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Fire and Fuels Report

Craggy Vegetation Management Project

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Siskiyou County, CA

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Fire and Fuels Resource Report

Introduction

This report discusses the historic role of fire in the Craggy Vegetation Management Project (Craggy Project) area and how current conditions reflect a departure from historic fire return intervals. The report then discloses the predicted effects of the proposed action and any action alternatives and compares the effects to those of an alternative where no action will occur (Alternative 1). The report also discusses current conditions with regard to the wildland urban interface and the effects of the alternatives within this area.

The need for action in the project area evolved primarily from changes in fire regimes over the last century. Historically, low- to mixed-severity fires in the area played a significant role in creating a high spatial complexity of vegetation, including openings of different sizes, forested stands that were generally more open and late-successional, and fire resilient forests. Fire suppression, along with other past management activities in the project area, resulted in uncharacteristically dense vegetation (see the Silviculture Resource Report, available on the project website: <http://www.fs.usda.gov/project/?project=31770> and high fuel loading, a decline in wildlife forage and habitat diversity, and an elevated risk of high-severity, stand-replacing wildfires. Since the 1955 Haystack Fire, which burned approximately 70 percent of the project area, only about 3,100 acres have burned. Presently, 80 percent or approximately 23,000 acres depart, moderately to severely, from historic fire return intervals.

Current concerns focus on high fire hazard (as defined by fuel loading and vegetation densities) and high fire risk (as defined by fire start occurrence) over time. Fire risk and associated fire hazard have led to concerns over fire behavior in and adjacent to private property and fire effects to resource values on National Forest lands (e.g. wildlife habitat, soil stability, human uses, hydrology, air quality). In addition, smoke from large fires that does not disperse has the potential to negatively impact the project area which has a high level of human use (see the Air Quality Resource Report, available on the project website).

The purpose of this project was generated from the Klamath National Forest Land and Resource Management Plan (Forest Plan) (USDA 1995, as amended); the Humbug Landscape Analysis and Design (USDA 1993); and the Yreka Area Fire Safe Council's Community Wildfire Protection Plan (Yreka Fire Safe Council 2013) with the objectives of reducing the wildfire threat to communities, reducing stand density to promote forest health, enhancing early seral foraging and winter range habitat, maintaining and improving habitat for sensitive plants, and limiting or reducing sediment discharge into streams. Treatments proposed in the project are aimed at reducing the threat of wildfire adjacent to private lands and communities as well as across a larger landscape level. One of the major goals of this project is to meet the standards of the wildland urban interface zones (defined later in this report).

Policy, Laws, and Direction

The following current laws, policy and direction related to fire and fuels apply to the Craggy Vegetation Management Project (Craggy Project):

Klamath National Forest Land and Resource Management Plan (Forest Plan);

Forest Service Manual 5100; and

Forest Service Manual 2000.

The Forest Plan provides two types of direction related to fuel management: Forest-wide direction (pages 4-54 and 4-55) and management area direction. Management area direction related to fuel management for the management areas that occur in the project area is found on pages 4-89, 4-94, 4-114, 4-116, 4-127, and 4-132. The Forest-wide direction states that fuels analysis should address the accumulation of fuels over time, including fuels generated from management activities (standard and guideline 22-16, page 4-55) and describe the hazard, risk and consequences of a wildfire (standard and guideline 22-19, page 4-55).

In the 2001 National Fire Plan (USDA USDI 2001), the Secretaries of Agriculture and Interior first directed federal agencies to develop treatments for building more fire resilient communities within the wildland urban interface. Since then, several other forms of national direction, such as the 10 Year Comprehensive Strategy (USDA USDI 2002) and a cohesive fuels treatment strategy (USDA USDI 2006), and the Flame Act of 2009, resulted in the cohesive strategy that identified at-risk communities as a key problem for fire management.

The Regional Forester of the Pacific Southwest region (Region 5) directed “that the one-hundred foot defensible space minimum be included in each Forest’s prioritization of current and out-year integrated vegetation management and hazardous fuel reduction program of work and projects” (RF letter (date)). In California, local and state laws also apply to private landowners and their responsibility for fuels treatments and fire prevention on their own land. The State of California Public Resources Code 4291, for example, requires landowners to “maintain defensible space of 100 feet from each side and from the front and rear of [any] structure...in a condition so that a wildfire burning under average weather conditions would be unlikely to ignite the structure.”

