaks in managing wildfire extent at the landscape scale needs more examination (Narayanaraj and Wimberly 2011). The benefits of a fuel break are only achieved if the fire suppression activities anchored to the fuel break are successful in limiting the size or perimeter of the fire (Syphard et al. 2011b). No changes in fire behavior or effects are achieved away from the fuel break or if a fuel break fails to stop fires. Additionally, fuel breaks often require more long-term maintenance than less intensive types of treatments (Graham et al. 2004).

Treatment combinations

Prescribed fire and mechanical treatments are commonly used in combination to modify vegetation for fire hazard reduction throughout the western U.S. For example, canopy and ladder fuels are first modified by mechanical thinning operations that target crown classes, stand basal area, and canopy bulk density. Surface fuels, including the logging slash created by mechanical thinning, are then reduced using prescribed fire. The types and sequence of fuel treatments selected for a given site depend on the amount of surface fuel present; the density of understory and mid-canopy trees; long-term potential effects of fuel treatments on vegetation, soil, and wildlife; short-term potential effects on smoke production; materials to be removed versus left on site; and costs (Peterson et al. 2005, Graham et al. 2010).

In many forest types, potential fire intensity and burn severity are significantly reduced only if canopy thinning treatments are accompanied by reduction in the surface fuels created from the thinning operations. Changing stand structure, while ignoring surface fuels, will only affect the likelihood of active crown fires and will not necessarily reduce the likelihood of surface fires that can potentially be intense enough to damage soils or cause significant overstory mortality. All fuel layers need to be managed over time and space to minimize the unwanted consequences of wildfires (Graham et al. 2010).

Given current accumulations of fuels in many forests of the western U.S., multiple prescribed fires—as the sole treatment or in combination with thinning—may initially be needed, followed by long-term maintenance burning or other fuel reduction to reduce crown fire hazard and the likelihood of high burn severity (Graham et al. 2010). Restoring forests to a condition in which fire alone can maintain the desired conditions may take multiple treatments over time (Graham et al. 2004, 2010).

Chapter 4. How is effectiveness of fuel treatments measured?

The direct goal of treating fuels is to modify potential fire behavior or its effects to achieve a defined purpose, but the reasons for wanting to affect fire behavior can be numerous and varied (Husari et al. 2006). Fuel treatments may be implemented to reduce wildfire severity (the effects of a fire's heat, or intensity, on biotic and abiotic ecosystem properties), to aid in fire suppression, to protect human settlements and manmade structures, or a combination of these or other reasons. Measures of the effectiveness of fuel treatments can vary depending on the objectives of treatment.

Because of the destructive nature of wildfires, it is not possible to experimentally treat forest stands, purposely subject them to wildfire, and then measure reductions in severity (Carey and Schumann 2003, Agee and Skinner 2005). Much of the research literature about fuel treatment effectiveness on wildfire severity has relied on computer modeling (e.g., Johnson et al. 2007, 2011; Jenkins 2011; Jones and Chung 2012; Fulé et al. 2012). However, a growing number of studies are measuring effectiveness by comparing on-the-ground wildfire severity in untreated versus treated stands following a wildfire (see **Chapter 5**). Until the last decade, most studies of pre- and post-fire treatment effectiveness were anecdotal or lacked scientific rigor due in part to lack of data about existing conditions in both treated and untreated stands prior to a wildfire (Omi and Martinson 2002, Skinner et al. 2004, Finney et al. 2005, Gorte 2009a).

Studies that focus on reductions in wildfire severity in treated versus untreated forest stands use a variety of methods for measuring fuel treatment effectiveness. For studies that have used on-the-ground measurements, typical forest inventory measures such as tree species, tree height, tree diameter, tree position in canopy, height to live crown, stand density, and basal area usually are measured in both treated and untreated stands. Because of the importance of reducing crown fire, measures of the amount of vegetation in tree crowns (e.g., crown bulk density) also are often estimated. Distance from treatment boundary also plays a role in treatment effectiveness, and therefore is measured in many studies (e.g., Skinner et al. 2004). These measurements are used to describe a forest stand's structure before and after treatment and before and after a wildfire. Observations of whether trees are alive or dead post-fire, or percent tree mortality, also are often made to assess wildfire severity (e.g., Skinner et al. 2004, Prichard et al. 2010, Pritchard and Kennedy 2012).

If the effects of wildfire on ecosystem components other than trees are of interest, other measures of ecosystem components—other types of plants, soils, etc.—can be taken (e.g., Omi et al. 2006). For example, one study looked at percent cover in the following categories pre- and post-wildfire: grasses, forb, shrubs, litter, rock, bare soil, woody live stem, and woody dead stem (Cram et al. 2006).

On-the-ground measures of the intensity of a wildfire as is passes through a forest stand include heights of needle scorch, bole char, crown scorch, and percent of crown volume scorch (Pollet and Omi 2002, Omi and Martinson 2004, Skinner et al. 2004, Cram et al. 2006, Prichard et al. 2010). Field observations are often categorized into standardized index ratings to describe stand damage and depth of ground char. For example, in several studies stand damage was rated as follows:

0: No damage – all tree crowns unscorched.
1: Spotty damage – partial scorch on at least one tree, but some trees unscorched.
2: Moderate damage – partial scorch on all tree crowns, but few trees completely scorched.

3: Heavy damage – nearly all tree crowns completely scorched, but few crowns consumed.

4: Extreme damage – nearly all tree crowns consumed (Omi et al. 2006).

The downward intensity of wildfire has been estimated with ground char rated as follows:

0: Unburned - no evidence of char.

1: Light – leaves and twigs charred.

2: Moderate - all twigs, leaves, and standing grasses consumed, logs charred.

3: Deep – large fuels partially consumed, mineral soil altered in color or texture (Omi et al 2006).

Satellite images also can be used to look for differences in forest characteristics before and after wildfires in treated and untreated areas. Several studies have used differenced normalized burn ratios (dNBR) from satellite imagery to infer wildfire severity (Finney et al. 2005, Thompson et al. 2007). Large differences between the pre- and post-fire dNBR ratios indicate high fire severity because of lower near-infrared reflectance associated with foliage on green vegetation (trees and understory) and higher mid-infrared reflectance associated with increased exposed and blackened soil, and decreased moisture content of the surface.

Sources of evidence for assessing fuel treatment effectiveness also have included ground and aerial reconnaissance, interviews with homeowners, firefighters, fire scientists and fire behavior experts, and videos and photos taken prior to, during and after wildfires (e.g., Harbert et al. 2007, Murphy et al. 2007, Graham et al. 2009; Murphy et al. 2010). Such measures are often associated with studies examining the effectiveness fuel treatments on fire suppression efforts and firefighter safety (Omi and Martinson 2004, Agee and Skinner 2005, Harbert et al. 2007, Bostwick et al. 2011).

Many of the measures of effectiveness in the U.S. Forest Service fuel treatment effectiveness monitoring program focus on suppression and firefighter safety (Romero and Menakis 2013). Treatments may affect management options, such as facilitating wildfire suppression by providing safe access and egress for firefighters, as well as possible counter-firing opportunities (Omi et al. 2006). For example, during the 2005 Bell Fire in northern California, a mechanical fuel treatment increased penetration of retardant to surface fuels, improved visual contact between fire crews and managers, and improved access to the main fire and suppression of spot fires (Moghaddas 2006, Moghaddas and Craggs 2007). In the 2007 GW Fire, treated and previously burned areas provided the only places from which the fire could be safely engaged (Harbert et al. 2007).

Fuel treatment objectives, and therefore measures of effectiveness, may differ between undeveloped forests and the WUI (Ager et al. 2010). Fuel treatments in wildland areas may be designed mostly to mitigate effects of large, severe wildfires and to restore fire-prone ecosystems. Treatment objectives in the WUI often include reducing potential property loss, and are especially challenging because of the variety of ownerships and diversity of property management objectives (Reinhardt et al. 2008, Evans et al. 2011). There is not always agreement about what fuel treatments are supposed to accomplish (Hamma 2011); therefore measures of effectiveness are not always congruent.

Chapter 5. How effective are fuel treatments during wildfires?

Hundreds of studies exist about fuel treatment effectiveness. Many have relied on computer modeling of hypothetical wildfire behavior, but a growing number of studies have evaluated treatment effectiveness based on forest conditions after a wildfire has passed through treated areas. This chapter focuses on results of studies for forest types and conditions and fuel treatments likely to be found in Idaho.

In addition to studies of individual wildfires, several literature reviews of fuel treatment effectiveness after wildfires have been published (e.g., Cary and Schumann 2003, Martinson and Omi 2003, Graham et al. 2004, Hudak et al. 2011), and the conclusions of those reviews are included herein. More recently, a formal "meta-analysis" of fuel treatment effects on fire severity was conducted (Martinson and Omi 2013), and its findings also are included. Meta-analysis is a quantitative, systematic approach to synthesizing research that combines and compares results of independent studies to assess direction, magnitude, and consistency of reported findings (Cooper et al. 2009).

Based on the research literature, numerous interacting factors determine the effectiveness of any particular fuel treatment during a wildfire, including:

- forest type,
- treatment type,
- size and spatial arrangement of treatments,
- time since treatment, and
- weather conditions.

Each of these factors is discussed under subheadings below.

Forest type

The effectiveness of fuel treatments can vary by forest type. Studies from the western U.S. have focused on fuel treatment and fire effects in dry forest types with low- or mixed-severity fire regimes. In both ponderosa pine-dominated and mixed-conifer forests, fuel treatments have been associated with reductions in the severity of wildfire effects (e.g., Omi and Martinson 2002, Pollet and Omi 2002, Graham et al. 2004, Cram et al. 2006, Wimberly et al. 2009, Murphy et al. 2010).

Research examining fuel treatments after wildfires in forests with historically high-severity, low-frequency fire regimes is scarce, and knowledge about their effectiveness is more uncertain (Omi and Martinson 2004). Fuel treatments that are part of ecological restoration treatments where higher-severity fires may be desirable (e.g., whitebark pine forests) have been found to be effective for moving toward those ecosystem restoration goals (Keane and Parsons 2010, Hood et al. 2012).

Treatment type

Fuel treatment effectiveness depends on the type of treatment. In general, studies have found prescribed fire treatments and mechanical treatments to be effective at reducing wildfire severity individually as well as in combination, with the caveat that surface/activity fuels (slash) from mechanical thinning also need to be treated. In addition, fuel treatments have been found to increase fire suppression effectiveness under some circumstances (Fites et al. 2007; Harbert et al. 2007; Murphy et al. 2007; Graham et al. 2009; Murphy et al. 2010; Syphard et al. 2011a, 2011b).

Most studies have found thinning by itself to be effective compared to no treatment (Martinson and Omi 2013). However, in some cases, thinning alone has produced greater fire severity when slash from thinning activities is left untreated on site (Skinner et al. 2004, Graham et al. 2004, Agee and Skinner 2005, Omi et al. 2006, Pritchard et al. 2010).

Although prescribed fire and mechanical thinning have individually been found to be effective, thinning offers more precise, consistent, and controlled results (Pollet and Omi 2002). Some sites with mechanical fuel treatment appear to have greater reductions in fire severity compared to sites with prescribed fire only. Mechanical fuel treatment prescriptions can specify the exact number of post-treatment residual trees per acre, and the treatment can be applied uniformly across the stand. By contrast, prescribed fire fuel treatment often varies across a stand and results in less precise stand structure changes (Pollet and Omi 1999a).

