Eiler Fire Salvage and Restoration Project

Report For

Fire and Fuels

Prepared by

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Introduction

This report addresses the issues and opportunities for Fire and Fuels Management within the Eiler Fire Salvage and Restoration Project (Eiler Project).

The Eiler Fire started on July 31st in the Thousand Lakes Wilderness on the Lassen National Forest (LNF), burned in a northerly direction, and was approximately five miles from the town of Burney in Northeast California before it was contained on October 3, 2014. The fire burned a total of 33,162 acres, including 14,926 acres of National Forest System (NFS) lands on the Hat Creek Ranger District and 18,080 acres of private lands. The Eiler Project covers an area stretching north of the wilderness, east of Burney Mountain, west of State Highway 89, and was contained approximately four miles northwest of Brown's Butte.

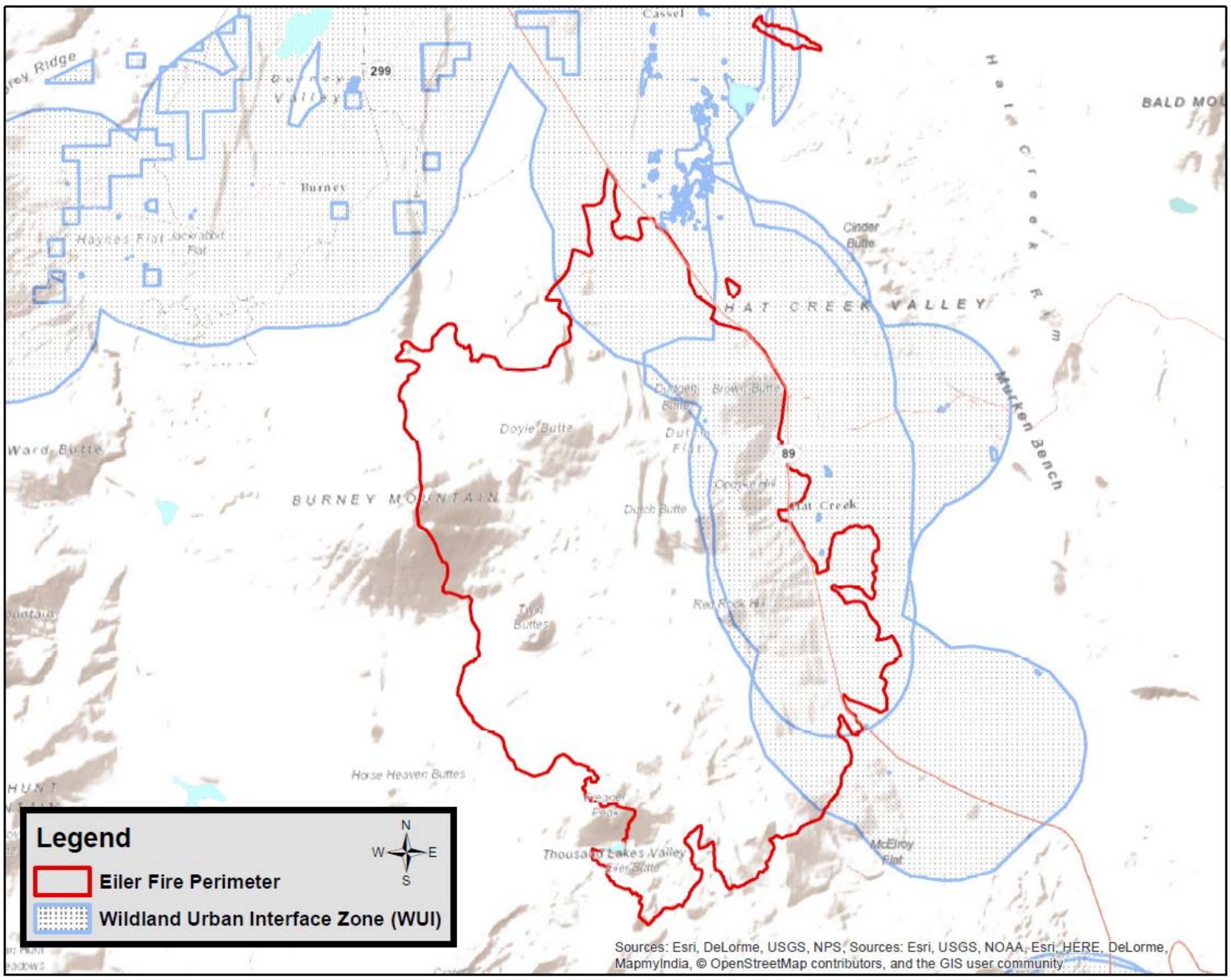

Figure 1: Vicinity Map.

Fuel levels, risk of injury, and damage from wildfires are components of the Purpose and Need for the Eiler Project. Bringing fuel load levels and fuel arrangement to conditions that reduce the likelihood of stand-replacement fire in regenerated stands, particularly during early stages of stand development, will promote the long term survival and growth of new conifers. Predicted increases in fire hazard in the high-severity areas of the fire could be mitigated by salvage harvest or by otherwise removing fire-killed trees or slash. Because the primary cause of high fire hazard in these areas would be the increased surface fuel loading as fire-killed trees fall and become downed woody material over time, removal of this heavy fuel load would prevent the predicted increase in fire hazard in these areas (Greenlee and Greenlee 2002; Peterson and Harrod 2011; Ritchie et al. 2013; Peterson et al. 2015).

Affected Environment

In many places in the western United States, a substantial amount of scientific evidence indicates that accumulations of fuels have reached levels far exceeding those found under “natural” or pre-European settlement conditions. These fuel accumulations result from human activities including fire suppression, grazing, logging, and tree planting. Natural disturbances, including fire, also contribute to these fuel accumulations. Organic matter is produced at a higher rate than it can be cycled by decay. Combustion during a fire rarely consumes more than 10 to 15 percent of the organic matter, even in stand-replacement fires, and often much less. Consequently, much of the forest remains in the form of live trees, standing dead trees, and logs on the ground (Agee and Franklin 2003). High severity crown fires result in high levels of tree mortality, consuming leaves and small branches but leaving the boles largely intact. Over time, a strong relationship can develop between the basal area of snags retained and the surface fuels accumulated (Ritchie et al. 2013). The accumulation of this woody material on the ground may increase the likelihood of severe stand replacing wildfires. As a consequence, subsequent occurrences of high-severity fires result in generally greater changes in plant compositions and structure than would occur if the communities had been subjected to more frequent low and mixed severity fires. Uncharacteristically high fuel levels create the potential for fires that are uncharacteristically intense (Agee and Franklin 2003). Elevated surface fuels can constitute an increased risk to the succeeding stand (Agee and Skinner 2005) and present a challenge and safety risk to fire crews in any subsequent burn of these areas.

Fire risk is elevated in areas of human development, high-recreational use, and along major roads. There is a need to reduce fuel loadings to meet desired levels and reduce adverse impacts from future wildfires within the affected environment of the Eiler Project.

Fire History and Historical Fires

Fire regimes in low elevation mixed conifer forests have been characterized as frequent and low to moderate in severity (Kilgore 1973; Kilgore and Taylor 1979; Bonnicksen and Stone 1982; Agee 1993). However, a fire history study conducted in the Thousand Lakes Wilderness (TLW) on the LNF (Bekker and Taylor 2010) determined that moderate to high severity fires had a dominate influence on mixed conifer stands and all other forest structural groups in the TLW, except for red fir-mountain hemlock stands. Moreover, these extensive high severity fires burned across all slope positions and aspects, probably due to the relatively undifferentiated topography of the TLW (Bekker and Taylor 2001).

Variation in some fire regime parameters in the TLW paralleled environmental and compositional gradients. Median point fire return intervals were shortest in lower montane mixed conifer and Jeffery pine-white fir stands (13-25 years) and upper montane red fir-white fir stands (14.5-19.5 years), intermediate in lodgepole pine stands (50-76.5 years), and longest in high-elevation red fir-mountain hemlock stands (100 years). The fire return intervals are conservative estimates of fire occurrence for compositional groups because low intensity fires may not scar trees and trees scarred by fires may heal over completely, leaving no external evidence of fire (Agee 1993; Taylor 1993; Taylor and Skinner 1998). The estimates, however, fall within the range for forests with similar composition elsewhere in the Sierra Nevada and Cascade ranges (e.g., Kilgore and Taylor 1979; Taylor 1993, 2000; Caprio and Swetnam 1995).

Fire severity patterns in the TLW, in contrast, did not vary much across compositional and environmental gradients. High severity fires comprised greater than 50 percent of the cumulative area burned between 1864 and 1939 in all forest groups and most of the remaining area burned at moderate severity. Fire severity patterns for burns earlier in the 19th century could not be reconstructed because recent severe burns consumed tree ring evidence of them. Therefore, it was uncertain if the similarity in fire severity identified across both environmental and compositional gradients was due to chance behavior of fires during recent burns or a persistent pattern for forests in the TLW (Bekker and Taylor 2001).

Structural variation in the TLW forests reflects the influence of extensive moderate to high severity fires, particularly in the late 1800s, as well as fire suppression efforts beginning in the early 1900s. Distinct pulses of tree recruitment followed the most recent (1883, 1885, 1889 and 1918) large and mainly high severity fires. Most forest structural groups have undergone increases in density and are experiencing compositional shifts from shade-intolerant and fire-tolerant pines to shade-tolerant and fire-intolerant fir in response to fire suppression (Bekker and Taylor 2010).