The Pacific Southwest Regional Forester provided the following direction to Forests: “Where consistent with existing Forest Land and Resource Management Plan direction, Forest Supervisors will provide for a one-hundred foot defensible space minimum for all structures on administrative sites, structures authorized by permit, and for developments adjacent to NFS [National Forest System] lands. Where needed to carry out this direction, applicable revisions to Forest Plans will be made during scheduled Forest Plan amendments, updates or revisions.”

Methodology

Fire behavior modeling was conducted using FlamMap. FlamMap is a fire behavior mapping and analysis program that computes fire behavior characteristics over a landscape of constant inputs of weather and fuel moisture conditions (Finney 2006). Outputs consist of fire type or crown fire potential (Scott and Reinhardt 2001) and flame length potential (Finney 1998). In addition, all fire model runs were calculated using LANDFIRE, which uses a vegetation layer to obtain fuel models. In addition to fuel models, LANDFIRE is comprised of elevation, aspect, slope, canopy cover, stand height, canopy bulk density, and canopy base height to predict fire behavior potential. The dominant vegetation type from the EVEG geographic information system layer was used for this analysis. The FlamMap model assumes uniform canopy characteristics and makes independent fire behavior calculations for each raster landscape (a 90 meter by 90 meter cell). As a result of these assumptions, the model frequently under-predicts active crown fires (Fule et al. 2001; Scott and Reinhardt 2001; Cruz et al. 2003; and Stratton 2004). Weather and fuel moisture conditions were calculated by a climatology program (Fire Family Plus) that collects historical weather data for analysis. Historical weather data was obtained from remote

automated weather stations at Oak Knoll and Collins Baldy. Ninetieth percentile weather (very dry) conditions were put into FlamMap for analysis of fire behavior potential.

Fire behavior modeling uses input variables to calculate fire behavior. The three primary variables affecting fire behavior are fuels, weather and topography. Because fuels are the primary variable that management activity can influence, they were the main variable used in this analysis of fire hazard. Potentially combustible fuels range in type from standing live trees and brush (woody fuels) to downed woody debris that ranges from less than a quarter inch in diameter (known as 1-hour fuels) to more than three inches in diameter (1000-hour fuels). Fuel moisture content and wind speed were based on 90th percentile weather conditions (Table 1).

Table 1: Modeling Inputs Based on Weather Conditions under 90th Percentile Conditions*

<i>Parameter</i>	<i>90th Percentile Weather Output</i>
Woody Fuel Moisture	66
Herbaceous Fuel Moisture	30
1000-Hour Fuel Moisture	7
100-Hour Fuel Moisture	5
10-Hour Fuel Moisture	4
1-Hour Fuel Moisture	3
Wind Speed	7
*90 th percentile weather conditions were based on the energy release component. The term means ‘very dry’.	

Analysis Indicators

Analysis indicators, as measured using information provided in the methodology section, are used to compare effects of alternatives. The analysis indicators and measures are described in this section.

Analysis Indicator: *Fire hazard* for the project area and within the wildland urban interface.

A major concern within the project boundary is the current fire hazard, defined by existing fuel loading and vegetation densities. Hazard is a source of danger. Wildland fire danger can be characterized by how a wildfire will burn or its likely fire behavior. A high fire risk (fire-start occurrence over time) and associated fire hazard in the project area have led to concerns over fire behavior and fire effects to resource values on Forest lands (e.g. wildlife and late-successional habitat, soil stability, hydrology, air quality, and others).

Measures:

- **Fire hazard:**

- ❖ Flame length potential – this was used in analysis for three different aspects: flame length within the project area, flame length within the project area by vegetation

categories, and flame length within the wildland urban interface. Flame length is a visual and measurement indicator of surface fire intensity. Flame length is defined as the distance along the slant of the flame from the midpoint of its base to its tip.

- ❖ **Fire type (crown-fire potential)** - this is an indicator on whether a fire is likely to stay on the surface or move through the crowns given a set of stand and burning conditions; this was used in analysis for the project area as a whole.
- **Fire behavior potential:** uses flame lengths and their potential effects to dominant vegetation types and sizes of trees under specified modeling conditions (acres of various flame lengths within vegetation types and sizes). This is a measurement indicator of effective acres treated, determined by flame lengths.