Some studies have found surface fuel treatments to be effective with or without prior treatment of canopy fuels (Pollet and Omi 2002, Graham et al. 2004, Omi et al. 2006, Graham et al. 2009, Arkle et al. 2012). The type of surface treatment can influence effectiveness. For example, prescribed fire not only can reduce surface litter, but also serve as a low thinning that removes small diameter trees, effectively increasing mean tree diameter and height to canopy and reducing canopy bulk density (Omi et al. 2006).

Mastication creates a fuel bed of shredded irregularly shaped particles, and resulting fire behavior differs from other woody fuels with important but largely unknown implications for ignition, fire spread, and combustion duration (Kreye et al. 2014). The few studies that exist have shown mixed results for mastication as a surface fuel treatment (Safford 2008, Safford et al. 2009, Knapp et al. 2011). More research is needed to fully understand fire behavior in masticated fuel beds and across treated sites in different ecosystems to evaluate the effectiveness of mastication as a fuel treatment that reduces negative wildfire effects (Kane et al. 2009, Reiner et al. 2009, Knapp et al. 2011, Kreye et al. 2014).

The most effective fuel treatment strategy appears to be thinning (removing ladder fuels and decreasing tree crown density) followed by prescribed fire, piling and burning of activity fuels, or other mechanical treatments that reduce the amount of surface fuel. This approach reduces canopy, ladder, and surface fuels, thereby reducing both the intensity and severity of potential wildfires, and enhancing suppression efforts (Graham et al. 2004, Raymond and Peterson 2005, Cram et el. 2006, Dailey et al. 2008, Pritchard et al. 2010, Hudak et al. 2011).

Size and spatial arrangement of treatments

The size and spatial arrangement of treated areas help determine their effectiveness. In general, larger treated areas are more effective at reducing wildfire severity for several reasons (Graham et al. 2004, Finney et al. 2005, Fites et al. 2007, Ritchie et al. 2007, Dailey et al. 2008). As wildfire burns into treated areas, it transitions from crown fire or high intensity surface fire to moderate intensity surface fire (Fites et al. 2007, Murphy et al. 2007), so the more treated area, the more area burned at lower intensities. In addition, at the stand level, several studies have shown that the effects of fuel treatments spread beyond the boundaries of the fuel treatment as fire of reduced intensity moves into adjacent untreated stands (e.g., Omi et al. 2006, Finney et al. 2005).

Also, as fire moves from untreated to treated areas, it is likely to damage or kill trees at the edges of the treated areas before fire intensity moderates; therefore, if the size of a treated areas is small, with proportionately more edge, the treatment's ability to moderate fire intensity is likely to be less (Graham et al. 2004, Skinner et al. 2004, Finney et al. 2005, Raymond and Peterson 2005). Lastly, in addition to having less fuel to burn and/or fuel arrangements that burn at lower intensities, larger treatment units also require longer burn times and, thus, better the chances that weather will moderate—e.g., wind shifts, nighttime—as fire burns through these areas (Finney et al. 2005).

The effectiveness of a fuel treatment may depend on the condition of the forest adjacent to a treated area. For example, previous wildfires (Finney et al. 2005, Thompson et al. 2007) and insect and disease outbreaks (Jenkins et al. 2008) in forests near fuel treatments have affected subsequent wildfire behavior.

Researchers are just beginning to understand how much of a forested landscape needs to be treated, or is feasible to treat, to effectively reduce the severity of wildfire effects. At the landscape scale, the net effect of fuels treatments will be the combination of changed surface fire behavior and crown fire potential. For example, treatments sometimes can increase rates of surface fire spread, raising the average rate of burned area expansion while simultaneously reducing the probability of extreme spread rates and behavior due to crown fires and associated spot fire-related growth (Cochrane et al. 2012).

The spatial patterns of fuel treatments on the landscape are likely to determine their effectiveness in modifying wildfire behavior because multiple stands and fuel conditions are involved in large fires. Treating small or isolated stands without assessing the broader landscape will most likely be ineffective in reducing wildfire extent and severity (Graham et al. 2004, 2010).

Computer modeling at the landscape scale is beginning to address the issues of fuel treatment placement (Finney 2001, Evans et al. 2011). For example, one study found that random fuel treatment arrangements were extremely inefficient in changing fire behavior—requiring 50 to 60 percent of the area to be treated compared to 20 percent if fuel treatments were located strategically (Finney et al. 2005). Another computer simulation study found that fuel treatments well outside the WUI could significantly reduce wildfire threats to property values (Ager et al. 2010). However, researchers caution about generalizing model results to landscapes beyond those included in the models (Ager et al. 2010, Syphard et al. 2011a, Collins and Skinner 2014).

Time since treatment

The effectiveness of fuel treatments varies with time since treatment (Martinson and Omi 2013). In general, recent treatments are more effective than older treatments (Carey and Schumann 2003, Cram et al. 2006, Martinson et al. 2003, Graham et al. 2004, Finney et al. 2005, Omi et al. 2006, Harbert et al. 2007, Hudak et al. 2011). This finding is intuitive because after treatment, vegetation continues to grow, or new vegetation grows. The longer the time since treatment, the more the site will tend toward pre-treatment conditions.

The longevity or duration of treatment effectiveness will vary with numerous factors (**Figure 5-1**; Yocom 2013). Longevity is likely to be specific to the type of treatment and site conditions (Hudak et al. 2011). Treatment effects will likely last longer in areas where vegetation development is slower than in areas of high productivity where vegetation development is more rapid and lush. Inferences from fire history show that the length of treatment effectiveness will vary with forest type and fire regime (Graham et al. 2004).

Fuel treatment for hazard reduction is a continual process that cannot be accomplished by a single treatment (Carey and Schumann 2003). Fuel treatments need to be maintained and reapplied periodically in order to remain effective (Ritchie et al. 2007, Syphard et al. 2011a). Also, the characteristics of and time since the most recent treatment may be more important than the characteristics of prior treatments (Finney et al. 2005).

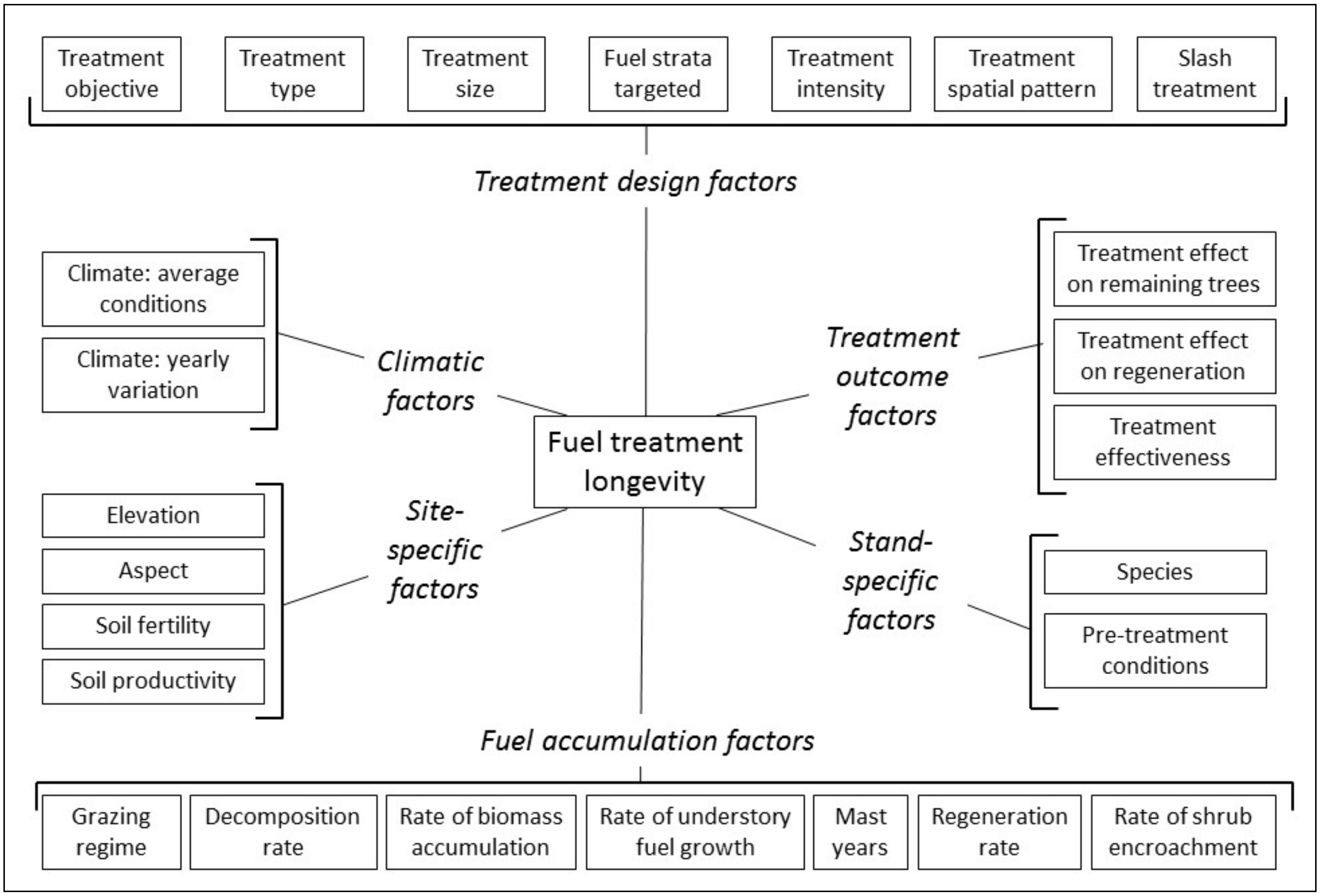

Figure 5-1. Factors affecting fuel treatment longevity.
Source: Yocom 2013.

Weather conditions

The effectiveness of fuel treatments depends on weather conditions when wildfire encounters them (Martinson et al. 2003, Omi et al. 2006, Harbert et al 2007, Lezberg et al. 2008, Safford 2008, Graham et al. 2009). Fuel treatments can increase the probability of modifying fire behavior during most weather conditions; however, extreme weather conditions, such as high temperature, low humidity, and/or high winds can create fire behavior that can burn through or breach many fuel treatments (Pollet and Omi 1999a, 2002; Graham et al. 2004, 2010; Harbert et al. 2007). Longer term weather conditions such as drought may also reduce treatment effectiveness (Omi and Martinson 2004). However, the relationship between weather severity and fuel treatment is not consistent. Sometimes fuel treatments have been effective under the most severe weather conditions (Omi et al. 2006).

Summary

Post-wildfire studies show that fuel treatments can mitigate wildfire severity, particularly within treated stands, as long as surface/activity fuels are treated (Omi and Martinson 2010, Stephens et al. 2012, Martinson and Omi 2013). Their effectiveness at the landscape level is less well documented, and likely depends on complex spatial and temporal interactions between treated areas, untreated areas, topography, and weather. In addition to lowering wildfire severity, fuel treatments also may assist with control and suppression efforts.