The patterns of fire severity identified for the TLW mixed conifer forests are inconsistent with general models of pre-Euro-American fire regimes in the Sierra Nevada (e.g., Kilgore 1973) and Cascade Range forests (e.g., Agee 1993). Fires in mixed conifer forests have been previously described as being frequent and low to moderate in severity. The predominately high and moderate severity fires within mixed conifer forests in the TLW indicate general models of mixed conifer forest should be modified to include greater variation in fire severity and suggest that there may be geographic variation in mixed conifer forest fire regimes (Bekker and Taylor 2001).

According to tree-ring reconstructions of the Palmer Drought Severity Index, results from the TLW study and other study locations in the southern Cascades demonstrate these extensive fires occurred in dry or very dry years in northern California (Bekker and Taylor 2010). Regional fire activity was high in warm and dry years in all forest types in the southern Cascades. Climate has been increasingly identified as a key driver of moderate and high severity fire in western coniferous forests (Schoennagel et al. 2004; Westerling et al. 2006).

Although the majority of the Eiler Fire burned out of the TLW in a northerly direction, the Eiler Project area would be expected to have a similar high and moderate severity fire regime, due to the projects close proximity to the TLW and the presence of species in the area that require high severity fire (Baker Cypress and manzanita brush fields).

The project and surrounding area has experienced fire caused by human and lightning activity, with the majority of the fire starts originating from lightning. Fire history for the project area shows that the majority of the fires are under an acre in size. A variety of sources caused the past fire activity, including: lightning, equipment, arson, smoking, and campfires. Early fire records grouped these fires into four categories: lightning, equipment, person, and unknown.

Table 1. Historical Fires Recorded in the Vicinity of the Eiler Project Area.

Decade	Number of Fires	Size	Cause
1940's	1 large fire	Approximately 800 acres	Unknown
1970 – 1979	4	All under 1 acre	Lightning and Equipment
1980 – 1989	6	All under 1 acre	Lightning and Person
1990 – 1999	5	All under 10 acres	Lightning and Equipment
1992	1	Approximately 400 acres	Equipment
2000 – 2009	1	Under 1 acre	Lightning
2009	1	1,815 acres	Lightning

Source: 2015 Hat Creek Ranger District Fire Records.

Fire Regime Condition Class

Fire Regime Condition Class (FRCC) is defined in terms of departure from the historical fire regime and vegetative attributes. FRCC is determined by the number of missed fire return intervals, with respect to the historical fire return interval, current stand structure, and species composition. The relative risk of fire-caused losses of key ecosystem components that define each FRCC class increases for each respectively higher numbered class, with little or no risk at the Class 1 level. Table 2 describes the condition classes and fire regimes that have been developed to categorize the current conditions.

Table 2. Fire Regime Condition Class Descriptions.

Condition Class Descriptions	
Condition Class	**Fire Regime**
1	Fire regimes are within a historical range and the risk of losing key ecosystem components is low. Vegetation attributes (species composition and structure) are intact and functional within a historical range.
2	Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more return intervals (either increased or decreased). This would result in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation attributes have been moderately altered from historical range.
3	Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation attributes have been moderately altered from their historical range.

Source: USDA FS and USDI 2001.

Prior to the fire, the Eiler Project area probably experienced moderate and high severity fire in some areas, and low to mixed severity fire in others. Due to the increased fire return interval and increased fire hazard in many areas, the area was classified as a Fire Regime Group IV and/or I. Table 3 describes the fire regime groups.

Table 3. Fire Regimes Expressed as Fire Return Interval and Fire Severity.

Fire Regime Group	Frequency (Fire Return Interval)	Severity
I	0-35 years	Low to Mixed Severity
II	0-35 years	High Severity - Stand Replacement
III	35-100 + years	Mixed Severity
IV	35-100 + years	High Severity - Stand Replacement
V	>200 years	High Severity - Stand Replacement

Source: (USDA FS and USDI 2001).

Based on the decreased fire return frequency and the departure of the structure of the stands within the area, the Eiler Project area was classified as FRCC III prior to the Eiler Fire.

Recent Fire Trends

In most of the western United States, recent research has indicated that fire size is increasing, large fires are becoming more frequent, and in at least some locations the annual percentage of high severity fire is also increasing (Miller et al. 2012a). Recent research has also demonstrated there has been an increased proportion of high-severity fire in yellow pine and mixed-conifer forests in the Sierra Nevada between 1984 and 2010 (Long et al. 2014; Miller and Safford 2012; Miller et al. 2009). Average and maximum sizes of contiguous areas ("patches") of stand-replacing, high-severity fire within these conifer forests approximately doubled across the period of analysis. Increasing areas of high-severity fire and high severity patch size can occur when greater area is burned at constant proportion of high-severity fire, or when the proportion of high-severity fire within fire perimeters increases, or some combination of both (Miller and Safford 2012; Miller et al. 2009). According to the authors, these increases co-occur with rising regional temperatures and increased long-term precipitation (Long et al. 2014). In California, notable increases in fire activity are predicted. They are driven largely by projected increases in temperature and decreases in snow pack and, to a lesser extent, increased fuel production from carbon dioxide "fertilization" (Flannigan et al. 2000; Lenihan et al. 2003, 2008; Westerling et al. 2011).

It is not clear how the increases in fire activity would affect the Sierra Nevada forests (Safford et al. 2012). Increased burn area does not necessarily result in increased proportions of high severity fire (Miller et al. 2012b). The size of high-severity patches may be a particularly important indicator of whether changes constitute a major shift, especially because natural recovery processes such as natural reseeding of conifers may be limited by the distance to live trees (Long et al. 2014; Crotteau et al. 2013). If high-severity proportions and patch sizes of fires are elevated (Miller and Safford 2012), decreased time between successive fires could lead to type conversion or local loss of a particular plant association (Safford et al. 2012). Even if proportions are not elevated but remain similar, this would translate into greater area burned at high severity as total burned area increases (Long et al. 2014).

If the proportion of high-severity fire continues to increase in concert with the proportion of area burned, increasing areas of old forest will be lost, emissions will rise, and fewer large diameter conifers – which store the most carbon and play a variety of other keystone ecological roles - will be retained (Miller and Safford 2012; Hurteau and Brooks 2011; National Research Council 2011; North and Hurteau 2011, Lutz et al. 2012). With continuing increases in the extent of high severity fire and high severity patch size, post-fire erosion, stream sedimentation, nutrient cycling, carbon sequestration and natural forest regeneration processes will also be increasingly impacted (Pickett and White 1985; Hobbs and others 1992; Gresswell 1999; Breashears and Allen 2002; Sugihara and others 2006; Allen 2007).

Pre- Fire Conditions

Prior to the Eiler Fire, the vegetative composition and structure of the area had undergone dramatic changes within the last 140 years. These changes included increased tree density, canopy cover, and surface and ladder fuel loadings, as well as decreased crown base height (CBH). These changes had been documented in scientific literature, forest reconnaissance reports, comparisons of transect data, and Government Land Office (GLO) data. This research indicated that landscape vegetative conditions within mixed conifer landscapes on the Hat Creek Ranger District (HCRD) was outside their range of historical variability in terms of vegetative pattern, structure, tree density, and species composition. This movement of ecosystems outside their historical condition was a result, at least in part, of approximately 140 years of grazing, 100 years of fire suppression, and 80 years of timber harvest.

Surface fuels that were once consumed by fires had accumulated and increased since the time of fire suppression. Over time, drought and insect activity contributed to an increased surface fuel loading due to trees dying and falling over. Past timber management practices of seed step shelterwood, overstory removal, and insect salvage removal had affected the surface fuel loading. Within some of the past timber sales, the slash was treated by machine piling and burning. Unfortunately, within the majority of the timber sales, the slash from the trees was left on the forest floor due to the widespread nature of the projects. Sometimes the slash was lopped and scattered; but, due to a Mediterranean climate, the area has a slow decay rate.

Many of the plantations that were in the project area used to be manzanita brush fields. These brush fields were identified in the GLO notes from 1881 to 1883. These brush fields were probably the result of high severity fires in the past. In the 1930's to 1960's the brush fields were converted into plantations. As the plantations grew over time, so did the brush in the understory. In some of the plantations the brush understory grew to approximately 5-10 feet tall, creating a continuous fuel ladder from the ground to the canopy of the trees.

High stand densities and high fuel loads are created when overstocked stands with heavy accumulations of surface, ladder, and canopy fuels are present. Combined, these factors increased the potential for stand replacing, high severity fire events which were unfortunately realized when the Eiler Fire burned across the landscape.

Post Fire: Current and Future Fuel Conditions

The fire burned approximately 33,162 acres of Federal and private land. The fire resulted in a mosaic of vegetation burn severity effects (based on basal area tree mortality) (Figure 2). There are areas where tree mortality is 100 percent while other areas still support a green tree component (see photos 3.7 – 3.17, 4.1, and 5.14 in Eiler Photo Appendix, Eiler Project Record). Table 4 summarizes the percent of the area burned by severity class. Generally, the lower to moderate burn severity effects are found on the outer edges of the fire with an average patch size of 35 acres. The high severity burn effects, which account for the majority of the burned area, are found in the center of the fire with one patch exceeding 17,700 acres, and an average patch size of 214 acres.

Table 4. Eiler Fire Area Percent Burn Severity.

	Severity - Percent Basal Area Tree Mortality		
	Low-Moderate (less than 50%)	Moderately High (50% to 75%)	Very High (greater than 75%)
Percent of Fire Area	25%	6%	69%

Source: Based upon data received from the Remote Sensing Applications Center (RSAC) at Salt Lake City, Utah. The RSAC produces a suite of products using the Rapid Assessment of Vegetation Condition after Wildfire (RAVG) process following containment of a wildfire that burns 1,000 acres or more of forested National Forest System land. The LNF obtained the geographic information system (GIS) information from ftp://fsweb.rsac.fs.fed.us/RAVG/Region5/2014/Eiler.