Flame Length Potential

Flame length is an indicator of how hot or severe a fire can become (i.e. a measure of heat output) and as a proxy for ease of fire suppression) used to model and predict fire behavior. Flame lengths are described in the Fire Management Plan and Appendix B of the Fireline Handbook (National Wildland Fire Coordinating Group 2006). This measure provides a means for assessing the potential for fires becoming difficult to suppress or contain, the potential to threaten communities at risk (i.e. wildland urban interface), and the potential to threaten resource values (e.g. wildlife habitat, soil stability, human uses, hydrology, air quality).

Table 2: Flame Length Potential and Fireline Intensity used to Describe Analysis of Measurement Indicators

Flame Length (feet)	Fireline Intensity (British Thermal Units per foot per second)	Description
Zero feet	0	<i>Very Low</i> – Non-flammable areas such as rock outcropping, water, etc.
Less than 4 feet	0 - 100	<i>Low</i> – Persons using hand tools can generally attack fires at the head or flanks of the fire.
4-8 feet	100 - 500	<i>Moderate</i> – Fires are too intense for direct attack on the head of the fire by persons using hand tools. Equipment such as dozers, engines and retardant aircraft can be effective.
8-11 feet	500 - 1,000	<i>High</i> – Fires may present serious control problems such as torching, crowning, and spotting. Control efforts at the head of the fire will probably be ineffective.
Greater than 11 feet	Greater than 1,000	<i>Very High</i> – Fires present serious control problems and control efforts are typically ineffective.

Fire Type (Crown Fire Potential)

Fire type potential is a measure of fire severity, of whether a fire is likely to stay on the surface or move through tree crowns given a set of vegetation and burning conditions. This measure is useful for analyzing the risk of losing a forested overstory to wildfire, or how resilient the forest overstory is to wildfire. Extensive crown fires can especially be an issue in vegetation types that are not adapted to respond to high intensity crown fires. Canopy characteristics (e.g. canopy base

height, canopy bulk density, stand height, and foliar moisture content), ladder fuels, and fuel loading are all factors that determine fire type.

Crown fire potential is defined by the following categories:

Surface fire – The fire remains on the forest floor. The combination of surface fire intensity and ladder fuels is not sufficient to move a fire into the crowns under the defined burning conditions.

Passive crown fire – Individual tree or group torching occurs. The combination of surface fire intensity and ladder fuels allows for movement into the crowns under the defined burning conditions, but canopy bulk density is too low for fire to spread through the crowns under the projected wind speeds.

Active crown fire – The combination of surface fire intensity, ladder fuels and canopy bulk density allows fire to move into, and spread through, the crowns under the defined burning conditions.

Fire Behavior Potential on Dominant Vegetation Type and Size Class

A major concern within the project area is fire effects potential to vegetation. This measurement indicator displays flame length potential on dominant vegetation types and size classes. The definitions of flame lengths and fireline intensity can be used to describe potential fire effects to vegetation categories and size classes for analysis.

Spatial and Temporal Bounding of Analysis Area

There are two spatial bounds for this analysis. The first will be the project boundary and the second will be the area within the wildland urban interface that is associated with the Craggy Project (see Appendix D of this report for a map of these analysis area delineations). The effects of alternatives on all analysis indicators will be analyzed for the Craggy project area. The effects of treatments on fire hazards as measured by flame lengths (a surrogate for fire intensity) for wildland urban interface areas will be disclosed.

The wildland urban interface is divided into three concentric zones:

Home Ignition Zone (Zone 1): This is a 100-foot zone around structures as identified by State of California Public Resource Code 4291. The goal of this zone is to have no crown fire and for flame lengths to be less than two feet, and “Fuels shall be maintained in a condition so that a wildfire burning under average weather conditions would be unlikely to ignite the structure” on 100 percent of the land base (State of California Public Resource Code 4291). Very little Federal System lands occur within 100 feet of structures, therefore the Craggy Project focuses primarily on the defense and threat zones, including areas adjacent to private land and the home ignition zone.

Defense Zone (Zone 2): This is a quarter mile buffer around structures and other human developments. The goal of this zone is to create an environment where firefighters can safely and effectively suppress wildfires by treating fuels and vegetation to reduce flame heights below four feet and have no crown fire under 90th percentile weather conditions on 100 percent of the land base (USDA USDI 2001 and Nowicki 2002).