Because of site- and wildfire-specific conditions, it is important that study results not be extrapolated too far beyond the forest or weather conditions that occurred during the fire (Skinner et al. 2004). In general, however, the most effective and appropriate sequence of fuel treatments will depend on the amount of surface fuel present; the density of understory and mid-canopy trees; long-term potential effects of fuel treatments on vegetation, soils, and wildlife; and short-term potential effects on smoke production. In forests that have not experienced fire for many decades, multiple fuel treatments are often required to achieve the desired fuel conditions. Thinning followed by prescribed burning reduces canopy, ladder, and surface fuels, thereby providing more protection from severe fires in the future. Potential fire intensity and/or severity in thinned stands are significantly reduced only if thinnings are accompanied by reducing the surface fuels created from the thinning operations (Graham et al. 2004).

In a review of post-wildfire fuel treatment studies Hudak et al. (2011) presented 10 findings about fuel treatment effectiveness:

1. Fire effects on overstory trees are most effectively mitigated by treatments that address both surface and crown fuels through combination treatments such as thinning followed by a prescribed burn; or by removing slash after thinning.
2. Prescribed burn treatments vary in their effectiveness.
3. Treatments become less effective with time since treatment.
4. Little is known about the importance of spatial arrangement and spatial heterogeneity of fuels and fuel treatments.
5. Placement of treatments with respect to topography, wind, and existing fuels can influence treatment effectiveness.
6. There is no magic formula. There is no general prescription that will work in all or even most stands. The great variety of stand conditions, topography, wildfire burning conditions and other variables make it impossible to identify target thresholds for fuel treatment effectiveness.
7. Fuel treatments are not designed to stop fires but rather to modify fire behavior.
8. Whether fuel treatments exacerbate undesirable fire behavior has been a point of contention. Though it is certainly possible for fuel treatments to increase fine fuels and surface temperature, thus creating a micro-climate that favors increased winds and lower relative humidity, future research should explore these factors as well as the scale at which they affect fire behavior.
9. Fuels are just one leg of the fire behavior triangle. Weather and topography affect fire behavior; in some cases they render the most robust fuel treatments useless.
10. There is much to be learned in fuel treatment design and implementation from the many years of experience gained by forest and rangeland managers who manage vegetation for other objectives (Hudak et al. 2011).

Chapter 6. What are the risks of implementing fuel treatments?

All forest management actions involve risk, whether the actions are fuel treatments or wildfire suppression. Risks can be short-term and from the activities themselves, such as an escaped prescribed fire, or long-term, such as negative effects on site productivity from soil compaction due to mechanical thinning operations. The key is to reduce risks so that an acceptable level of results is attained. This calls for specific quantified management objectives.

Prescribed fire implementation

Prescribed fire as a fuel treatment involves several risks. Fire may escape the boundaries intended by managers and cause unintended resource and economic damages. In practice, however, escapes are rare relative to the large number of prescribed fires successfully conducted every year (Graham et al. 2004).

Post-treatment stand structure is generally less predictable following prescribed fire than with mechanical treatments (Graham et al. 2004, 2010). For example, a prescribed fire may burn hotter than intended, scorching crowns of overstory trees leading to unintended damage or delayed mortality (van Mantgem et al. 2011). On the other hand, patches of wetter fuels may not burn as completely as intended, leaving more fuel to burn in a subsequent wildfire. Prescribed fire treatments also may increase nutrient availability, which further stimulates production of fine fuels that add intensity to future wildfires (Omi et al. 2006).

Prescribed fire also is challenging to implement because weather and fuel moisture conditions restrict the times at which prescribed burning can take place in many forests, especially those with high tree densities and heavy fuels (Graham et al. 2004). Many stands may be too dense to use prescribed fire safely without first using mechanical thinning to remove some material (Peterson et al. 2005).

Concerns about air quality and violations of air quality policy also limit the times at which prescribed fire can be implemented. However, even with its risks and challenges, prescribed fire, by influencing multiple strata of fuels, can effectively modify both fire behavior and burn severity (Graham et al. 2010).

Activity fuels from mechanical treatments

One of the risks of mechanical thinning is an increase in surface fuels, unless they are removed from the stand or otherwise treated (Graham et al. 2004, Omi et al. 2006). Surface fuels resulting from fuel treatments can be removed by mechanical treatment or prescribed burning. The effects of treatments will vary depending on the size, composition, and location of fuels left on site. For example, thin layers of wood chips spread on the forest floor tend to dry and rewet readily. However, deep layers of chips and chip piles may have insufficient air circulation, making poor conditions for decomposition. Also, when layers of small woody material are spread on the forest floor and decomposition occurs, the decomposing organisms utilize large amounts of nitrogen, reducing its availability to plants. Therefore, crushing, chipping, mulching, or mastication treatments need to consider impacts on decomposition processes and potential contribution to the severity of future wildfires (Graham et al. 2004, Kane et al. 2009).

The wildfire risks associated with activity fuels from mechanical treatments are managed through state policies (see **Chapter 7**). The Idaho Department of Lands has activity fuel (slash) management rules that determine potential fire hazard and appropriate hazard reduction activities.

Effects on understory microclimate

Both thinning and prescribed fire may modify understory microclimate that was previously buffered by overstory vegetation (Graham et al. 2004, Omi et al. 2006). Thinned stands with open tree canopies may allow incoming solar radiation to penetrate to the forest floor, which can increase surface temperatures, decrease fine fuel moisture, and decrease relative humidity compared to unthinned stands—conditions that can increase how fast a fire consumes fuel and produces energy. In turn, an increase in surface fire intensity may increase the likelihood that overstory tree crowns ignite (Graham et al. 2004, 2009). In addition to drying fuels more quickly, more open stands may increase wind gust speeds (Omi et al 2006). Several studies, however, have found little evidence that the effects of fuel treatments on microclimates lead to fire behavior that increases the severity of post-fire effects (Pollett and Omi 2002, Collins and Skinner 2014).

Uncertainties at the landscape scale

Numerous researchers have urged caution regarding application of multiple fuel treatments across the landscape. Some of the concern is about cumulative effects across the landscape (e.g., Rhodes and Baker 2008, Collins et al. 2010). Some concern is because most current knowledge is based on observation at the stand level, not across larger landscapes (e.g., Omi and Martinson 2004, Husari et al. 2006, Reinhardt et al. 2008, Cawson et al. 2012). For example, at the landscape scale, fire behavior in individual stands may be unrelated to overall fire severity patterns (Reinhardt et al. 2008). Researchers caution about making inferences beyond study sites (e.g., Omi et al. 2006). The science of the effects of large implementation of fuel treatments has not kept up with the scale at which they may need to be applied (Ryan 2010), but landscape scale studies are becoming more common (e.g., Cochrane et al. 2012, Collins et al. 2013).

Differences among forest types

Much of what is known about fuel treatment effectiveness is based on observation and experimentation in lower-elevation forests with frequent, low-severity fire regimes, such as ponderosa pine forests. Uncertainty about fuel treatment effectiveness is greater in other forest types such as higher-elevation and subalpine systems, characterized by mixed- or high-severity fire regimes, or both. Extrapolating results from lower-elevation, frequent, low-severity regimes is inappropriate for other forest types (Omi and Martinson 2004).

Invasive species

Both mechanical thinning and prescribed fire fuel treatments have some potential to promote establishment of non-native plant species; however, the research literature is mixed about the extent of the risk. Some studies suggest that wildfires have a greater impact on the establishment of non-native species than fuel treatments (Hunter et al. 2006, Omi et al. 2006). Fuel treatments that increase the availability of light, water, and nutrients can favor the spread of non-native species. In addition, unseen non-native seeds may be carried with humans and mechanical equipment used in fuel treatments. Mechanical equipment can cause soil disturbances that favor non-native plant establishment (Omi et al. 2006). Fuel treatments can also result in higher intensity fire on a small, localized scale that may facilitate establishment of non-native species. For example, burning of slash piles, which can result in high fire intensity on a local scale, has been shown to promote establishment of non-native species (Hunter et al. 2006). However, wildfires tend to be more intense and severe than prescribed fires and result in more favorable conditions for non-native species (Omi et al. 2006).

Risks to wildlife

Fuel treatments are likely to have varying effects on wildlife depending on which strata of vegetation is treated and what wildlife species depend on that strata for their habitat or habitats of their prey (Graham et al. 2010, Pilliod et al. 2006, Jain et al. 2012). In the dry forests of the western U.S., fire-dependent wildlife species, species that prefer open habitats, and species associated with early successional vegetation or that consume seeds and fruit generally may benefit from fuel treatment activities (Pilliod et al. 2006). Species that prefer closed-canopy forests or dense understory, and species closely associated with those habitat elements that are removed or consumed by fuel treatments are more likely to be negatively affected by fuel treatments (Pilliod et al. 2006).

For example, several studies of bird communities have not found major negative effects on bird species overall, but there is substantial variation in the effects on individual species (Farris et al. 2010, Gaines et al. 2010, Hurteau et al. 2010). Fuel treatments may affect the accumulation and disposition of snags and coarse woody debris, and the retention, disposition, juxtaposition, size, and amount of canopy cover, seral stages, and structural stages occurring on a site (Graham et al. 2010).

Many species of wildlife co-evolved with fire, but reintroduction of fire through implementation of prescribed fire needs to be monitored for its effects on wildlife species (Stephens and Ruth 2005). For example, one study examined the risks to an endangered land snail from prescribed burning and determined the risks to the population were low particularly when compared to uncontrolled, higher-intensity wildfire (Gaines et al. 2011). Another study found that prescribed burning reduced the severity of effects of subsequent wildfire on aquatic and riparian habitats in central Idaho (Pilliod and Arkle 2012). Overall, there are large gaps in information needed to evaluate the effects of fuel treatments on many species of wildlife (Pilliod et al. 2006, Collins et al. 2010).

Water quality and quantity

Fuel treatments affect watershed processes and therefore may affect both water quality and quantity in the short and long term, but effects are likely to be highly variable depending on treatment and site characteristics (Dwire et al. 2010, McCormick et al. 2010, Reid 2010, Robichaud et al. 2010, Troendle et al. 2010, Cawson et al. 2012). For example, fuel treatments that alter canopy cover can influence sedimentation and peak flow by altering rainfall intensity on established snow packs and raindrop intensity on the forest floor. However, the effects must be placed within the context of the soil type, geology, and other biophysical characteristics to understand the impacts to water quality and quantity (Graham et al. 2010).

For most treatments and sites, fuel treatments are unlikely to have significant effects on water yields either on site or downstream. Prescribed fires are probably less likely to influence water yield than mechanical treatments because of the smaller reduction in basal area and lack of ground disturbance by heavy machinery (Troendle et al. 2010).

Mechanical thinning treatments can increase runoff and sediment production, but the effects are usually small, localized, and short-lived (Robichaud et al. 2010). Mechanical thinning treatments that involve yarding of timber have a greater potential for increased runoff, erosion, and sediment yields because of the more extensive removal of the forest canopy, greater ground disturbance due to skid trails, cable rows, and landings, need for road access, and increase in heavy truck traffic. Maintenance of treated areas also involves repeated access and disturbances with their associated effects, but overall the cumulative effects may be less than that of a high-severity wildfire (Robichaud et al. 2010, Rhoades et al. 2011).

Fuel treatments have the potential to affect water quality, but the implementation of best management practices (BMPs) can minimize the potential effects (Dwire et al. 2010, Stednick 2010). Minimizing the amount of disturbed area and creating buffer zones around riparian areas are two examples of practices that can minimize adverse effects. Federal forest managers appear to be proceeding cautiously when implementing fuel treatment projects in riparian areas in order to protect water quality and other resource values (Stone et al. 2010).