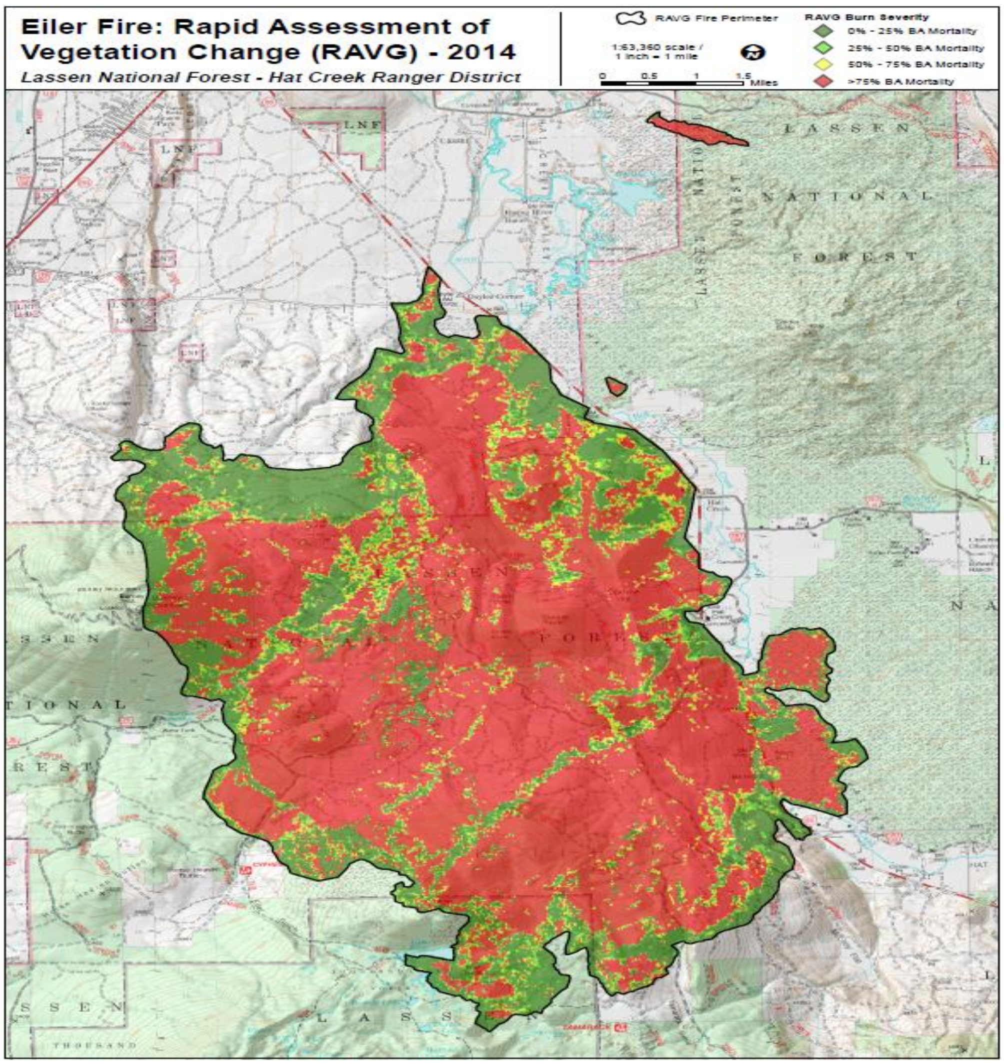

Figure 2: Fire Severity Map.

Trees that were killed by the Eiler Fire pose a hazard to the public and forest workers that are traveling and working in these areas. As snags age over time, they become less stable and increase the safety risk to all forest users (Ritchie et al. 2013).

The Eiler Fire resulted in a significant reduction to near total elimination of surface and small understory (ladder) fuels. In the short-term, this change in fuel loading and composition is expected to reduce wildfire intensities and rates of spread for several years (Photo 1).

Photo 1. High-severity fire in the Eiler Project area.

However, as the standing dead trees decay and fall to the ground, these areas will become occupied by high snag densities and a complex arrangement of fallen trees, broken tops, and branches, intermixed and suspended within an increasingly heavy shrub component. In the longer-term, these conditions would result in a heavily increased surface fuel loading (Photos 2 and 3).

Photos 2 and 3. Extreme fire behavior near Dutch Flat. Trees were snapped due to high winds.

Studies have shown that there is a strong positive relationship between initial fire severity and severity of a subsequent reburn (e.g. Holden et al. 2010; Thompson and Spies 2010; van Wagtendonk et. al 2012; Parks et al. 2014). The two principal mechanisms identified as being strongly tied to fire severity in the initial fires and the reburn were snag basal area and shrub cover. Results suggest that high to moderate severity fire in an initial fire can lead to an increase in standing snags and shrub vegetation, which in combination with severe fire weather, can promote high severity fire in the subsequent reburn of an area. Areas that initially burned at higher severities tended to reburn at higher severities, whereas areas that initially burned at lower severities tended to reburn at lower severities (Coppoletta, personal communication, 2015). Studies have shown that fuels can recover to their pre-burn levels in nine to 15 years (Thompson and Spies 2009; van Wagtendonk and Moore 2010). The window of low reburn potential can close relatively quickly (5-10 years) as regenerating vegetation and litter accumulates on the surface (Donato et al. 2013).

In areas of uncharacteristically large patches of high- and moderate-severity burn, the fuel loading is a long-term concern. Typically eight to 20 years following a fire, standing dead trees fall to the ground and become down woody material, known as coarse woody debris (CWD). CWD is typically defined as dead standing and downed pieces larger than three inches in diameter, which corresponds to the size class that defines large woody debris.

Studies have shown that the initial pulse of elevated surface fuels in logged stands is relatively short-lived as deposition and accumulation of surface fuels from decaying snags causes surface fuel loadings in unlogged stands to exceed those of logged stands within five to 10 years after wildfire (Monsanto and Agee 2008; Keyser et al. 2009; Ritchie et al. 2013; Peterson et al. 2015).

A study of post fire effects over an eight year period at Blacks Mountain Experimental Forest on the LNF found that fire-killed snags fell rapidly over time, leading to elevated surface fuel levels in areas where no salvage harvest was done. Initially, increased levels of surface fuels were associated with higher levels of salvage intensity; however, this relationship reversed as material came down from standing snags and quickly overwhelmed the levels of any material observed early in the study. Most ponderosa pine snags had fallen within eight years of the fire in the 11.8 to 17.7 inch class, compared to 41 percent in the greater than 17.7 inch class. Over time, a strong relationship developed between the basal area of snags retained and the surface fuels accumulated (Ritchie et al. 2013).

The 2012 Whittington Forest Health Restoration Project (Whittington Project) encompassed an area north of Whittington Butte, south of Burney Mountain, and west of Eiler Gulch. Eiler Gulch, and the eastern portion of the Whittington Project, is within the western portion of the Eiler Fire. Within the Whittington project, trees per acre within the mixed conifer stands ranged from 100 to over 500. The average diameter in sampled stands ranged from 12 to 23 inches. The trees per acre in the plantations/brushfields ranged from 140 to 190. The average diameter ranged from 17 to 18 inches.

Using the stand information collected for the Whittington Project, the tons per acre of standing dead snags would range from 33 to well over 100 in the mixed conifer and plantations/brush fields for this project.

Due to the close proximity and partial inclusion of the Eiler Project within the Whittington Project, it can be assumed that the Eiler Project would contain similar tons per acre estimates within the fire perimeter.

Table 5: Loading of Standing Dead Ponderosa Pine Coarse Woody Debris (tons per acre) by Number of Snags per acre and d.b.h. (inches).

Number	d.b.h.							
	6	8	10	12	14	16	20	24
4	0.2	0.4	0.8	1.3	2.0	2.9	5.3	8.6
6	0.3	0.6	1.2	2.0	3.1	4.4	8.0	12
8	0.4	0.9	1.6	2.7	4.1	5.9	11	17
10	0.5	1.1	2.0	3.3	5.1	7.4	13	22
15	0.7	1.6	2.9	5.0	7.7	11	20	32
20	1.0	2.1	3.9	6.6	10	15	27	43
25	1.2	2.7	4.9	8.3	13	18	33	54
30	1.4	3.2	5.9	10	15	22	40	64
40	1.9	4.3	7.8	13	20	29	53	**86**
50	2.4	5.4	9.8	17	26	37	**67**	
100	4.8	11	20	**33**	51	74		
200	9.6	21	39	66	102			
300	14	32	58	**100**				
400	19	43	78					
500	24	54	98					

Source: Brown 2003. Tons per acre estimates for Douglas-fir and lodgepole pine are comparable to the estimates for ponderosa pine shown above.

In many areas, it is estimated that over 100 tons of standing dead material exists per acre within the Eiler Project, which over time, would fall down and contribute to CWD. Elevated surface fuels would constitute a significant risk to succeeding stands (Agee and Skinner 2005), present challenges and safety risks to fire crews in any subsequent burns of the project area, and increase the potential for high severity reburn and high severity fire effects.