Threat Zone (Zone 3): This is a 1.5 mile buffer around structures and other human developments. The goal of this zone is to treat fuels and vegetation to reduce crown fire to a surface fire before reaching the community fire defense zone under 90th percentile weather

conditions (USDA USDI 2001). Research suggests (Finney 2001, and Schmidt et al. 2008) that at least 20 percent of the land base should be strategically treated to increase landscape level fire resilience.

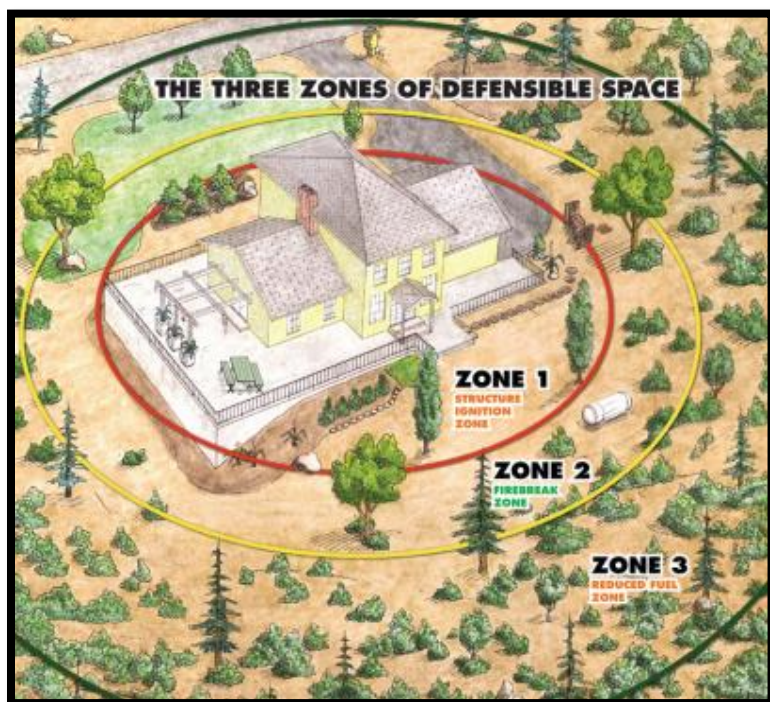


Figure 1: Wildland Urban Interface Zones

*(figure not to scale)

Flame length potential in the wildland urban interface zones is an indicator of how effective treatments are within each zone. Flame length potential may also be used as a proxy for community safety or resilience to wildfire. Nowicki (2002) states “The protection of houses and communities from the threat of forest fire depends upon the proper treatment of the wildland-urban interface, the area directly adjacent to houses and communities. The protection of the house depends entirely on treatment of the home ignition zone.....regardless of what treatments are implemented in the adjacent forest.” Cohen (2008) also notes that the home ignition zone principally determines a home’s ignition potential.

Lowering flame lengths to a level conducive to safe and effective firefighting is the main goal of fuel reduction in the wildland urban interface. In order to reduce both direct flame impingement and resulting home ignition, as well as to provide space for firefighters to suppress the fire directly, the 100-foot home ignition zone should have flame lengths of two feet or less. In the surrounding quarter mile defense zone, flame lengths of four feet or less are essential in providing an extra buffer for firefighter safety, and lessen the chances of firebrands from nearby vegetation igniting structures. Fuel reduction in the outlying 1.5 mile threat zone can help to lower the intensity of an approaching front into the defense zone, but does not have a noticeable effect on reducing home ignitions. Strategically based treatments, such as on ridgelines and roads, help reduce fire behavior in areas often utilized by fire suppression resources. In addition, roads serve as important ingress and egress routes during emergencies such as wildfire and may serve as alternative routes for safety and evacuation if needed.

The analysis will show current conditions in various time periods. To display outputs from modeling results, short-term effects for all alternatives are displayed at five years in the future, mid-term effects are ten years, and long-term effects are greater than twenty years. Effects are shown for these time periods whether or not any treatments occur. After approximately twenty years, and in some cases sooner, modeling indicates fuels treatments are no longer display an effect on reducing fire and there is a potential need for maintenance in order for treatments to continue to stay effective. Therefore, even though the Silviculture resource report indicates that the project actions will have an effect on stand density for 20 years or more, displaying the results of alternatives on fire and fuels for 20 years or more would not provide meaningful information for comparison of effects on fire hazard and fuel behavior potential and is not included in tables in this report.