Soils and productivity

Numerous soil impacts can occur from fuel treatments, but the impacts are variable, depending on the type of treatment, its implementation, and site-specific factors (Graham et al. 2010, Page-Dumroese et al. 2010, Busse et al. 2014). Management considerations for soils related to prescribed fire include changes in soil properties and functions caused by heating, increased soil water repellency, decreased soil nitrogen availability, effects of repeated burning treatments, concentrated effects of pile burning, and retention of coarse woody debris (Busse et al. 2014). Management considerations for soils related to mechanical treatments include nutrient removal from the site, soil compaction from machinery, and unknown consequences of mastication (Busse et al. 2014). For prescribed fire, risks of negative consequences to soils can be minimized by burning under appropriate fuel and weather conditions (Graham et al. 2010, Page-Dumroese et al. 2010). For mechanical treatments, appropriate equipment configuration and timing treatments when soil moisture is lower can minimize risks of negative effects to soils (Page-Dumroese et al. 2010, Busse et al. 2014).

Other resources and risks

Forests are complex ecosystems, and fuel treatments, like all management activities, have the potential to affect many aspects of forest structure, its processes, and resources. Potential risks not addressed above include effects on human-caused ignitions due to increased access (Syphard et al. 2007, Narayanaraj and Wimberly 2012), visual quality (Graham et al. 2010), susceptibility to insect infestation (Fettig et al. 2010, Hessburg et al. 2010, Stark et al. 2013), and carbon storage and emissions (Hurteau and Brooks 2011, North and Hurteau 2011). Research projects such as the multi-site, multivariate Fire and Fire Surrogate Study are designed to measure many of these other consequences and risks of fuel treatments (McIver and Fettig 2010; McIver et al. 2012, 2013).

Chapter 7. What policies currently guide implementation of fuel treatments?

Wildfires have been a focal point of U.S. forest policy since the Big Burn or Great Fires of 1910 in Idaho and Montana burned 3 million acres and killed 87 people (Pyne 2001, Egan 2009). Idaho's reputation as a place where large wildfires occur has not diminished, but due to suppression efforts since then the 1910 fires remain Idaho's largest wildfire event. However, since 2000 the average size of wildfires has been increasing throughout the western states, spawning a wildfire policy called the *National Cohesive Wildland Fire Management Strategy* (WiFLC 2014). It addresses forest and rangeland wildfire risk issues in part through the goal of maintaining and restoring resilient landscapes. The strategy's other two goals are creating fire-adapted communities and improving response to wildfires.

Policies guiding forest management and implementation of fuel treatments in Idaho vary depending on who owns and manages the forest lands. In Idaho, about 81% of all forest lands are owned and managed by two federal agencies: the U.S. Forest Service (USFS, 77%) and the Bureau of Land Management (BLM, 4%; **Figure 7-1**). About 7% of Idaho's forest lands (1.5 million acres) are managed by the Idaho Department of Lands (IDL); these "endowment lands" were granted from the federal public domain at statehood and are held in trust for public schools and other public institution beneficiaries (see O'Laughlin et al. 2011). About 6% of Idaho's forests are owned by private corporations, and another 6% are owned by private noncorporate entities, including private individuals, families, and American Indian tribes (Smith et al. 2009). The focus of this report is publicly managed forest lands; therefore, our focus is on the policies of the USFS, BLM, and IDL.

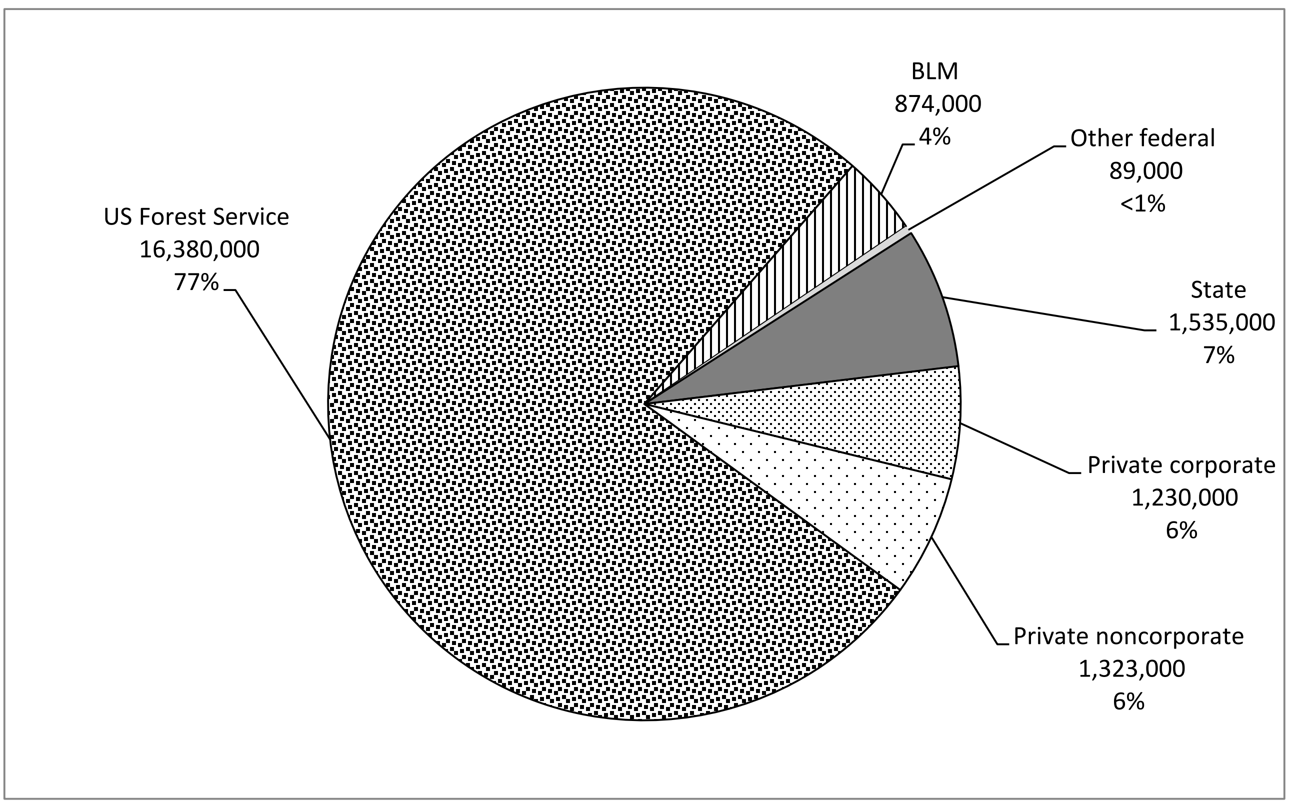

Figure 7-1. Forest land ownership in Idaho (number of acres, % of total).
Data source: Smith et al. (2009).

National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA; 42 USC 4321 et seq.) is the cornerstone of U.S. environmental laws. It requires that the environmental effects of an action by a federal agency, or federally-funded action, be considered before the action is taken. The procedural requirements of NEPA require that federal agencies develop an environmental assessment (EA) or environmental impact statement (EIS) for a proposed action. The full implications of NEPA for federal forest management are beyond the scope of this report; however, provisions for meeting the requirements of NEPA are woven throughout the fire and fuels management policies of the federal agencies responsible for most of Idaho's forests.

Federal Agencies

U.S. Forest Service (USFS). The U.S. Forest Service manages the 16.4 million acres of forest lands in Idaho that are part of the National Forest System. Numerous laws govern the management of national forests, and therefore affect implementation of fuel treatments. These laws include: NEPA, the Organic Administration Act of 1897 (16 USC 473 et seq.), the Multiple-Use Sustained-Yield Act of 1960 (16 USC 528 et seq.), the Forest and Rangeland Renewable Resource Act of 1974 as amended by the National Forest Management Act of 1976 (16 USC 1600 et seq.), and the Clean Water Act (33 USC 1251 et seq., 1323 et seq.). An in-depth review of all these laws and their relationship to fuel treatment implementation is beyond the scope of this report; however, a brief review of several important provisions follows.

In general, management of each national forest is guided by a land and resource management plan (LRMP) developed under provisions of the National Forest Management Act (NFMA). NFMA regulations state that LRMPs guide management of national forest lands so that

> "they are ecologically sustainable and contribute to social and economic sustainability; consist of ecosystems and watersheds with ecological integrity and diverse plant and animal communities; and have the capacity to provide people and communities with ecosystem services and multiple uses that provide a range of social, economic, and ecological benefits for the present and into the future" (36 CFR 219.1).

Plans must take into account dominant ecological processes, such as wildland fire, and consider opportunities to restore fire-adapted ecosystems (36 CFR 219.8).

LRMPs include desired conditions and objectives for wildland fire behaviors and fuel conditions to be achieved at a landscape scale by fuels management activities (FSH 1909.12). They also identify areas generally suitable for use of wildland fire, prescribed fire treatments, and non-fire fuels treatments considering social, economic, political, and resource constraints (FSH 1909.12). USFS managers integrate fuels management and fire management programs in support of resource management objectives provided in LRMPs (FSM 5150.3). Priorities for fuel treatment projects are to be established in LRMPs and initiated in accordance with the LRMP and its attendant Fire Management Plan (FSM 5151; see **Federal Wildland Fire Policy** section below).

USFS managers are required to use economic analysis in the decision process for evaluating proposed fuel treatment programs and activities, and for selecting the practices used to perform fuel treatments (FSM 5152). The objective of USFS fuels management is to identify, develop, and maintain fuel profiles that contribute to the most cost-efficient fire protection and use program in support of land and resource management direction in the LRMP (FSM 5150.2).

Bureau of Land Management (BLM). The Federal Land Policy and Management Act of 1976 (FLPMA; 43 USC 1701 et seq.) outlines the functions of the BLM, provides for administration of public lands through the BLM, provides for management of the public lands on a multiple-use and sustained-yield basis, and requires land use planning, including public involvement and a continuing inventory of resources. FLPMA's required land use plans are similar to the LRMPs of the national forests.

Under FLPMA regulations, when BLM determines that vegetation, soil, or other resources on public lands are at substantial risk of wildfire due to drought, fuels buildup, or other reasons, the BLM may undertake fuels reduction or treatment projects using prescribed burning or mechanical, chemical, or biological thinning methods (43 CFR 5003.1).

The BLM manages its forests through the Public Domain Forestry Management Program (BLM 2014a). Fuel treatments on BLM lands are funded, in part, through the Forest Ecosystem Health and Recovery Fund, which is authorized through FY 2015 (P.L. 111-88). The BLM conducts evaluations of its fire planning, fuels management, and community assistance programs at the state level every four years (BLM 2014b).

Federal Wildland Fire Policy

The wildland fire policies of the federal land management agencies have evolved over the last 20 years. Most of the first-generation land/resource management plans required by NFMA and FLPMA and completed in the 1980s did not address wildfire or fire control; however, current plans integrate fire management goals and standards, including restoring fire-adapted ecosystems (Keiter 2006). Federal land managers are now required to prepare Fire Management Plans that are tiered to land/resource management plans and establish explicit operational guidelines for managing wildland fires (USDA and USDI 2001a; see for example Boise National Forest 2014 and Clearwater and Nez Perce National Forests 2008).