Fire Hazard Assessment

Fire hazard identifies the availability of fuels to sustain a fire. Fire hazard for any particular forest stand or landscape reflects the potential magnitude of fire behavior and fire effects as a function of fuel conditions. Understanding the structure of fuels and their role in the initiation and propagation of fire is the key to developing effective fuel management strategies. Forest fuels that are the major components of fire hazard are described in three categories. Surface fuels are composed of grass, herbs, low-lying shrubs, litter, and dead and down woody material. Ladder fuels are composed of live and dead shrubs and understory trees. Canopy fuels are the live and dead material in the canopy of trees (Peterson et al. 2003). Anderson (1982) identifies fine surface fuels as the primary carrier of fire at the flaming front. Fine surface fuels are CWD with diameters of up to three inches. These fuels are an important factor in determining how fast a surface fire would spread and how hot it would burn under given atmospheric and topographic conditions. Fine surface fuels directly affect fire intensity and spread by linking fire from the surface into the ladder fuels, which can lead to propagation of fire into the crowns of trees.

Fire behavior is the manner in which a fire reacts to available fuels, weather, and topography. A change in any of these components results in a change in fire behavior (DeBano et al. 1998). Fire behavior is described by flame length and rate of spread (Rothermel 1983). Fire behavior is complex, with many contributing factors, the most critical of which are topography (slope, aspect, elevation), weather (climate, air temperature, wind, relative humidity, atmospheric stability), and fuels (size, type, moisture content, total loading, arrangement) (Agee 1993). Topography and weather at a given location are beyond the ability of management to control. Available fuel is the only factor that can be readily changed by management action. Weather conditions such as drought, temperature, humidity, and wind play a major role in the spread of wildland fires. These conditions are influenced by topography as well as global influences such as La Niña and El Niño. Weather conditions are a major factor in the initiation and spread of all wildland fires, but Omi and Martinson (2002) found that stands with prior fuel treatments experienced lower fire severity than untreated stands burning under the same weather and topographic conditions. Fuel management modifies fire behavior, ameliorates fire effects, and reduces fire suppression costs and danger (DeBano et al. 1998). Manipulating fuels reduces fire intensity and severity, allowing firefighters and land managers more control of wildland fires by modifying fire behavior in the fire environment (Pollet and Omi 2002).

A fire hazard assessment analyzes crown fire potential as well as that of a surface fire. Crown fires normally are highly destructive, difficult to control, and present the greatest safety hazard to firefighters and the public. In general, crown fires burn at higher intensities and result in more severe effects than surface fires. Crown fires generally spread many times faster than surface fires (Rothermel 1983). Agee (1996) states that crown fire potential can be managed through prevention of the conditions that initiate crown fires and allow crown fires to spread. Therefore, fuels management must address treating the factors that lower the probability of the initiation and spread of crown fires. These factors include height of the forest canopy above the ground (canopy base height), the density of the crowns (canopy bulk density), and surface fuel loading (Omi and Martinson 2002).

Fire severity is also considered an element of fire hazard. Fire severity refers to the effects of fire on the ecosystem. It depends on fuel consumption and heat flux into all living components. Downward heat transfer into the soil is an important determinant of fire severity. Large woody fuels have little influence on spread and intensity of the initiating surface fire in current fire behavior models; however, they contribute to development of large fires and high fire severity. Torching, crowning, and spotting, which contribute to large fire growth, are greater where large woody fuels have accumulated under a forest canopy and can contribute to surface fire heat release. Fire persistence, resistance-to-control, and burnout time (which affects soil heating) are significantly influenced by the loading, size, and decay state of large woody fuel (Brown et al. 2003).

Resistance-to-control is generally viewed as an estimate of the suppression force required for controlling a unit of fire perimeter. It is the relative difficulty of constructing and holding a control line as affected by resistance to line construction and fire behavior. The ratings in following table were based on the assumption that few downed pieces greater than a 10 inch diameter were present. In computing the ratings, the number of large pieces (greater than 10 inch) by length class is more important than their loading in determining resistance-to-control. The more pieces greater than 10 inch diameter, the less three to 10 inch diameter material would be required to reach the high and extreme resistance-to-control ratings. Fire hazard, including resistance-to control and fire behavior, reaches high to extreme ratings when downed CWD exceeds 30 to 40 tons per acre. Excessive soil heating is likely at approximately 40 tons per acre and higher (Brown et al. 2003).

Table 6. Relationship of Fuel Loading to Resistance-to-Control.

0 to 3 Inch Diameter (Tons Per Acre)	3 to 10 Inch Diameter (Tons Per Acre)	
	High	Extreme
5	25	40
10	15	25
15	5	15

Source: Brown 2003.

Currently, the fire hazard in the project area is rated as low, due to the lack of surface fuels present that were consumed during the Eiler Fire (Photo 4). As trees fall over time, the fire hazard in the project area would be rated as predominately high and extreme due to the heavy surface fuel loadings of CWD which are estimated to be in excess of 100 tons per acre in many areas.

Photo 4. Lack of surface fuels found within the majority of the high-severity burn areas.

Under these severe burning conditions, a fire would remove or destructively alter soil organic matter, volatize nutrients, decrease water-absorbing capacity, and kill living plant parts and microorganisms (Brown et al. 2003). This factor could, given 90th percentile fire weather, result in a wildland fire of large size and severe negative environmental effects. There would still be areas within the project area that have a low wildland fire hazard rating (i.e. meadows and rocky areas); however, these areas exist as small and discontinuous patches that, on their own, would be ineffective in slowing or stopping a large wildland fire.

Desired Fuel Conditions and Fire Behavior

Removing burned trees and fuels where tree mortality exceeds the need for snag and log recruitment is the first step toward meeting the desired fuels conditions and protecting multiple resources, including soils and watersheds, from future high-severity fires. In order to reintroduce fire into these areas as soon as possible, the current fuel load needs to be reduced and the continuity needs to be reduced to a level where fire would burn in patchy, mostly low, and some moderate, vegetative burn severities.

The amount of CWD that provides desirable biological benefits, without creating an unacceptable fire hazard or potential for high severity reburn, is an optimum quantity that can be useful for guiding management actions. To arrive at this optimum, various sources of information about the roles of CWD in the forest and its historical dynamics should be considered, which include: fire hazard, soil heating/protection, soil productivity, and wildlife needs. Depending on the resource area of concern, optimum quantities of CWD range from zero to approximately 40 tons per acre. The optimum range of CWD that provides an acceptable risk of fire hazard while providing benefits to soil and wildlife is recommended to be five to 20 tons per acre for warm, dry ponderosa pine and Douglas-fir types, and 10 to 30 tons per acre for cool Douglas-fir, lodgepole pine, and lower subalpine fir types (Brown et al. 2003). The estimated 100 tons per acre is well above the optimum range of managing for CWD, as it relates to the fire and fuels resource area.

The goals of the salvage harvest and area fuels treatments are to reduce the density of standing dead trees in order to reduce future surface fuels, so that another wildland fire burning under 90th percentile weather would produce, on average, a flame length of four feet or less and fireline intensities and fire severity would be reduced. The desired fuel conditions would reduce the chance of a “reburn”, which has a specific meaning. Reburn results when falldown of the old burned forest contributes heavily to the fire behavior and fire effects of the next fire (Brown et al. 2003).

The desired fuels conditions within the project area include a reduction of the surface fuels in order to reduce the predicted flame lengths, fire intensities, resistance-to-control, probability of future crown fire initiation and spread, and predicted mortality within the stands. Fuels management can include reducing the loading of available fuels, lowering fuel flammability, or isolating or breaking up large continuous bodies of fuels (DeBano et al. 1998). Studies have shown that post-fire salvage harvest can reduce future surface woody fuel levels and the threat of high-severity fire in forests that are regenerating following wildfires (Ritchie et al. 2013, Peterson et al. 2015). For these reasons, the comparison of alternatives in this analysis focuses on the reduction of surface fuels, flame length, fireline intensity, and resistance-to-control.

Environmental Effects

Alternative 1 - Proposed Action

The purpose of the Eiler Project is to immediately reduce numerous safety hazards caused by the Eiler Fire, capture the limited, remaining forest product economic value, reduce fuel loads, adequately prepare sites for costly regeneration and reduce future fuel loadings that create conditions prime for devastating reburns, and then quickly reforest suitable portions of the landscape deforested by the Eiler Fire before these sites become fully occupied by competing vegetation.

The proposed action was developed to accomplish the purpose and need for the Eiler Project by evaluating existing vegetation conditions, burn patterns and intensities, and land allocations within the analysis area. The objectives for treatments within the Eiler Project were developed and designed to achieve more than just the desired fire behavior conditions and fuels reduction goals. Salvage harvest would be the first step in the process to capture the economic value of hazard trees and dead trees, which pays for their removal from the forest and potentially for other future restoration treatments. Post-fire management treatments are generally focused in areas that experienced moderately high to very high vegetation burn severity effects.

Hazard Tree Removal

The LNF proposes to fell and remove or fell and leave in place fire-affected hazard trees posing critical threats to safety along 34 miles of maintenance level 2 (ML2) and higher roads, and along two miles of trail within the Eiler Fire perimeter. Merchantable trees would be removed using area salvage. Sub-merchantable trees and non-merchantable hazard trees would be felled and left in place, or piled and the piles burned, or broadcast burned depending upon the amount of surface fuel loading present.

Area Salvage Harvesting

The Forest Service is proposing to salvage harvest fire-killed and fire-injured trees within the perimeter of the Eiler Fire. Merchantable trees would be removed as sawlogs if operations occur in a timely manner before the wood deteriorates. Non-merchantable trees of smaller diameters would be removed as biomass, masticated, felled and lopped, machine or hand piled and burned, and/or broadcast burned to meet desired fuels conditions.