Affected Environment

Affected Environment for the Project Area

In the general area that includes the project area, fire has played a major role in shaping vegetation composition and structure (Agee 2007, Skinner et al. 2006, Taylor and Skinner 1998). Historically, the montane ecological zones are characterized by frequent fires of low- to mixed-severity (Skinner et al. 2006, Taylor and Skinner 1998). Lightning, European settlers and American Indian-ignited fires were the primary factors shaping the vegetation (Taylor and Skinner 1998).

Stand and vegetation structures along with severity patterns within this regime are highly dependent on the complex combination of topography, vegetation and climate in the area (Agee 2007, Skinner et al. 2006). Generally, upper slope positions and south- and west-facing slopes burn at higher frequencies and with higher severities than lower slope positions and north- and east-facing slopes (Weatherspoon and Skinner 1995, Taylor and Skinner 1998, Skinner et al. 2006, Jimerson and Jones 2003). Spatial variation in soil productivity, in conjunction with steep gradients of elevations and aspects, controls the rates of fuel accumulation (Skinner et al. 2006). Disturbance history affects the fuel profile and is linked to severity patterns on the landscape (Miller et al. 2009, Alexander et al. 2006).

The steep and complex landscape creates a unique interaction with fire weather and elevation during the hot, dry summers when a high pressure system prevails and smoke does not dissipate; this often results in temperature inversions. While these inversions can lead to benign fire behavior, they can also create public health issues and concerns over high densities of smoke particulates that cover large areas and can persist for many days. When the temperature inversions are broken by high winds, fire behavior can increase significantly, resulting in large areas of high-severity fire.

Numerous fire starts still occur in the project area. However, with the onset of fire suppression in the early 1900s and increased effectiveness of suppressing fires with mechanized equipment (fire engines, dozers, aircraft, etc.) in later years, most of the fires are kept small. As a result, forest vegetation has changed from a heterogeneous pattern to a more homogeneous pattern of smaller openings in a matrix of denser forests (Skinner et al. 2006). Therefore, one of the most extensive problems related to the health of this watershed is the over-accumulation of vegetation and fuel loading due to a lack of disturbance from fire. Although severity patterns are still largely dependent on physical factors (e.g. slope position, aspect, slope percentage, elevation, etc.), the

current vegetation composition and structure have created conditions that increase the likelihood of larger areas of intense and severe fire (Skinner et al. 2006, Taylor and Skinner 2003, Scott and Reinhardt 2001).

Much of the current vegetation conditions in the project area are an artifact of the 1955 Haystack Fire which burned most of the area (see the silviculture resource report available on the project website for further information). Since 1955, only about 3,100 acres have burned in wildfires within the project boundary. As a result, the need for action in the project area evolved primarily from changes in fire regimes over the last century. Historically, low- to mixed-severity fires in the area played a significant role in creating a high spatial complexity of vegetation including openings of different sizes, forested stands that were generally more open and late-successional, and closed-canopy forests. Fire suppression, along with other past management activities in the project area, has resulted in uncharacteristically dense vegetation and high fuel loading, a decline in wildlife forage and habitat diversity, and an elevated risk of high-severity, stand-replacing fires including areas adjacent to communities.

The project area is located in an area of a high concentration of lightning strikes but fire suppression has largely eliminated large fires in the project area. As a result, 80 percent of the project area is moderately or severely departed from historic fire return intervals. In other words, most of the Craggy Project area has missed four or more fire return intervals since suppression began on the Forest; 90 percent of the project area has not been burned by wildfire since the 1955 Haystack Fire.

Current concerns focus on high fire hazard (as defined by fuel loading and vegetation densities) and high fire risk (as defined by fire start occurrence) over time. Fire risk and associated fire hazard have led to concerns over fire behavior in and adjacent to private property and fire effects to resource values on Forest land (e.g. wildlife habitat, soil stability, human uses, hydrology, air quality). In addition, smoke from large fires that does not disperse has the potential to negatively impact the project area which has a high level of human use.