The first comprehensive statement of wildland fire policy coordinated between the Departments of Agriculture (i.e., USFS) and the Interior (i.e., BLM), *Federal Wildland Fire Management: Policy and Program Review*, was adopted in 1995 in response to 1994's severe fire season that resulted in the deaths of 34 wildland firefighters across the U.S. (USDA and USDI 1995). The policy recognized that fire is a natural part of many ecosystems, that hazardous fuels build-up was an increasing problem on many wildlands, and that fuel treatments were needed in many areas. Several severe fire seasons in the early 2000s resulted in a series of reports and plans designed to further improve federal fire management planning and coordination (Keiter 2006).

National Fire Plan. In 2000, the President asked the Secretaries of the Departments of Agriculture and the Interior to prepare a report on how best to respond to severe fires, reduce impacts of wildland fires on rural communities, and ensure sufficient firefighting resources in the future. The resulting report became known as the "national fire plan" (USDA and USDI 2000). Many of the national fire plan's recommendations were about reducing hazardous fuel accumulations and increasing the amount of hazardous fuel reduction treatments, particularly on lands at the wildland-urban interface (WUI).

One month after the national fire plan was submitted to the President, Congress supported the national fire plan through language in the FY 2001 Interior and Related Agencies Appropriations Act (P.L. 106-291). Congress mandated several reporting requirements including the creation of a coordinated, national 10-year comprehensive strategy (USDA and USDI 2001b). Congress significantly increased appropriations for fire-related activities, particularly for hazardous fuels treatments, and called on the federal agencies to work collaboratively and cooperatively with states in the development of the strategy and as full partners in planning, decision making, and implementation. The federal agencies, state governors, and other partners released the strategy in August 2001 (USDA and USDI 2001b). Two of the goals of the 10-year strategy were to reduce hazardous fuels and restore fire adapted ecosystems (USDA and USDI 2001b). The implementation plan for the strategy was approved in May 2002 (USDA et al. 2002) and updated in 2006 (USDA et al. 2006).

Healthy Forests Initiative (HFI) and Healthy Forests Restoration Act (HFRA). In 2002, the President introduced a series of administrative reforms to assist the federal agencies in more effectively dealing with hazardous fuels. This series of reforms became known as the Healthy Forests Initiative (HFI). HFI included new “categorical exclusions” that allowed certain fuel treatment projects to proceed in full compliance with the NEPA, but without lengthy environmental documentation, and new guidance on conducting environmental assessments for fuel reduction projects and restoring fire-adapted ecosystems (USFS and BLM 2004).

In 2003, Congress enacted the Healthy Forests Restoration Act (HFRA; P.L. 108-148; 16 U.S.C. 6501 et seq.) “to reduce wildfire risk to communities, municipal water supplies, and other at-risk Federal land through a collaborative process of planning, prioritizing, and implementing hazardous fuel reduction projects.” HFRA authorizes the BLM and USFS to conduct hazardous fuel reduction projects on federal lands in WUI areas and on certain other federal lands using expedited procedures. The expedited procedures include limiting the number of alternatives required for NEPA compliance, establishing a “pre-decisional administrative review” process, and limiting judicial review of projects.

In general, projects proposed under HFRA are required to develop only two alternatives to meet NEPA requirements: a proposed agency action and a no-action alternative. If an additional action alternative is proposed during scoping or during HFRA’s collaborative process, the agency must consider that alternative. If a HFRA project is proposed in the WUI, the agency is only required to develop the proposed agency action and one action alternative, unless the project is within 1.5 miles of an at-risk community, in which case an alternative action is not required. If the at-risk community has a wildfire protection plan and the agency action does not implement its recommendations, then the agency is required to develop the community’s plan as an action alternative.

HFRA expedites the approval process for hazardous fuel reduction projects by establishing a pre-decisional administrative review process—commonly called an “objection.” The process is the sole means by which administrative review of a proposed authorized hazardous fuel reduction project may be sought. Only individuals and organizations who have submitted specific written comments during the opportunity for public comment provided during preparation of a NEPA environmental assessment or environmental impact statement for the proposed authorized hazardous fuel reduction project may file an objection.

In 2012, the USFS adopted a HFRA-based pre-decisional review process for all LRMP-related plans and projects (36 CFR 219, Subpart B). In 2014, Congress replaced the administrative appeals process authorized by with Appeals Reform Act of 1993 (P.L. 102-381) with the HFRA pre-decisional administrative review process (P.L. 113-79; Hoover 2014).

HFRA also expedites hazardous fuel reduction projects by restricting judicial review. Issues raised by the plaintiffs during judicial review must have raised during the pre-decisional administrative process.

In February 2014, HFRA was amended by the federal farm bill (Agricultural Act of 2014; P.L. 113-79) to permanently authorize "stewardship end-result contracting," which was first temporarily authorized as a pilot program in 1999. Stewardship end-result contracting allows the USFS and BLM to enter into contracts up to 10 years in length that focus on land and resource conditions rather than outputs (USFS 2014a). Fuel treatment projects are eligible for inclusion in stewardship end-result contracts.

The same bill (Agricultural Act 2014; P.L. 113-79) also amended HFRA to authorize state governors to request that the U.S. Department of Agriculture designate landscape-scale treatment areas on national forests that are at high risk of insect and disease mortality. Projects carried out under this authority will be considered hazardous fuels reductions projects under HFRA. In March 2014, Idaho submitted a list of 50 proposed treatment areas covering almost 1.9 million acres, and they were approved by the Secretary of the U.S. Department of Agriculture in May 2014 (USFS 2014d).

As a result of HFI and HFRA, the USFS and BLM created NEPA categorical exclusions for hazardous fuels reduction activities using prescribed fire that do not to exceed 4,500 acres, and mechanical methods for crushing, piling, thinning, pruning, cutting, chipping, mulching, and mowing, not to exceed 1,000 acres, provided that: the areas are in a WUI or Condition Classes 2 or 3 outside a WUI; are identified through a collaborative framework as described in *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-Year Comprehensive Strategy Implementation Plan* (USDA and USDI et al. 2002); are not conducted in wilderness areas or do not impair the suitability of wilderness study areas for preservation as wilderness; do not include the use of herbicides or pesticides or the construction of new permanent roads or other new permanent infrastructure; but are allowed to include the sale of vegetative material if the primary purpose of the activity is hazardous fuels reduction (36 CFR 220.6). However, the USFS is enjoined from using its hazardous fuels categorical exclusion until it complies with court orders in *Sierra Club* v. *Bosworth* (510 F.3d 1016, 9th Cir. 2007; USFS 2014b).

Numerous hazardous fuels projects have been implemented in Idaho and across the U.S. as a result of HFRA. From FY 2003 to FY 2011, 1.3 million acres of HFRA fuel treatments were accomplished in Idaho (**Table 7-1**; Forests and Rangelands 2012). Slightly over half (52.3%) of the acres were treated by the USFS, and slightly under half (42.5%) were treated by BLM. About half (50.9%) of the acres treated were in the WUI. Mechanical treatments were used more than fire treatments in the WUI (71.0% mechanical vs. 29.0% fire), whereas outside the WUI treatments were more evenly split between fire and mechanical treatments (56.1% mechanical vs. 43.8% fire).

HFI and HFRA were in part a result of the federal land management agencies reviewing the 1995 wildland fire policy (USDA and USDI 1995) in the early 2000s. The 2001 *Review and Update of the 1995 Federal Wildland Fire Management Policy* (USDA and USDI 2001a) re-emphasized the need for fuels treatment on many federal lands, but cautioned that implementation of fuels reduction strategies was hampered by limited resources. HFI and HFRA authorized more spending on fuel treatment programs, but much of the increased spending was redirected funds from other programs.

Table 7-1. HFRA fuel treatment accomplishments in Idaho, FY 2003 to FY 2011, acres.

Federal	Inside WUI			Outside WUI				
Agency*	Fire	Mechanical	Total	Fire	Mechanical	Total	Total	
BIA	4,356	23,281	27,637	7,192	11,831	19,023	46,660	(3.6%)
BLM	65,482	241,378	306,860	77,947	169,891	247,838	554,698	(42.5%)
FWS	2,673	10,391	13,064	4,494	3,080	8,066	21,130	(1.6%)
NPS	-	-	-	7	14	21	21	(<0.1%)
USFS	119,863	196,162	316,025	190,861	174,736	365,597	681,622	(52.3%)
Total	192,374	471,212	663,586	280,501	359,552	640,545	1,304,131	(100%)

*BIA=Bureau of Indian Affairs, BLM=Bureau of Land Management, FWS=Fish and Wildlife Service, NPS=National Park Service, USFS=U.S. Forest Service.
Data source: Forests and Rangelands 2012.

2009 Guidance for Implementation of Federal Wildland Fire Management Policy. In 2003, the federal agencies published a strategy for implementing the updated wildland fire management policy (USDA and USDI 2003). That implementation policy was updated in 2009 with *Guidance for Implementation of Federal Wildland Fire Management Policy* (USDA and USDI 2009). The guidance provides the philosophy, direction, and implementation of fire management planning, activities and projects on federal lands and is intended to "be used to provide consistent implementation of federal wildland fire policy." Specific action items within the 2009 guidance are addressed by the *Interagency Standards for Fire and Fire Aviation Operations* (USDI and USDA 2011), which is updated yearly.

Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009. In late 2009 the Federal Land Assistance, Management, and Enhancement Act (FLAME) became law (P.L. 111-88). The act mandated the development of a national cohesive wildland fire management strategy to comprehensively address wildland fire management across all lands in the U.S. Elements of the strategy were to include:

- identifying the most cost-effective means for allocating fire management budget resources;
- providing for reinvestment in non-fire programs by the Secretary of the Interior and the Secretary of Agriculture;
- employing appropriate management response to wildfires;
- assessing the level of risk to communities;
- allocating hazardous fuels reduction funds based on the priority of hazardous fuels reduction projects;
- assessing the impacts of climate change on the frequency and severity of wildfire; and
- studying the effects of invasive species on wildfire risk.

The strategy is to be updated at least once every five years.

The cohesive strategy required by FLAME was developed by the Wildland Fire Leadership Council (WiFLC). This is an intergovernmental committee of federal, state, tribal, county, and municipal government officials established by the Secretaries of Agriculture and the Interior in 2002 to support the implementation and coordination of federal fire management policy (WiFLC 2010).

In March 2011, the WiFLC released two documents: *A National Cohesive Wildland Fire Management Strategy* (WiFLC 2011a) and *The Federal Land Assistance, Management and Enhancement Act of 2009 Report to Congress* (WiFLC 2011b). The documents provided the framework for a three-phase, strategic effort to restore and maintain resilient landscapes, create fire-adapted communities, and respond to wildfires. The creation of the two documents was considered phase one and served as the foundation for the remaining phases.

In June 2012, the WiFLC released *A National Cohesive Wildland Fire Management Strategy Phase II National Report* (WiFLC 2012). Phase II consisted of regional assessments to connect national goals to the needs and challenges found at regional and local levels. Three regional strategy committees representing the Northeast, Southeast, and West examined how wildfire and its management threaten areas and issues that Americans value, including wildlife habitats, watershed quality, and local economies.