The salvage harvest operations would utilize ground-based, mechanical harvesting to remove fire-killed and fire-injured trees from treatment areas on slopes 35 percent or less. On slopes greater than 35 percent, hand-felling and yarding by helicopter would be used to salvage harvest fire-killed and fire-injured trees from treatment areas. Area salvage harvesting would occur on approximately 3,048 acres. Natural and activity-generated fuels would be broadcast burned or piled mechanically or by hand, and piles burned. The number of acres treated by broadcast burning or pile burning is dependent on the amount of biomass removed from within the mechanical or hand treatment units. If more biomass is removed, the number of broadcast or pile burning acres would most likely decrease. The maximum for burning is used in this proposal.

Area Fuel Treatments

In areas that were deforested but the size of the remaining timber is sub-merchantable, the Forest Service is proposing to treat fire-killed and fire-injured trees. Non-merchantable trees of smaller diameters would be removed as biomass, masticated, felled and lopped, machine or hand piled and burned, or broadcast burned. Trees designated for removal and snag retention would use the same guidelines as discussed above under Area Salvage.

Mechanical

The fuel treatment operations could utilize ground-based, mechanical equipment to remove or arrange fire-killed and fire-injured trees from treatment areas on slopes 35 percent or less. Mechanical area fuels treatments would occur on approximately 517 acres. Activity-generated fuels would be broadcast burned or piled mechanically or by hand, and piles burned.

Hand

Hand felling would be used on slopes greater than 35 percent, in areas inaccessible to mechanical equipment, and in areas where the biomass is not removed (see photos 3.7, 5.3, and 5.4 in Eiler Photo Appendix, Eiler Project Record). Hand area fuels treatments would occur on approximately 3,602 acres. Natural and activity-generated fuels would be broadcast burned or piled mechanically or by hand, and piles burned.

The number of acres treated by broadcast burning or pile burning is dependent on the amount of biomass removed from within the mechanical or hand treatment units. If more biomass is removed, the number of broadcast or pile burning acres would most likely decrease. The maximum for burning is used in this proposal.

Baker Cypress

Fuel treatments proposed in Baker cypress stands depend upon cypress density (Photo 5). On 200 acres where cypress occurs as isolated trees or small stands, standing fuels would be mechanically piled and burned. On 150 acres where pre-fire densities of cypress were high, and natural regeneration of cypress trees is expected to be high, hand thinning treatments would occur only in areas where impacts to Baker cypress seedlings could be avoided.

Photo 5. Baker Cypress found along forest road 34N60.

On 10 acres within the Eiler Gulch area where Baker cypress is scattered along the riparian corridor, hand thinning and pile burning activities are proposed. No additional site preparation would occur, although windrow spreading may occur within Baker cypress treatment units where windrows are not occupied by Baker cypress.

The remainder of the cypress occurs within hazard tree units or salvage units where impacts to the cypress would be minimized through project design features. Broadcast burning activities are not proposed within Baker cypress occurrences.

Reforestation

Reforestation is proposed on approximately 5,645 acres within the project area in sites prepared by salvage harvest and fuels treatment. In addition, sprouting shrubs and vegetation may need to be treated adjacent to planted trees to reduce competition for site resources in order to assure establishment. This may be done through manual or mechanical cutting methods such as grubbing, mastication, or the use of brush cutters. All site preparation would occur prior to planting.

Fire Behavior Modeling and Fire Effects

Fire behavior was modeled using Behave Plus version (5.0.5). Behave Plus, like all models, has limitations and assumptions. Behave Plus uses existing models and algorithms to simulate fires. Behave Plus predicts fire behavior based on continuous fuel bed and fuel moisture, while wind and slope remain constant. It was designed to predict the spread of a fire and describes fire behavior only in the flaming front. The primary driving force in the calculations is dead fuel less than one-fourth inch in diameter. Fuels larger than three inches in diameter are not included in the calculations and the model is primarily intended to describe fires advancing steadily and does not include multiple sources of ignition (Andrews 1986).

A fuel model is a set of fuelbed inputs needed by a particular fire behavior or fire effects model. Fuel models describe surface fuel loadings. The fuel models used for this analysis are based on the original 13 fire behavior fuel models tabulated by Rothermel (1972) and Albini (1976) and come from the Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model. Widespread use of the Rothermel fire spread model and desire for more options in selecting a fuel model indicated the need for a new set of models to: improve the accuracy of fire behavior predictions outside of the severe period of the fire season, such as prescribed fire and fire use applications; increase the number of fuel models applicable in high-humidity areas; increase the number of fuel models for forest litter and litter with grass or shrub understory; and increase the ability to simulate changes in fire behavior as a result of fuel treatment by offering more fuel model choices, especially in timber-dominated fuelbeds. A new set of standard fire behavior fuel models was developed (Scott and Burgan 2005). Like the original set of 13, the new fire behavior fuel model set is applicable to fire behavior modeling systems that use Rothermel's surface fire spread model. The development of the new set of fire behavior fuel models allows for a better representation of actual fuel loadings found on a site and, as a result, produces more accurate fire behavior predictions.

The Manzanita Lake Remote Automated Weather Station (RAWS), located approximately 15 miles north of the project area, was selected to obtain the 90th percentile weather used for all of the fire behavior modeling. The 90th percentile weather represents the average-worst weather conditions during the fire season. The 90th percentile weather is a climatological breakpoint. Climatological breakpoints are established to provide agency specific, National Fire Danger Rating System based decision points for all appropriate management responses in a Fire Danger Rating Area. The 90th percentile fire weather indices were obtained from station recordings from 1972 to 2015 and are displayed in Table 7.

Table 7. 90th Percentile Fire Weather Data used to Model Effects for the Eiler Project.

Fuel / Weather Variable	90th Percentile Values
1 Hour Fuel Moisture, %	3
10 Hour Fuel Moisture, %	4
100 Hour Fuel Moisture, %	8
1000 Hour Fuel Moisture, %	9
Herbaceous Fuel Moisture, %	3
Woody Fuel Moisture, %	70
20 Foot Wind Speed, MPH	10
Dry Bulb Temperature, Degrees F	83

Source: Manzanita Lake RAWS (1972-2015).

Flame length is the average distance, in feet, from the base of the flame to the flame tip. Although the flame tip may only be four feet above the ground, the flame length can be considerably longer. This results from the effect of wind speed on the flame. Direct attack of a fire by hand crews is not recommended by standard firefighting operating procedures when flame lengths are more than four feet. Additionally, flame lengths of more than eight feet would exclude the use of any ground forces for direct attack of a fire. Direct attack is preferred to indirect attack because it is generally safer for firefighting personnel and can keep wildland fires smaller than indirect attack methods.

Fireline intensity, expressed in British Thermal Units (Btu/ft/sec), is the rate of heat energy released during combustion per unit length of fire front.

Table 8. Relationship of Surface Fire Behavior to Fire Suppression Actions.

Flame Length (feet)	Fireline Intensity (Btu/ft/sec)	Fire Suppression Actions
< 4	< 100	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
4 - 8	100 - 500	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.
8 - 11	500 - 1000	Fires may present serious control problems such as torching, crowning, and spotting.
> 11	> 1000	Crowning, spotting, and major fire runs are probable. Control efforts at head of fire are ineffective.

Source: Fireline Handbook Appendix B: Fire Behavior.

Across the landscape a combination of treatments were developed to achieve the desired conditions for Alternative 1. These treatments would be implemented in the hazard tree removal, area salvage harvesting, area fuels treatment, and reforestation treatment areas. Within the Eiler Project treatment areas, fire behavior was modeled for vegetation types with a fuels reduction objective. Modeling parameters for weather are shown in Table 7. Fuel models were chosen to represent the primary fuel types and surface fuel conditions that would be found throughout the project area over time. Fuel models used in fire behavior modeling, after proposed treatments, were based on average surface fuel loading reductions observed in similar post fire treatments conducted on the LNF. The results of modeling these treatments are shown in Table 9.

Table 9. Alternative 1 - Fire Behavior Modeling Results within the Eiler Project Area using 90th Percentile Weather.

Alternative 1				
	Fuel Models	**Flame Length (feet)**	**Fireline Intensity (Btu/ft/sec)**	**Fire Suppression Actions**
Years 1 - 5	TU1/TL1/SH1	0 - 3	2 - 53	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
Years 6 - 10	TU2/TL3/TL8/SH1	1 - 4	6 - 114	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
Years 11 - 20	TU2/TL4/TL5/TL8/SH2	1 - 5	6 - 215	Primarily, fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire. But in some areas, fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.
Desired Conditions: Direct Attack Suppression Methods		≤ 4	≤ 100	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
		≤ 8	≤ 500	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.

Source: Fire behavior outputs from Behave Plus 5.0.5. Note: Fuel models were chosen to represent the primary fuel types and surface fuel conditions that would be found throughout the project area over time.

Flame lengths and fireline intensities would be reduced within the treatment areas. Resistance-to-control would be improved and the predicted fire behavior for Alternative 1 would allow fire suppression resources to use direct attack methods throughout the project area.

Direct and Indirect Effects to Fuels and Fire Behavior

Within the Eiler Project, a combination of treatment methods would be utilized to accomplish the project goals and desired conditions within the Hazard Tree Removal, Area Salvage Harvest, Area Fuels Treatment, and Reforestation areas. Mechanical thinning, hand thinning, prescribed fire, and mastication are the proposed fuels treatment methods. The effects of these treatments are described in the following sections.