Many of these concerns have been validated by recent wildfires near the project boundary (e.g. the 2016 Grade Fire, the 2014 Happy Camp Complex fires, the 2014 Beaver fire and the 2006 Humbug Fire). The 2014 fires were driven by heavy fuels accumulation, weather conditions, limited access for firefighting forces, rugged terrain, and many other factors that contribute to large fire growth. During these fires, structures were lost and air quality standards exceeded the California Air Resource Board thresholds. In addition, areas of high fire severity experienced soil erosion, loss of wildlife habitat and degraded other natural resources. In 2006, the Humbug fire threatened the town of Yreka, growing to about 40 acres. More recently, the 2016 Grade Fire burned approximately 750 acres at the north end of Yreka; it destroyed structures and infrastructure and threatened more. Similar vegetation conditions exist in the project area as those experienced in these recent wildfires. Risk of wildfire is likely the largest natural disaster threat to the communities within and adjacent to the Craggy project area.

According to the Yreka Area Fire Safe Council Community Wildfire Protection Plan (Yreka CWPP 2013), more than 80 percent of the fire safe council area is at very high risk of significant damage from wildfire. There are approximately 3,655 landowner parcels within the fire council area. The Craggy Project Area encompasses portions of this fire safe council area and is aimed at reducing the fire risk as identified within the CWPP on Forest System lands.

According to the Forest geographic information system layers, a total of 72 fire starts have occurred within the project boundary over an almost 30-year analysis period (1985 to 2015). This is an average of about 2.4 fires per year. Out of the 72 fire starts, 58 were lightning-caused and 14 were human-caused.

Large fire history (fires greater than 10 acres) shows that approximately 63,727 acres have burned within the project boundary since 1905. This indicates that many acres burned multiple times. However, only 3,100 acres have burned since 1955.