Phase III involved taking the qualitative information gathered in Phase II and translating it into quantitative models that help inform management actions on the ground. As part of Phase III, each region developed a regional risk analysis report. Among the recommendations related to fuel treatments in the Western region's report are: encouraging federal agencies to expedite fuel treatments, and identifying and prioritizing landscapes for treatment (WRSC 2012). In addition, Phase III involved developing regional action plans. The actions recommended in the Western region's action plan are related to its three goals:

- Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.
- Human populations and infrastructure can withstand a wildfire without loss of life and property.
- All jurisdictions participate in making and implementing safe, effective, efficient, risk-based wildfire management decisions (WRSC 2013).

The importance of managing lands with fuels treatment projects to mitigate fire risk is captured in this quotation from the Phase III western regional science-based risk analysis report:

> "Analysis shows us where fires are occurring, where future fires are likely to occur, and where we might be able to intervene with mitigation efforts to reduce fuels to reduce the severity of future fires. The landscape needs active management to reduce fuels in order to reduce losses of homes, lives, and resources to wildfire. Experience with fuels treatment projects has demonstrated the value of fuels reduction to reduce wildfire suppression costs and protect land and resources" (WRSC 2012, p. 4).

In April 2014, *The National Strategy: The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy* (WiFLC 2014) was completed. The vision for the next century expressed in the *National Strategy* is to "safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a nation, live with fire." The three primary principles identified as necessary for achieving the vision are:

- Restore and maintain landscapes: Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.
- Fire-adapted communities: Human populations and infrastructure can withstand a wildfire without loss of life and property.
- Wildfire response: All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions (WiFLC 2014).

The *National Strategy* recognizes that vegetation and fuels management is a major challenge to achieving its vision (**Figure 7-2**). The strategy recognizes that a variety of fuel treatment strategies are needed and suggests that areas of the western U.S. be a primary emphasis for broad-scale fuels management (WiFLC 2014).

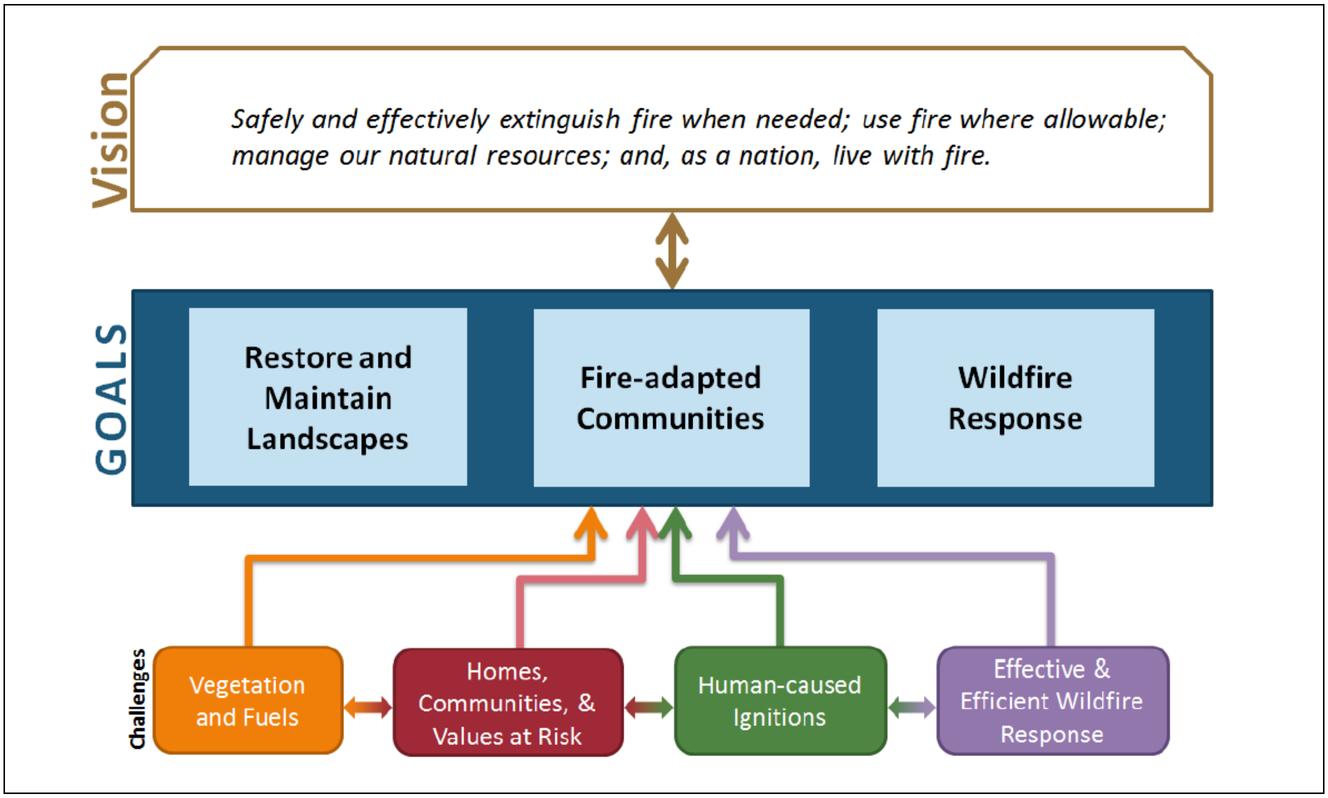

Figure 7-2. Vision, national goals and national challenges from *The National Strategy: The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy.*

Source: WiFLC 2014.

Collaborative Forest Landscape Restoration Program. In 2009, Congress passed the Forest Landscape Restoration Act (Title IV of P.L. 111-11, the Omnibus Public Land Management Act of 2009), which established the Collaborative Forest Landscape Restoration Program to encourage collaborative, science-based ecosystem restoration of forest landscapes by reestablishing natural fire regimes and reducing the risk of uncharacteristic wildfire. Proposed projects must be developed through a collaborative process, identify and prioritize restoration treatments for a 10-year period within a landscape that is at least 50,000 acres, be comprised primarily of national forest land, be in need of active ecosystem restoration, and be accessible by existing or proposed wood-processing infrastructure at an appropriate scale to use woody biomass and small-diameter wood removed in ecological restoration treatments. Projects are submitted to the Secretary of Agriculture through the USFS Regional Foresters and are competitively selected for funding by the Secretary after review by an advisory panel. The act established a Collaborative Forest Landscape Restoration Fund to pay up to 50 percent of implementation and monitoring costs of projects.

In 2010, the Selway-Middle Fork Clearwater Project, a joint effort between the Clearwater Basin Collaborative and the Nez Perce and Clearwater National Forests, received $1 million in funding through the program. The project work includes: 2,600 acres of commercial harvest and prescribed burning, application of prescribed fire to approximately 10,000 acres, replacement of a culvert to restore fish passage, and the decommissioning of 75 miles of road (USFS 2010a).

In 2012, two additional Collaborative Forest Landscape Restoration Fund projects were funded in Idaho: the Weiser-Little Salmon Headwaters project on the Payette National Forest ($2.45 million) and the Lower Kootenai River Watershed project on the Panhandle National Forest ($324,000). The Weiser-Little Salmon Headwaters project proposes to treat and restore approximately 190,000 acres of low elevation ponderosa pine forest to historic stand structure and functional conditions (Payette National Forest 2011). The Lower Kootenai River Watershed project proposes to treat 39,430 acres to reduce the risk of wildfire and increase the resilience of the landscape to wildfire (Kootenai Valley Resource Initiative 2011).

Good Neighbor Authority. In addition to amending HFRA to permanently authorize stewardship end-result contracting (see previous section), the federal farm bill (Agricultural Act of 2014, P.L. 113-79) reauthorized the USFS and BLM's "Good Neighbor Authority" and extended the authority nationwide. The authority allows the USFS and BLM to enter into agreements with state agencies to conduct fuel treatments on federal lands. Previously the authority was limited to Colorado and Utah (Hoover 2014).

Prescribed fire. The USFS and the BLM operate under similar policies for implementation of prescribed fire. USFS policies are detailed in Forest Service Manual chapter 5140 *Fire Use* (USFS 2008), and BLM policies are detailed in BLM Manual section MS-9211 *Fire Planning* (BLM 2012). Both agencies' policies are guided by the *Interagency Prescribed Fire Planning and Implementation Procedures Guide* (USDA and USDI 2013). The prescribed fire program goals for the federal agencies are to:

- Provide for firefighter and public safety as the first priority;
- Ensure that risk management is incorporated into all prescribed fire planning and implementation;
- Use prescribed fire in a safe, carefully planned, and cost-efficient manner;
- Reduce wildfire risk to communities, municipal watersheds and other values and to benefit, protect, maintain, sustain, and enhance natural and cultural resources; and
- Use prescribed fire to restore natural ecological processes and functions, and to achieve land-management objectives (USDA and USDI 2013).

Additional prescribed fire implementation guidance is provided in the *Interagency Standards for Fire and Fire Aviation Operations* (USDI and USDA 2014), including:

- All hazardous fuels reduction (HFR) treatment projects will support resource management objectives as identified in their agency-specific land/resource management plans;
- All HFR treatment projects will have plans that contain measurable objectives;
- All HFR treatment projects will comply with NEPA and all other regulatory requirements;
- All HFR management projects will be tracked and progress will be reported within required timeframes; and
- All HFR treatment projects will be monitored to determine if treatment objectives were met and to document weather, fire behavior, fuels information, and smoke dispersion.

Federal agencies also can use wildland fires with unplanned ignitions (e.g., lightning-caused fires) in a manner similar to prescribed fire, provided that the fire fills prescribed management objectives in the land/resource management plans and associated fire management plans (USDA and USDI 2009). The use of unplanned wildland fires may be limited in some forests because of structural changes that have occurred in forest stands (Pollet and Omi 2002).

State policies

Similar to the situation with federal policies, state of Idaho policies that potentially relate to fuel treatment projects on forest lands are spread across a variety of statutes, implementing rules and regulations, and the responsibilities of several agencies. For example, if planned fuel treatments use prescribed burning, the Idaho Department of Lands is involved because of wildfire and forest practices policy and the Idaho Department of Environmental Quality also is involved because of air quality policy. In addition, fuel treatment implementation cannot harm wildlife, whose management and protection fall under the authority of the Idaho Fish and Game Commission (Idaho Code 36-102) and the Idaho Department of Fish and Game, which implements the commission's policies.

The Idaho Department of Lands (IDL) has dual responsibilities as both the manager of state's endowment forest lands and the regulator of forest practices on private forest lands. In general, IDL is charged with protecting all forests in the state (Idaho Code 38-102).

Fuel treatments. Idaho statutes providing the authority for IDL to regulate fuel treatments on forest land include the Idaho Forestry Act (Idaho Code 38-101 et seq.), fire hazard reduction programs (Idaho Code 38-401 et seq.), and the Idaho Forest Practices Act (Idaho Code 38-1301 et seq.). Harvesting of trees, management of slash, use of chemicals, and use of prescribed fire on forest land are forest practices and subject to provisions of the Idaho Forest Practices Act and its regulations (IDAPA 20.02.01).

Landowners or operators performing fuel treatments must obtain a notification of forest practice from IDL before conducting the practice (IDAPA 20.02.01.020.05). In addition, a Certificate of Compliance–Fire Hazard Management Agreement must be obtained by anyone who conducts an operation involving the harvesting of forest products or potential forest products (IDAPA 20.04.02.030). Upon completion of a forest practice, a Certificate of Clearance must be obtained to certify that either hazard reduction has been accomplished, will be accomplished via a contract with IDL, or an additional fee has been paid (IDAPA 20.04.02.140).