Direct and Indirect Effects of Mechanical Thinning

The direct effect of salvage harvest and area fuels treatments would be a reduction of snags on the landscape. Treatments proposed in Alternative 1 would remove future surface fuels, which would reduce the vertical arrangement and horizontal continuity of the surface fuels (Peterson et al. 2005, Graham et al. 2004). Salvage harvest treatments would remove a substantial portion of the large woody fuels that would contribute to a future complex arrangement of dead and live surface fuels. Whole-tree yarding would be used during salvage and area fuel treatment operations to reduce the creation of slash generated by harvest activity. Removal of limbs and tops by such methods would greatly reduce activity-generated surface fuels (Agee and Skinner 2005). These treatments may result in incidental activity-generated fuel accumulations. In the short term following the proposed treatments, fire behavior, as defined by flame lengths and fire intensity, could be increased slightly as compared to that expected without treatment. However, these activity-generated fuels would be broadcast burned or piled mechanically or by hand, and piles burned, so any potential increases to fire behavior would be reduced.

In the long term, within the proposed treatment areas, fire behavior and fire severity would be expected to be lower due to the decrease in CWD compared to no treatment. Salvage harvest would remove the larger diameter merchantable material from the site. Yarding of unmerchantable-sized material, biomass removal (from approximately four inches to 12 inches diameter), or broadcast burning would treat the high density of unmerchantable material. Broadcast or pile burning would treat the smaller diameter material and material not included in the previous treatment. After treatments, the CWD is estimated to be approximately five to 15 tons per acre in the less than three inch size class; these areas could be directly attacked with suppression resources, increasing the chance of containing wildfires in the project area while maintaining resource needs (Brown et al. 2003; Fites et al. 2007). Fire-killed trees have lost most of their moisture making them brittle and more susceptible to breakage (Lowell et al. 2010). During the felling and removal process it is anticipated that there would be higher than normal breakage typically associated with timber felling. This compacted material would have minimal effect on fire behavior and resistance-to-control. Completed project activities would reduce CWD, lowering fire effects within the treated units.

Fuels on the forest floor would consist of small diameter material and scattered larger logs. Snags and large logs may be present within the units to meet resource needs and Lassen Forest Plan Direction. These guidelines were developed with consideration for fire and its role in developing and sustaining these ecosystems. Within the salvage harvest tractor units, snag retention leave islands would be distributed across the unit to maintain diversity. These patches would generally be two to five acres is size, and would comprise approximately 25 percent of the acres within each unit. Within the helicopter units, approximately 100 square feet of basal area per acre of snags would be left to maintain black-backed woodpecker habitat ranging from 10 inches diameter to an upper diameter that will vary by unit. Snags deemed as safety hazards during operations will be felled and left on site. Duff and litter layers are currently not present at a level that would affect fire behavior and retaining the small diameter material on site would help accelerate the development of these layers.

Reducing the surface fuel loading would decrease the potential for reburn. Fire severity would also be decreased, which would reduce the damaging effects to soils and wildlife. In the areas proposed for reforestation, these effects would decrease over time. As trees grow and the plantations become older, the predicted fire behavior would increase in these areas until the plantations are pre-commercially thinned. As the vegetation matures, fuel loadings would eventually increase. Out-year fire effects are expected to be dominated by young shrubs, small trees, and conifers reoccupying these sites.

Within the treated units, the reduction of CWD through salvage harvest and treatment of non-merchantable fire killed material would lower fire intensities and fire effects (Peterson et al. 2009), and provide advantageous areas for fire suppression actions (Fites et al. 2007). Resistance-to-control would be reduced and suppression forces would not be hindered by the high density of snags or CWD and could enter these areas and take appropriate actions to manage wildfires. The reduction in snags would result in reduced spotting that is often associated with snags when they burn. Firefighter safety would also be increased within the treatment areas, due to the reduction of standing snags and overhead hazards.

The effect on fire suppression forces beyond year 20 would depend on the continued maintenance of the stands. Stands that are maintained and managed to achieve the desired condition would not adversely impact future suppression.

Salvage harvest and area fuels treatments would contribute to long-term restoration objectives in dry coniferous forests by restoring surface fuels to levels more consistent with low and mixed-severity fire regimes. At the stand scale, post-fire salvage harvest reduces surface fuels over the longer term, particularly in the large diameter classes, which should increase management options for applying prescribed fire treatments or allowing future wildfires to burn without causing excessive damage to forest vegetation and soils (Peterson et al. 2015).

In comparison to the No Action Alternative, over time, Alternative 1 would result in relatively lower surface fuel loads, reduced potential flame lengths, fireline intensities, resistance-to-control, and potential mortality. Fuel loadings and potential flame lengths would be lowest in ground-based salvage harvest units where the treatment of submerchantable material (via biomass harvesting and removal or site preparation) would occur. While there is still potential for future mortality in treated areas, it would remain lower than that of Alternative 2 for wildfires occurring under 90th percentile weather conditions.

Direct and Indirect Effects of Hand Thinning

Within the proposed hand thinning treatment areas, the vertical arrangement of the fuels would be changed. Standing dead snags would become surface fuels. Felled material would be lopped and scattered and later broadcast burned or piled and the piles burned.

In areas where lopping and scattering occurs, the surface fuel loading would be increased. An increased surface fuel load could contribute to slightly increased flame lengths, fire line intensities, and resistance to control.

Direct and Indirect Effects of Prescribed Fire

Prescribed fire (broadcast and pile burning) would follow mechanical and hand thinning treatment operations to reduce the natural and activity generated surface fuel accumulations within the Eiler Project. Spot burning, otherwise known as jackpot burning, is a modified form of broadcast burning where greater accumulations of downed woody material are ignited and the fire is confined to these spots, due to the scattered and disconnected fuel loading within the broadcast burn unit perimeter. Jackpot burning would be the primary form of broadcast burning utilized in the project area. The number of acres treated by broadcast burning or pile burning is dependent on the amount of biomass removed from within the mechanical or hand treatment units. If more biomass is removed, the number of broadcast or pile burning acres would most likely decrease.

The prescribed fire treatments would reduce surface fuel loading by consuming litter and downed woody debris. This treatment is likely to induce scorch in the lower canopy of any remaining trees and may cause limited mortality in trees. Where bare mineral soil is exposed, sprouting and regeneration would reinvigorate the understory plant community (Kauffman and Martin 1990). The radiant heat produced from machine and hand pile burning could cause crown and cambial scorch on nearby residual trees, and could cause incidental mortality, but on a very limited basis. Understory vegetation would not be affected, with the exception of localized areas where any remaining duff and litter would be consumed during pile burning.

Future prescribed fire treatments, following the initial treatment, would keep the shrub layer in an early development phase with a greater percentage of newer, moister, and less flammable foliage. The horizontal and vertical continuity of the shrubs would be reduced. The brush species that resprout following fire would be younger, would have less dead material to contribute as available fuel, and would not be as dense. This would serve to ameliorate the effects of an increase in shrub growth. Underburning may also reduce fire intolerant shrubs.

Direct and Indirect Effects of Mastication

Within plantations, mastication (chipping, crushing, and compacting) of both trees and shrubs could be used to reduce competition in order to improve residual tree growth and vigor. Although using prescribed fire would be the preferred method of surface fuel treatment in non-planted areas, mastication could occur in stands, or portions of stands, to reduce heavy surface fuel loads in areas after mechanical or hand thinning activities. Mastication would alter the structure and arrangement of the surface and ladder fuel loading and reduce the expected flame lengths and rate of spread in the event of a wildland fire and during prescribed fire operations.

The direct effects of mastication would be a reduction of the aerial fuels and an increase of the surface fuel loading. Although the surface fuel loading would be increased, it would also be compacted. Fire behavior would be expected to be decreased due to the compaction of the surface fuels. This compaction would decrease the packing ratio of the surface fuels and would lead to shorter flame lengths, lower rates of spread, and a longer burning, higher severity fire. The residence time of a fire would be expected to be longer.

The indirect effects of the mastication treatments would be a reduction of growth in the grass and forb species, due to the increased surface fuels creating a deeper and more compact duff and litter layer. The layer would decline over time due to decomposition and the use of prescribed fire, eventually allowing re-establishment of understory vegetation.

Cumulative Effects

The Fire and Fuels cumulative effects analysis area for the Eiler Project includes the area within the project boundary. The existing fuels conditions and resulting predicted fire behavior are the result of past management practices that include DFPZ construction, area thinning, biomass thinning, salvage harvest, hand thinning, mastication, tree planting, wildfire, prescribed fire, grazing, and fire suppression. These activities have resulted in a range of fuel loadings and have created the existing fire and fuel conditions within the project area. Without periodic maintenance, and in the absence of fire, even areas that received previous fuels reduction treatments will continue to accumulate canopy, ladder, and surface fuels (PORFFA Summary, Eiler Fire Project Record).

Cumulative effects for Alternative 1 include safer access to the area due to the hazard tree removal along main roads and ML2 roads in this project. In addition, fuels treatments would improve the safety for all users. The treatment of CWD and smaller fire-killed vegetation would result in a reduction in fire behavior, fire effects, and resistance-to-control, thereby increasing safety during a wildfire event. Reduced fire behavior would allow suppression forces to take appropriate action and use direct attack methods. Fire spread on public lands would be altered, reducing the chance of fire spreading between the public and private lands interface.

The combined effects of these proposed treatments would increase the ability of fire suppression personnel to both safely and effectively limit the size and severity of wildland fires, while allowing for the reintroduction of fire into these areas under more moderate weather conditions. Firefighter safety would be improved with the removal of the overhead snags as they pose one of the greatest hazards to firefighters. Suppression efficiency would be improved within the treatment areas by creating an environment where wildfires would burn at lower intensities and where firefighting production rates would be increased because less ground fuels would need to be cleared for fireline construction and backfiring operations. Treated areas would provide a safer and more efficient environment for fire crews to stop wildland fires that could potentially spread and destroy private property, communities, watersheds, and wildlife.