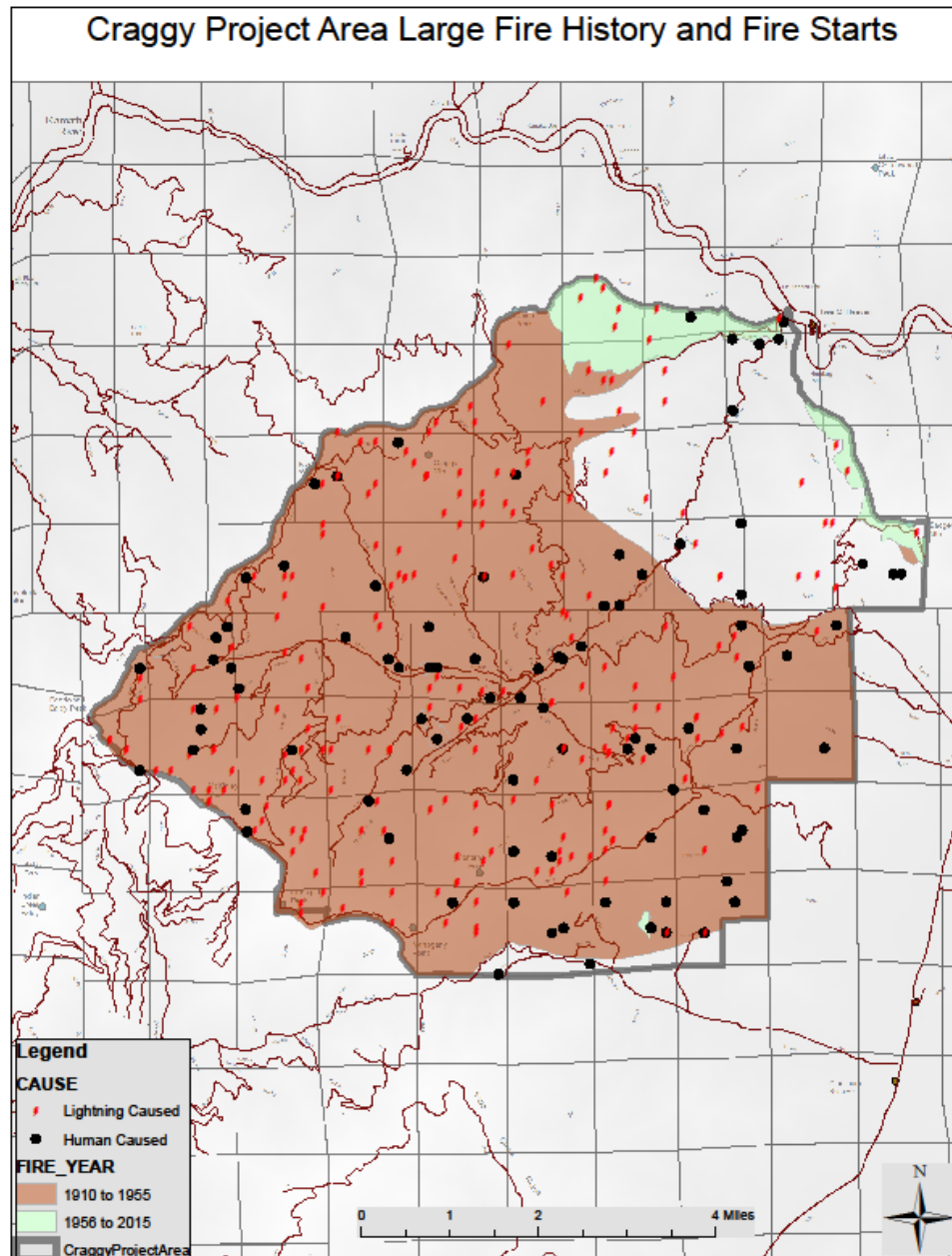


Figure 2: Areas Within the Project Area that have Burned Prior to and after 1955

Fire Hazard Measured by Flame Length

Table 3 below displays current predicted flame lengths in the project area under 90th percentile weather conditions.

Table 3: Flame Length Potential for the Project Area for Alternative 1 in Acres and Percent of the Project Area

Percentile Weather	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
90th Percentile	5,262 (18%)	5,497 (19%)	7,413 (25%)	11,544 (39%)

Fire Type (Surface, Passive Crown or Active Crown Fire)

Table 4 below displays fire type in the project area under 90th percentile weather conditions.

Table 4: Fire Type Potential for the Project Area for Alternative 1 in Acres and Percent of the Project Area.

Percentile Weather	Surface Fire	Passive Crown Fire	Active Crown Fire
90th Percentile	18,987 (64%)	8,111 (27%)	2,618 (9%)

Fire Regime Impacts to Vegetation

The fire regime is the most widespread and dynamic disturbance regime affecting the analysis area. Numerous fire starts occur within the analysis area every year. Fires occurring in the area affect vegetation communities with varying severities. Patterns of fire severity can be attributed to vegetation type, solar radiation, weather patterns, and slope positions. Upper slopes, ridgetops, and south and west facing aspects typically experience higher fire severity. As a result, shrubs and fire adapted species such as knobcone pine and other even-aged trees dominate such areas. Lower slopes and north and east facing aspects typically experience lower fire severity. These areas typically have multi-aged stands and burn with less frequency. With lower fuel loadings, landscape features such as streams and ridgetops are often sufficient to impede fire spread.

Current vegetation patterns are also attributed to disturbance history. Much of the analysis area (nearly 90 percent) has been fire free since 1955. As a result, the build-up of ladder and surface fuels has increased the probability of high severity stand replacing fire. Although current vegetation and severity patterns are largely dependent on factors mentioned above, large patches of high severity fire have been observed in areas that typically burned at low severity in recent burns near the project area. Therefore, current vegetation patterns and seral stage distribution have changed significantly since the onset of the fire suppression era approximately 100 years ago.

An analysis was conducted to determine current fire behavior potential on dominant vegetation communities and size class. This was done to get a better understanding of potential fire effects on current vegetation types and size class distribution as shown in Tables 5 and 6.

Table 5: Fire Behavior Potential on Dominant Vegetation Type for the Project Area for Alternative 1 in Acres

Dominant Vegetation Type	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
Annual Grass	235	213	216	556
Barren	322	0	0	0
Douglas Fir	848	701	982	1,566
Mixed Chaparral	824	1,867	1,614	2,950
Montane Chaparral	319	441	937	1,350
Montane Hardwood Conifer	324	327	454	870
Montane Hardwood	464	416	746	1,091
Montane Riparian	30	24	14	29
Perennial Grass	80	126	56	74
Ponderosa Pine	302	279	237	322
Sagebrush	19	12	7	7
Sierran Mixed Conifer	1,455	896	1,922	2,633
White Fir	164	43	40	51
Total	5,386	5,345	7,225	11,499

The dominant vegetation type from the EVEG GIS layer was used for this analysis.

Table 6: Fire Behavior Potential on Size Class for the Project Area for Alternative 1 in Acres

Size Class (diameter)	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
1-5.9 inches	226	357	154	123
6-10.9 inches	119	221	222	289
11-23.9 inches	1,146	1,069	1,842	2,574
Greater than 24 inches	1,882	1,180	2,074	3,244
Total	3,373	2,827	4,292	6,230

Affected Environment for the Wildland Urban Interface

Table 7 below shows the acres of Forest lands and private lands by wildland urban interface zone within the project area.