IDL's slash management rules use a points system to determine potential fire hazard and appropriate hazard reduction activities. Points are computed based on forest type, stand density, fuel quantity, site aspect and slope, season of forest practice, and hazard offsets such as slash disposal, access, availability of water, adjacent fuel breaks, and landowner protection plan (IDAPA 20.02.01.070).

Prescribed fire. IDL is responsible for control and management of fire on private forest lands in Idaho (Idaho Code 38-101 et seq.). IDL requires permits for all open burning during the fire season (May 10 to October 20) to ensure that burning is kept under control and prevented from spreading to other property (Idaho Code 38-115). Burning of specifically designated blocks or areas of forest land must be conducted in accordance with a prescribed burn plan approved by the fire warden in the area where the burn occurs (IDAPA 20.04.02.110). IDL burn permits specify that burning must be conducted in accordance with the Idaho Department of Environmental Quality's open burning rule (IDAPA 58.01.01.600; see ***Air quality policies*** section below).

Wildfire protection planning. Several federal policies have provided incentives for the state of Idaho to undertake wildfire protection planning, including the planning, funding, and implementation of hazardous fuels reduction projects in forests. Through the Disaster Mitigation Act of 2000 (P.L. 106-390), the Federal Emergency Management Agency (FEMA) requires states and communities within states to create hazard mitigation plans as a condition for maximizing federal funding to states and communities for hazard reduction and disaster response activities. The most recent edition of the *State of Idaho Hazard Mitigation Plan* was completed in 2013 and prominently addresses wildfire as a hazard (Idaho Bureau of Homeland Security 2013). The plan calls for the continuation of programs that reduce fuels loads in critical areas and establishment of mitigation actions in accordance with the *National Cohesive Wildland Fire Management Strategy* (see **Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009** section above). Forty-three of the 47 local mitigation plans in Idaho identify wildfire as a significant hazard (Idaho Bureau of Homeland Security 2013).

As a result of the Disaster Mitigation Act of 2000, as well as the national fire plan and its implementation strategy (see **National Fire Plan** section above), Idaho completed the *Idaho Statewide Implementation Strategy for the National Fire Plan* in 2002. The plan was revised in 2006 (IDL 2006). The plan called for the creation of county-level wildfire hazard mitigation plans. In 2003, HFRA (see **Healthy Forests Initiative (HFI) and Healthy Forests Restoration Act (HFRA)** section above) directed federal agencies to prioritize fuel reduction projects on lands identified in “community wildfire protection plans.” Communities in Idaho met the mandate of HFRA by creating plans at the county level—County Wildfire Protection Plans (CWPPs).

CWPPs were created by countywide collaborative groups made up of wildfire agencies, fire departments, emergency managers and other interested parties (IDL 2008). Every county in Idaho has completed a CWPP, which identifies hazards and prioritizes treatments to reduce them. Federal agencies must consider priorities identified in the CWPP when developing fire management plans or when conducting hazardous fuels treatments (IDL 2008). As a matter of practice, each county’s CWPP has been integrated into its all-hazard mitigation plan required by the Disaster Mitigation Act of 2000 (Idaho Bureau of Homeland Security 2013).

Air quality policies. Air quality policies related to fuel treatments, particularly prescribed burning and wildfires, were examined in depth in a previous PAG report (Cook and O’Laughlin 2004); however, some federal air quality policies have changed since then. The following summarizes and updates the information in that report.

The federal Clean Air Act is the basis for most air quality regulation nationwide. The U.S. Environmental Protection Agency (EPA) is the federal agency charged with implementing the Clean Air Act. Although the Clean Air Act is a federal law, the states are responsible for much of its implementation. States develop State Implementation Plans (SIPs) that define and describe customized programs that the state will implement to meet the requirements of the Clean Air Act. The state agency in Idaho responsible for implementing Clean Air Act provisions is the Idaho Department of Environmental Quality (IDEQ).

The EPA sets limits on how much pollution can be in the air through the National Ambient Air Quality Standards (NAAQS). NAAQS have been established for six air pollutants: particulate matter, sulfur dioxide, nitrogen dioxide, ozone, carbon monoxide, and lead. An area that IDEQ finds to be in violation of a NAAQS may be designated as a nonattainment area by the EPA. Nonattainment status has numerous implications for an area, including increased controls and limitations on the sources and amounts of emissions allowed.

Particulate matter (PM_{10} and $PM_{2.5}$) is the primary pollutant of concern in smoke, whether from prescribed fires or wildfires. Most of the particulate matter in smoke is $PM_{2.5}$.

EPA regulates emissions from wildfires and prescribed fires under its “exceptional events rule” (40 CFR 50.14). EPA does not count violations of a NAAQS that are caused by exceptional events toward nonattainment designation if a state can document that a violation was caused by an exceptional event. Wildfires are considered exceptional events because they are “natural events”—defined by EPA as events “in which human activity plays little or no direct causal role,” even if a wildfire is human-caused.

Violations of a NAAQS from prescribed fires are treated slightly differently by EPA. They are not counted toward nonattainment designation if the state either

- has certified to EPA that it has adopted and is implementing a “smoke management program” (SMP), or
- the state ensures that the burner who caused the violation employed basic smoke management practices, and the state undertakes a review of its approach to ensure public health is being protected and considers developing a smoke management program.

Idaho has the requisite SMP. It was created and is administered jointly with the state of Montana by the Montana/Idaho Airshed Group (2010). The group is comprised of member organizations that conduct a large amount of prescribed burning and regulatory and health agencies that regulate this burning in the states of Idaho and Montana. The intent of the Montana/Idaho Smoke Management Program is to minimize or prevent smoke impacts while using fire to accomplish land management objectives. The SMP identifies the responsibilities of Montana and Idaho air regulatory agencies, federal, state, tribal, and private land managers as well as provides accurate and reliable guidance to the individuals conducting prescribed fires. In Idaho, land manager participation in the SMP is entirely voluntary.

Other Idaho policies that address air quality and prescribed burning include IDEQ’s Air Pollution Emergency Rule that regulates activities when air pollution levels are high enough to cause a health emergency (IDAPA 58.01.01.550-562) and IDEQ’s opening burning rule that regulates the types of materials that can be burned in the open (IDAPA 58.01.01.600). Prescribed fire is allowed provided it meets the following conditions (IDAPA 58.01.01.614):

- If a burning permit or prescribed fire permit is required by IDL, USFS, or any other state or federal agency responsible for land management, the burner must meet all permit and/or plan conditions and terms which control smoke; or
- If permits from these other agencies are not required, burners must meet conditions in the Montana/Idaho Smoke Management Program. In Idaho, participation in the smoke management program is voluntary (Cook and O’Laughlin 2004).

Summary

Most of Idaho’s forests are the responsibility of the U.S. Forest Service (see **Figure 7-1**). There is not a single, overarching federal law that guides fuels treatment implementation on federal forests, but rather numerous laws, regulations, and other documents that provide policy guidance. In addition to land use planning laws and regulations, laws protecting air quality play important roles for some fuel treatment methods, particularly prescribed fire. States are responsible for implementing many requirements of federal clean air statutes, and states have primary responsibility for laws that protect state and private forest lands from wildfire.

Chapter 8. What policy options might improve fuel treatment effectiveness in Idaho's forests?

As the previous chapter illustrates fuel treatment implementation is affected by numerous intertwined federal and state policies. In addition, wildfire management involves a combination of federal, state, and local responsibilities and policies. Policies have not always been congruent and there is room for improvement (DellaSala et al. 2004, Stephens and Ruth 2005, Keiter 2006, Wishnie 2008, Janke 2011). Suggestions for improvements to fuel treatment implementation policies are summarized below.

As a result of passage and implementation of the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009 (see **Chapter 7**), federal, state, local, and tribal governments, non-governmental organizations, and public stakeholders have worked to develop the *National Cohesive Wildland Fire Management Strategy* ("National Strategy"; WiFLC 2014). The strategy is an attempt to bring more cohesiveness and effectiveness to wildland fire policy. The National Strategy addresses many of the issues outlined below, but because of its newness, the effectiveness of implementation of the strategy has not been evaluated.

Articulate goals and objectives clearly

Several researchers have suggested that more clarity is needed as to what makes fuel treatment programs successful (e.g., Reinhardt et al. 2008). For example, a goal such as wildfire hazard reduction means different things to different people. A goal of fuel treatments is modifying potential fire behavior and effects, but effects on who or what vary (Stephens and Ruth 2005).

Some constituencies may see the goal of fuel treatments as advancing opportunities for fire suppression while protecting firefighter safety (e.g., Harbert et al. 2007). The National Strategy (WiFLC 2014) identifies reducing risk to firefighters as a guiding principle and core value for all fire management activities. Others may see reduction in acres burned by wildfire as an appropriate goal, but some researchers have suggested that focusing on reducing the number of acres burned leads to an overemphasis on suppression, which contributed to the current wildfire problem (Reinhardt et al. 2008).

Other constituencies may see the goal of fuel treatments as restoring forests to some particular historical condition. However, specifying restoration as a fuel treatment goal is complicated because ecosystem composition and structure are complex and constantly changing. In addition, reference conditions may not be attainable in the future because of changes to controlling factors such as climate (DellaSala et al. 2004, QFR 2009). Historical conditions also may not be socially acceptable today (Hunter et al. 2007). For example, high-severity, stand-replacement fires were historically the norm for some forest types, but may not be acceptable today if such forests exist in the WUI.

Other constituencies may see the goal of fuel treatment as furthering ecological integrity (Schoennagel et al. 2004a); however, measures of ecological integrity vary (QFR 2009). Others may see the goal of fuel treatments as increasing resilience, or the ability of the landscape to regain normal function and development after fire (SAF 1998).

The goals of fuel treatments and wildfire management are sometimes stated in terms of risk management and reduction (e.g., Calkin et al. 2011a and 2011b). However, disparate definitions of risk and what resources are at risk have led to calls for more standardized risk analysis related to fuel treatments and wildfire (O'Laughlin 2008, O'Laughlin 2010, Miller and Ager 2013). Quantitative risk analysis for wildfire is challenging (Finney 2005).

Fuel treatment goals are usually an integration of ecological, economic, and social values (Graham et al. 2004). The context of place is important for determining treatment goals (Agee and Skinner 2005). Fuel treatments are not undertaken as ends in and of themselves, but their place in larger land management priorities is not always clear. Fuel treatments can accomplish multiple land management objectives (QFR 2009), and the objectives need to be stated clearly.

The National Strategy (WiFLC 2014) recognizes that fuel treatment goals and objectives are likely to be dependent on and vary by location and involve a variety of ecological and social factors. For example, fuel treatment goals and objectives in WUI areas may be very different than those in non-WUI areas.

Improve accountability

Given that resources to accomplish fuel treatments are limited, implementing them where they will do the most good seems appropriate. In order to make the process of implementing fuel treatments more accountable, better planning information and more systematic implementation decision processes are needed on several fronts.

Improved information about the levels of hazards in specific locations is needed (QFR 2009, Calkin et al. 2011a). For example, many decisions about where to implement fuel treatments are currently made using the forest condition-class system, which is a broad scale assessment technique, but too broad for what is needed (Stephens and Ruth 2005, Calkin et al. 2011a). Decision support systems to help improve the effectiveness of fuel treatment implementation are under development (e.g., Hessberg et al. 2007).