Air Quality

The Eiler Project area is located north of a Class One Airshed, the Thousand Lakes Wilderness. The community of Hat Creek lies on the eastern side of the project area and Burney is to the north of the project area. The project area is located in the Shasta County Air Quality District and is part of the Northeast Plateau Air Basin.

Air quality within the project area is within national and state standards for visibility, particulate levels (PM10), and pollutants. The airshed is influenced by a westerly airflow from the northern Sacramento Valley up and across the Cascade crest. The project area's air quality could be affected by pollutants from downwind population centers such as the city of Redding, agriculture, by adjacent private forest activities producing seasonal dust and smoke, as well as by recreational activities using dirt roads in and around the project area. These effects are short term (less than 24 hours) and localized.

Direct and Indirect Effects

Under Alternative 1, there would be areas where piles would be burned and areas where broadcast burning treatments would occur. These areas would be treated as part of the district's prescribed fire program and, as such, all burning would be take place on permissive burn days. Depending on weather conditions and timing of other projects, it could take between three to five years to treat these areas following completion of the salvage harvest and area fuel treatments. Broadcast burning would take place in the fall and spring. Handpiles and machine piles would be burned in the fall-winter burn season. Currently, Shasta County meets National Ambient Air Quality Standards (NAAQS).

Prescribed burning would only occur on 'permissive' burn days as defined by the California Air Resources Board (CARB). CARB makes daily determinations of smoke transport conditions and grants permission to burn only on days with adequate smoke transport and dispersal conditions. Short-term production of smoke and associated emissions would occur during prescribed burning in the project area. However, daily coordination among local fire management officials, adherence to the smoke management plan (SMP), and the daily determination of smoke transport conditions by CARB would help to ensure that the smoke and related emissions for the proposed prescribed fire activities would stay within the standards of the Clean Air Act. The direct effects to air quality would be minimal and mitigated by following the guidance of the SMP and CARB.

In accordance with Title 17 of the California Code of Regulations, a SMP would be submitted to and approved by Shasta County prior to any prescribed fire ignitions that are part of the proposed action. Adherence to the SMP for pile and broadcast burning would decrease the chance of negative impacts to communities and other smoke sensitive areas. It would also help to ensure that emissions from pile or broadcast burning would not violate the NAAQS emission standards. Since the proposed project area falls within a federal attainment area for air quality, no conformity determination is required.

Treatment of fuels under Alternative 1 would result in decreased smoke production and associated emissions in the event of a wildland fire. This decrease in emissions would help to reduce smoke related impacts to nearby communities. Short-term impacts from smoke and associated particulate matter from the proposed prescribed fire treatments, combined with emissions from other vegetation burning on public and private land, is possible. However, as discussed earlier, these possible impacts would be mitigated by adherence to the SMP and CARB. In addition to these safeguards, a daily Air Quality Conference Call is conducted during the prescribed fire season. They are attended by representatives of the Air Quality Management Districts, the California Air Resources Board, Geographical Area Coordination Center meteorologists, and agencies that are conducting prescribed fire operations. These calls help ensure that burning only occurs when atmospheric conditions are conducive to good smoke dispersion and that the cumulative effects of all prescribed burning remain at levels that are within the provisions of the Clean Air Act.

Fugitive dust could result from salvage harvest operations such as skidding and hauling during dry seasons. This would be mitigated by standard contract requirements for road watering or other dust abatement techniques.

Cumulative Effects

The area for the cumulative effects analysis discussion is the project area, the Thousand Lakes Wilderness to the south, Burney Mountain to the north, the project boundary to the west, and Hat Creek valley to the East. This cumulative effects analysis area was developed based on prevailing winds flows (from the southwest), the location of class one air sheds, and the location of population centers.

The cumulative effects analysis for Air Quality considers ongoing, proposed, and reasonably foreseeable future actions. Past actions affecting air quality for the past five years in the area include the burning of some machine piles and miscellaneous handpiles on both federal and private lands. This burning occurred on permissive burn days. There has also been some dust created in the area from hunting, fire wood gathering, and other recreational uses. Due to the fact that wind events and storms take place (and move or remove the particulates from the air) the impacts from smoke events are short term (less than two weeks). There have been no large fires in the project area, but in 1999, 2000, 2002, 2008, and 2009, the air quality was impacted from large fires burning elsewhere in northern California and Oregon. These smoke events, depending on the prevailing winds and the high pressure system aloft, lasted from two to three days to one to two weeks. Again, due to the westerly flow of winds and precipitation events dispersing the smoke, there were no cumulative impacts from smoke.

Alternative 1 would not increase the amount of prescribed fire activities in the area above what has been implemented for the last five years and would not impact the air quality of the area, when combined with ongoing and reasonably foreseeable future actions, beyond what has occurred during this time.

Alternative 2 – No Action

Under Alternative 2, none of the activities proposed under Alternative 1 would be implemented. Hazard tree felling could occur along roads currently open to the public, trails, and developed recreation sites. The hazard trees could be felled and left in as part of road maintenance as per LRMP direction. No fuels treatments, site preparation, or reforestation would occur.

Direct and Indirect Effects

Existing stand conditions would persist and develop unaltered by active management. Down woody material would continue to accumulate at a rate that is greater than decomposition, contributing to the surface fuel layer. Standing snags would persist and the site would be rapidly colonized by grasses, forbs, and shrubs (Russell et al. 1998; Collins and Roller 2013), which can further add to hazardous surface fuel conditions (Albini 1976). These surface fuel conditions can leave recently burned areas prone to repeat fire in relatively short succession (5 to 15 years) (Coppoletta, personal communication, 2015).

It is a reasonable expectation that the site would develop comparable to that of similar local fires that have burned in the recent past where salvage did not occur. On these sites, grasses and shrubs, such as Ceanothus and Manzanita, have occupied the site while standing snags dominate the overstory of the high severity burn areas. The extent of shrub vegetation dramatically increased as a result of high severity fire during the initial fires. Shrub fuels within the project area would be well established within five to 10 years, based on shrub regeneration observed in past local fires like the 2000 Storrie Fire, 2008 BTU Complex (Coppoletta, personal communication, 2015), 1999 Lookout, Pidgeon, and Bucks Fires, and the 2008 Rich Fire. Within one study, the shrub cover was generally high, with approximately 60 percent of both stand replacing patches and individual plots exceeding 60 percent cover. The shrubs averaged three feet tall in these areas (Collins and Roller 2013).

Both grass-forb cover and shrub cover present formidable competition for water and light with naturally established seedlings. Large areas of untreated burned trees would exist. Brush intermixed with grass, forbs, and standing snags would dominate these areas. Over time, these snags would fall, resulting in brush fields with high surface fuel loads arranged in a jackstraw pattern. This competing vegetation would likely result in decreased survival of tree seedlings and would definitely inhibit growth for years, if not decades. Over time, ladder and crown fuels would develop where natural regeneration was established via seed from surviving mature conifers.

Hundreds of dead trees and very few live trees per acre characterize the forest structure. Snags have the highest fall rates in the first ten years within the smaller diameter classes, while larger snags persist for relatively longer time periods. This is generally documented in existing scientific literature (Cluck and Smith 2007). Nearly all snags would be expected to fall by approximately 20 years post-fire thus contributing to greater fuel loads (Greenlee and Greenlee 2002; Ritchie et al. 2013). The limbs and boles from these fallen trees would accumulate as surface fuels. Over time, these fuels are expected to increase each decade as trees fall over. Studies have suggested that extensive stand replacing, high severity fire in an initial fire leads to an increase in standing snags and shrub vegetation, which would promote more stand replacing, high severity fire in a subsequent reburn (Thompson and Spies 2010; Collins and Roller 2013; Coppoletta, personal communication, 2015). Surface fuels are projected to be well over 100 tons per acre, increasing the resistance-to-control, and ultimately increasing the potential for a high severity reburn and high severity fire effects. In the event of a wildfire, this would create serious control problems, high suppression costs, and high volumes of smoke emissions.

In the future the increased shrub densities, high snag densities, and large numbers of down logs across the Eiler Project area would impede fire line construction, increase safety hazards, and increase spotting potential in the event of another wildfire. The Lassen National Forest has direct experience with this as the 2012 Chips Fire burned several hundred acres within the footprint of the 2000 Storrie Fire. While flame lengths and rates of spread in the previously burned area were generally lower than those observed outside of it, numerous standing snags in this area prevented safe direct attack by ground-based fire suppression forces. Additional recent evidence of wildfire control problems within previously burned areas has been verified on the Tahoe National Forest by the 2013 American Fire, which burned in the footprint of the 2008 Westville Fire. Under such conditions, fire containment lines must be constructed far from the fireline where it is safe and practical to do so, ultimately increasing fire size. Increased soil heating from burning logs kills soil microorganisms and reduces soil productivity. Failure to remove dead trees before they deteriorate may have severe consequences when the next wildfire occurs. Predicted flame lengths and fireline intensities are displayed in Table 10.

Table 10. Alternative 2 - Fire Behavior Modeling Results within the Eiler Project Area using 90th Percentile Weather.

Alternative 2				
	Fuel Models	Flame Length (feet)	Fireline Intensity (Btu/ft/sec)	Fire Suppression Actions
Years 1 - 5	TU2/TL1/SH1	0 - 4	2 - 114	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
Years 6 - 10	TU5/TL3/TL4/TL8/SH2	1 - 8	6 - 586	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.
Years 11 - 20	TU5/TL5/TL7/TL8/SH7/SB1	2 - 17	25 - 2520	Crowning, spotting, and major fire runs are probable. Control efforts at head of fire are ineffective.
Desired Conditions: Direct Attack Suppression Methods		≤ 4	≤ 100	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
		≤ 8	≤ 500	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.