Although managers have access to studies on stand-level fuel treatment effectiveness, such as the ones reviewed in this report, there is no system for making implementation decisions based on treatment or cost effectiveness (GAO 2007, Mell et al. 2010). For example, federal agencies currently use number of acres treated as a measure of accomplishment, but that measure says nothing about the effectiveness of the treatments (Stephens and Ruth 2005, Hudak et al. 2011). Strategic placement of fuel treatments on the landscape may make them more effective at reducing fire effects and more cost effective (Pollet and Omi 2002, Stephens and Ruth 2005, Dailey et al. 2008, QFR 2009).

Managers also need better information about how projects that are locally important fit in to regional or national priorities. For example, although the Healthy Forests Restoration Act calls for 50% of projects to be near or within the WUI, researchers found that west-wide only 11% have been (Schoennagel et al. 2009). In Idaho, slightly over 50% of acres treated have been in the WUI (see **Table 7-1**). However, without a more systematic approach—methodical, based on criteria, and applied consistently—it is difficult to know whether treatment costs are warranted or to compare the cost effectiveness of different potential treatments to decide how to optimally allocate funds (Stephens and Ruth 2005, GAO 2007, Colburn 2008, Gorte 2009b).

Steps are being taken to improve planning information and make fuel treatment implementation more accountable. For example, LANDFIRE (Landscape Fire and Resource Management Planning Tools Project) is producing consistent and comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the U.S., including layers of vegetation composition and structure, surface and canopy fuel characteristics, and historical fire regimes. These data can then be used in prediction models for landscape-level fire behavior assessments and fuel treatment optimization planning (Ryan and Opperman 2013).

Although fuel treatments have been shown to aid in fire suppression, the effects on fire suppression costs have not been as widely studied (Thompson et al. 2013). Researchers are working on models that quantify impacts of fuels treatments on suppressions costs, so they can evaluate where to implement fuel treatments. One such program under development by the U.S.Forest Service is Risk and Cost Analysis Tools Package (R-CAT), developed to evaluate fuel treatments in Collaborative Forest Landscape Restoration Program projects (USFS 2010b). Suppression costs only represent part of the costs of wildfire. Researchers have begun to systematically examine the full costs of wildfires and compare them to the costs of fuel treatments (Snider et al. 2006, Mason et al. 2006, WeFLC 2010, Combrink et al. 2013, ERI 2013).

Federal managers also are considering more systematic approaches to implementation decisions (e.g., USDI 2012). For example, federal managers have suggested establishing an integrated fuels management portfolio, which would transform fuels management from a project/output perspective to a larger investment strategy in support of greater land management priorities and multi-jurisdictional goals (QFR 2009). The portfolio would support multiple programs—starting with the fuels reduction zones in fire-adapted communities and reaching efforts to treat larger landscapes in more remote areas and public lands between the WUI and wilderness (QFR 2009). An integrated fuels management portfolio would also involve taking advantage of opportunities presented by the occurrence of wildfires. Fuels projects are often done to reduce risk in anticipation of a wildfire. The occurrence of a wildfire has not often been used as a factor in the selection of areas for fuel treatments, either to maintain the burned area in an appropriate ecological condition, to maintain fuels at a prescribed level, or to generally take advantage of reduced fuels and risk following the occurrence of a wildfire (QFR 2009).

The National Strategy (WiFLC 2014) recognizes that accountability is important and calls for establishing national performance measures specific to the strategy. The strategy calls for tracking the efficiency of investments in activities, including fuel treatments, to determine which investments are most cost-effective.

Collaborate with others

Numerous researchers have suggested that enhancing collaboration between levels of government and with communities and stakeholders is important for increasing the effectiveness of fuel treatment programs (Stephens and Ruth 2005, Evans 2008, Kaufmann et al. 2009, QFR 2009). Part of collaboration is clarifying, and perhaps realigning, the roles and responsibilities of various levels of government in implementing fuel treatments, managing wildfire, and protecting communities (QFR 2009, WRSC 2013).

Some researchers have suggested creating or strengthening policies that increase the ability of federal, state, and local agencies to implement fuel treatments across land ownerships, such as Good Neighbor Authority (see **Chapter 7**). In addition, cost sharing among agencies, across levels of government, and between public and private entities could be promoted (Schoennagel et al. 2009). Collaborative and cooperative programs allow participating entities to leverage resources (QFR 2009).

To be most effective, management agencies need to build and maintain citizen trust and credibility that fuel treatments are effective and meet the community's needs (Absher and Vaske 2011, Paveglio et al. 2011, Toman et al. 2011, McCaffrey and Olsen 2012). For example, focusing on building support for bioenergy facilities that can use the wood generated by fuels treatment projects may increase stakeholder support (QFR 2009).

Dialogue is needed between tribal, state and local authorities including elected officials, business and private property owners, and the larger public (Stephens and Ruth 2005, QFR 2009).

The National Strategy (WiFLC 2014) identifies collaborative engagement—"which includes governance, shared information and resources, communications, and monitoring and accountability"—as necessary for successful implementation. The strategy specifically recognizes the importance of collaboration in fuels management projects involving a mix of public and private lands.

Embrace adaptive management

Numerous researchers have suggested that fuel treatment and wildfire management policies take an adaptive management approach (e.g., Omi and Martinson 2004, Schoennagel et al. 2004a, Stephens and Ruth 2005, Colburn 2008, Kaufmann et al. 2009, Page-Dumroese et al. 2010, McIver et al. 2012). Adaptive management uses management actions as sources of learning, treats management actions as experiments, and relies heavily on monitoring and evaluation of results (Stankey et al. 2005). Adaptive management allows successes on the ground to serve as opportunities to gain knowledge and experience, and to reflect and to revise policies and prescriptions, and serve as precedents for eventual broader application (Stephens and Ruth 2005).

Adaptive management is increasingly important because of the constantly changing environment, including such things as future wildfires, human population incursions, episodic drought, warming and cooling trends, and insect and pest outbreaks (Omi and Martinson 2004; Kolden and Brown 2010). Monitoring is an important part of adaptive management, and there is a need for more broad scale monitoring of fuel treatment effectiveness as well as the non-target effects of treatments (Rhodes and Odion 2004, Harbert et al. 2007, Schoennagel et al. 2009, Evans et al. 2011).

The National Strategy (WiFLC 2014) does not mention adaptive management by name; however, elements of adaptive management are recognized. For example, the strategy calls for decisions to be made on the best available science and recognizes that fire adaptation is a continuous process.

Loosen constraints on public agencies

Numerous policy, budgetary, market, and social constraints currently limit the extent of fuel treatments that can be undertaken. For example, air quality policy may limit implementation of prescribed fire to only a few weeks each year (Quinn-Davidson and Varner 2012). With such limitations, it is not possible to use prescribed fire as a fuel treatment on a large scale (Pollet and Omi 2002, Stephens and Ruth 2005, Collins et al. 2010). Air quality policies that fully recognize the trade-off between moderate, controlled amounts of smoke from prescribed fire versus large, uncontrolled amounts of smoke from wildfires are needed (Cook and O'Laughlin 2004, Engel 2013).

Planning laws and regulations for NEPA/NFMA/FLPMA may constrain fuel treatment implementation (Stephens and Ruth 2005, Collins et al. 2010). In some instances, requirements of federal law and due process permit a single interest to override and derail collaborative efforts to institute regional or local fuel management plans (Stephens and Ruth 2005). However, one study of U.S. Forest Service fuel reduction project decisions found appeals or objections were filed only in 19% of decisions; two percent of decisions were litigated; and in the majority of cases, projects that were challenged were implemented unchanged (GAO 2010). In some cases it may not be the laws and regulations themselves that are impeding projects, but institutional aversion to risk of litigation (Mortimer et al. 2011).

Fuel treatments, regardless of type, cost money to implement. The federal budgeting and appropriations processes for both fuels management and fire suppression have been called inadequate and in need of revamping (Stephens and Ruth 2005). For example, the cost of wildfire suppression grew from 13% of the U.S. Forest Service budget in 2004 to over 40% in 2014 (USFS 2014c). Suppression costs in excess of budgeted funds were covered by transferring funds from other programs, including those that funded fuel treatments. The U.S. Forest Service FY 2015 budget proposes revamping the funding of fire suppression so that funding intended for fuel treatments and other land management activities is not diverted (USFS 2014c). In addition, the U.S. Forest Service FY 2015 budget proposes to consolidate several programs into an Integrated Resource Restoration program so that land management activities, including fuel treatments, are administered in a more coordinated and efficient manner (USFS 2014c).

Costs of some mechanical fuel treatments can be offset partially by selling by-products of treatments, particularly small timber. However, one of the constraints to mechanical thinning in some areas is the lack of infrastructure—locally available contractors, smallwood processing facilities, and/or biomass-to-energy conversion facilities—for the material that is removed during thinning (GAO 2005 and 2006, Collins et al. 2010). Policies that promote thinning and guarantee smallwood timber supplies may be necessary before private sector entities are willing to invest in operations and facilities. Numerous states have adopted policies that promote the utilization of forest biomass outputs (Becker et al. 2011). The effects of increased forest biomass on markets and economies will vary depending on the scale of fuel treatment programs (USFS 2005, Prestemon et al. 2006).

Some constraints are not formally imbedded in policy, but result from institutional and social norms. For example, the use of wildland fire from unplanned ignitions to meet resource objectives, or letting naturally-caused fires burn via prescription, has been limited and could be used more effectively (Stephens and Ruth 2005, Dale 2006, Palmer 2012). More use of fire for resource objectives will require adaptation in public attitudes towards fire management as well as institutional attitudes within fire organizations such as the U.S. Forest Service and Bureau of Land Management (Dale 2006, North et al. 2012, Ewell and Kerr 2013, Thompson 2014).

The public will also have to become more willing to accept risks associated with fuel treatments and the adaptations necessary to manage wildfire (Toman et al. 2013, Gill et al. 2013, Toman et al. 2014). The WUI is a particularly challenging place to implement fuel treatments because of the human values associated with the built environment, homes, and communities (Vogt et al. 2005, Toman et al. 2012, Stein et al. 2013). Policies need to better define the WUI and the priorities for fuel treatments within it (GAO 2007, Mell et al. 2010, Calkin et al. 2011c). Policies that regulate development and human settlement in wildland areas and the WUI also are needed to lessen risks when wildfires occur (Gude et al. 2008, Schoennagel et al. 2009, Hamma 2011, Paveglio et al. 2013, Calkin et al. 2014). The National Strategy (WiFLC 2014) focuses particular attention on the WUI, with one of its three goals being fire-adapted communities.

Conclusion

Fuel treatments generally have been shown to be effective at reducing wildfire severity at the stand level, but the research is less clear about treatment effectiveness at the landscape scale and thus how much of the landscape needs to be treated to reduce wildfire severity overall. Current policies tend toward the “more is better” approach, using number of acres treated as the measure of fuel treatment program success. More clearly articulated goals and measures of success are needed for fuel treatment implementation policies.

Despite elevated risks from wildfire, fuel treatment policy is inherently about political choices of priorities and programs, and it is unclear where fuel treatments fall in national political priorities (Stephens and Ruth 2005). The public must understand that there will be no quick fixes or magic bullets, and undoing the effects of a century of fire exclusion will require patience, persistence, cooperation, and tolerance for mistakes (Omi and Martinson 2004).

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