Source: Fire behavior outputs from Behave Plus 5.0.5. Note: Fuel models were chosen to represent the primary fuel types and surface fuel conditions that would be found throughout the project area over time.

Under Alternative 2, flame lengths could exceed four feet after five years and are projected to exceed 10 feet within 20 years. Fireline intensities could exceed 500 Btu/ft/sec in six to 10 years and are projected to exceed 1,000 Btu/ft/sec after 10 years. Resistance-to-control would be high within the first 10 years and extreme after 20 years. These increased flame lengths, fireline intensities, and resistance-to-control are a direct result of fire burning in dead and down logs, branches, and shrubs. Fires burning in stands under 90th percentile weather conditions are expected to result in serious control problems. Fires would be too intense for direct attack on the head by persons using hand tools, heavy equipment, and aircraft retardant. Firelines may not be relied on to hold the fire. Fires would present serious control problems like torching out, crowning, and spotting. Firefighters would have to employ indirect suppression methods. This would allow fires to become larger, more expensive, and potentially more hazardous for firefighters and the public. Associated smoke from a large, intense wildland fire could create both nuisance and health concerns in nearby communities for considerable durations (days or weeks). Under Alternative 2, the increased flame lengths, fireline intensities, and resistance-to-control would be expected to continue and become more problematic in the future.

Cumulative Effects

The scope of analysis and the effects of past, ongoing, and future foreseeable actions under Alternative 2 would be identical to those discussed for Alternative 1. Under Alternative 2, none of the activities proposed under Alternative 1would be implemented with the exception of hazard tree felling along roads currently open to the public, trails, and developed recreation sites. No fuels treatments, site preparation, or reforestation would occur. The hazard trees would be felled and left in place or piled and burned as part of road maintenance. This would provide for safe travel and recreation opportunities in these areas; however, large areas of untreated burned areas with brush and standing snags would exist. Access to these areas would be inhibited by hazard trees. Within a relatively short period of time throughout the project and along untreated roads, the standing snags would become downed logs and the surface fuel load would be increased. Limited access to areas within the analysis area would slow firefighter access for direct attack suppression methods.

As snags continue to fall, the surface fuel loading throughout the project area would continue to increase. Increased surface fuels would result in increased flame lengths, fireline intensities, and resistance-to-control problems thus leading to increased firefighter risk. Lives, property, and natural resources in and around the Eiler Project area would continue to be at risk from future wildland fires that have the potential to be both large in size and damaging to the ecosystem well beyond the scope of what has occurred in this area historically. Fire Regime Condition Classes would remain at their current levels. In the event of a wildland fire in the project area, under future fuel loading conditions and 90th percentile fire weather, large-scale loss of key ecosystem components would result. Twenty years in the future, these conditions would be more pronounced without some type of fuels reduction treatment to reduce the fire hazard in the area. The cumulative effects of Alternative 2 would create an increase in fire behavior over time and negative fire effects on the landscape.

Direct, Indirect and Cumulative Effects to Air Quality

Alternative 2 would not create any short-term impacts to the local areas from prescribed fire. The air quality within the project area would remain within national and state levels for visibility, particulate levels, and pollutants. The project area's air quality could be affected by pollutants from downwind population centers such as the city of Redding, agriculture, by adjacent private forest activities producing seasonal dust and smoke, as well as by recreational activities using dirt roads in and around the project area.

However, as surface fuel loadings increase over time, the risk of a major air quality impact from a large wildland fire burning in the area would be increased under Alternative 2. The amount of smoke created in the event of a large wildland fire burning in the project area could be increased for several reasons. There could be more acres burned in a shorter period of time and the fire would burn under hotter and drier conditions. Therefore, the amount of fuel consumed would increase and fuels would burn that would otherwise have been removed under Alternative 1.

Additionally, smoke impacts to local communities would be more severe in the event of a wildland fire due to the normal summertime inversions. Inversions cause smoke to linger near the surface in low-lying areas and can last for extended periods (2-3 weeks), especially during summertime conditions. Summertime inversions have negatively impacted the area during years when large wildland fires have burned in northern California, including 1987, 1992, 1999, 2000, 2002, 2008, and 2009.

Alternative 3 – Roadside Hazard Only

Direct and Indirect Effects

Under Alternative 3, commercial sized hazards would be removed along ML2 and higher roads. Sub-merchantable hazards would be felled and left in place or piled and burned. The maximum extent of these activities would be limited to approximately 150 feet of either side of main roadways. This would provide for safe travel along forest roads; however, due to the scale and scope of the project, large areas of untreated burned areas with brush and standing snags would exist. Access to these areas would be inhibited by hazard trees. Within a relatively short period of time throughout the project and along untreated roads, the standing snags would become downed logs and the surface fuel load would be increased. Limited access to areas within the analysis area would slow firefighter access for direct attack suppression methods.

No other site preparation or reforestation would occur along these roads. No other actions would occur within the fire perimeter. Therefore, the direct and indirect effects for Alternative 3 are almost identical to the No Action Alternative.

Table 11. Alternative 3 - Fire Behavior Modeling Results within the Eiler Project Area using 90th Percentile Weather.

Alternative 3				
	Fuel Models	**Flame Length (feet)**	**Fireline Intensity (Btu/ft/sec)**	**Fire Suppression Actions**
Years 1 - 5	TU2/TL1/ SH1	0 - 4	2 - 114	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
Years 6 - 10	TU5/TL3/ TL4/TL8/ SH2	1 - 8	6 - 586	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.
Years 11 - 20	TU5/TL5/ TL7/TL8/ SH7/SB1	2 - 17	25 - 2520	Crowning, spotting, and major fire runs are probable. Control efforts at head of fire are ineffective.
Desired Conditions: Direct Attack Suppression Methods		≤ 4	≤ 100	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.
		≤ 8	≤ 500	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.

Source: Fire behavior outputs from Behave Plus 5.0.5. Note: Fuel models were chosen to represent the primary fuel types and surface fuel conditions that would be found throughout the project area over time.

Cumulative Effects

The scope of analysis and the effects of past, ongoing and future foreseeable actions under Alternative 3 would be identical to those discussed for Alternatives 1 and 2. Under Alternative 3, none of the activities proposed under Alternative 1 would be implemented with the exception of hazard tree felling along roads currently open to the public, trails, and developed recreation sites. From a fuels management perspective, as it relates to fuels and fire behavior reduction, there is very little difference in the cumulative effects between the actions occurring for Alternatives 2 and Alternative 3. Therefore, the cumulative effects for Alternative 3 are considered to be identical to Alternative 2.

When the effects of Alternative 3 are combined with the effects of implementing the foreseeable private and Forest activities as stated in the PORFFA, this alternative would not aid in meeting fuels management and fire suppression objectives. The cumulative effects of Alternative 3 would be an increase in fire behavior over time and negative fire effects on the landscape. Overall, Alternative 3 would not have much impact on reducing future surface fuels and the impact they would have on predicted fire behavior and fire effects throughout the project area.

Summary of Effects Analysis for all Alternatives

Travel for public and forest workers would become increasingly hazardous as snags began to decay and fall, with the implementation of the No Action Alternative or Alternative 3. The fire behavior in the area would exceed firefighter capabilities within a few years and suppression actions would be limited to indirect tactics. Firefighter safety would not be improved within the majority of the project area. Future fires would be expected to burn with high intensities and cause high severity effects, impacting resources and killing most vegetation.

Therefore, forest guidelines and direction for hazardous fuels reduction and fire management would not be met after approximately five to eight years due to the implementation of Alternative 2 or Alternative 3.

Implementing Alternative 1 would reduce flame lengths, fireline intensities, and resistance-to-control, as summarized in Table 12. Safety within the overall project area would be improved for both the public and forest workers. Firefighter safety would be improved, due to the reduction of overhead hazards in the project area. The reduced fire behavior of the area would improve fire suppression options and allow firefighters to employ direct attack methods.

Table 12. Fire Behavior and Fire Effects by Alternative.

	Years 1 – 5		Years 6 – 10		Years 11 - 20	
	Flame Length	Fireline Intensity	Flame Length	Fireline Intensity	Flame Length	Fireline Intensity
Alternative 1	0 - 3	2 - 53	1 - 4	6 - 114	1 - 5	6 - 215
Alternative 2	0 - 4	2 - 114	1 - 8	6 - 586	2 - 17	25 - 2520
Alternative 3	0 - 4	2 - 114	1 - 8	6 - 586	2 - 17	25 - 2520
Desired Conditions: Direct Attack Suppression Methods	≤ 4	≤ 100	Fires can generally be attacked at the head or flanks by persons using hand tools. Hand line should hold the fire.			
	≤ 8	≤ 500	Fires are too intense for direct attack at the head by persons using hand tools. Hand line cannot be relied on to hold the fire. Equipment such as dozers, pumpers, and aircraft retardant can be effective.			

Alternative 1 reduces most of the CWD surface fuels to within approximately five to 15 tons per acre, which correlates to a reduction in fire behavior, fire effects, and improved resistance-to-control. The reduction of surface fuels increases the opportunities for fire suppression resources to contain fires from spreading between the private and public interface. The reduction of overhead hazards would create safer conditions for everyone visiting and/or working within the project area.

For Alternatives 2 and 3, projected surface fuels would not be reduced, and fuel loadings are estimated to range from 33 to well over 100 tons per acre over time. The accumulation of these surface fuels would contribute to conditions that would create increased fire behavior, fire severity, and resistance-to-control during the next wildfire event. Firefighter and public safety would not be improved throughout the majority of the project area.

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