Table 7: Forest and Private Lands by Wildland Urban Interface Zone within the Project Area.

Wildland Urban Interface	Federal Acres	Private Acres	Total Acres	% Federal
Home Ignition Zone	49	160	209	23
Defense Zone	1,035	1,110	2,145	48
Threat Zone	17,259	4,622	21,881	79
Total Wildland Urban Interface Acres	18,343	5,892	24,235	76

Table 8 below depicts flame length potential within each wildland urban interface zone under current conditions and under 90th percentile weather conditions.

Table 8: Current Flame Length Potential within the Wildland Urban Interface Zone

Flame Lengths	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4 feet)	12	207	2,874
Moderate (4-8 feet)	6	126	3,183
High (8-11 feet)	9	297	4,387
Very High (greater than 11 feet)	22	405	6,812
Total	49	1,035	17,256

Environmental Consequences

Alternative 1

Direct and Indirect Effects in the Project Area and Wildland Urban Interface

Under Alternative 1, there will be no direct effects. The continued level of management and use will occur. Proposed treatments will not occur, and the desired conditions for the project area and wildland urban interface will not be reached. Fire hazard potential (flame length potential and fire type) and fire effects to vegetation will remain as described in the affected environment.

Without the influence of silviculture and fuels treatments, and fire under prescribed conditions to restore and maintain vegetation diversity, many stands will continue to have decreasing resilience to the current fire regime and will exhibit an increase in susceptibility to insects and disease. Other stands are likely to continue to lose their structural and compositional diversity. Indirectly, taking no action allows the current fuel loading conditions to continue in an increasingly negative manner. As vegetation continues to grow with no management actions and no reduction in fuel loading, fuels will continue to accumulate away from desired conditions and potentially increase due to tree mortality. An increasing percentage of the project area will gain the potential for high flame lengths, which correlates with uncharacteristically high severity fire. The dominant vegetation type would likely change in many areas from a forested condition to brush fields due to tree mortality and this will decrease available seed trees that provide natural reforestation. As a result, size class would also decrease on average across the project area. Without strategically placing treatments, there would continue to be a heightened threat to the communities within and adjacent to the project area and within the wildland urban interface. Other resource specialists will discuss the impacts of these high fire severity effects on other values within the project boundary, including watershed, timber products, and wildlife.

Cumulative Effects

Vegetation structure will continue to change over time, leading to increased fire hazard as stands of trees and vegetation continue to grow denser and fuel loading increases. As a result, fire type, flame length potential, and fire effects to vegetation are also likely to increase. In addition, the fire threat to communities will continue to be high and increase over time as fuel loading and vegetation density increases. The effects of other ongoing and reasonably foreseeable actions

within the project area, including timber harvest and various fuels treatments on private and public land (see Appendix C of the Craggy Environmental Impact Statement), will likely decrease the density of trees in the watershed, reduce ladder fuels, and slightly decrease the likelihood of crown fire and flame length potential, and therefore reduce the risk of wildfire to private property and resources. However, adding these effects to Alternative 1 will have less than significant cumulative impacts on the increased fire hazard in the project area and the area within the wildland urban interface over the next 20 years because of the limited scale of these projects.

Alternative 2

Direct and Indirect Effects in the Project Area

Under Alternative 2, 10,600 acres of treatment in the 29,500-acre project area will lead the project area (both in treated areas and adjacent stands) toward resilient forest conditions. These effects are demonstrated in Tables 9 through 12 below.

Table 9: Flame Length Potential for the Project Area for Alternative 2 in Acres and Percent of the Project Area

Flame Length	Short-term Post-Treatment (5 years)	Mid-term Post-treatment (10 years)
0-4 feet	16,329 (55%)	11,178 (38%)
4-8 feet	6,264 (21%)	9,755 (33%)
8-11 feet	1,204 (4%)	1,718 (5%)
Greater than 11 feet	5,884 (20%)	7,029 (24%)

Table 10: Fire Type Potential for the Project Area for Alternative 2 in Acres and Percent of the Project Area

Fire Type	Short-term Post-Treatment (5 years)	Mid-term Post-treatment (10 years)
Surface	22,437 (79%)	20,140 (68%)
Passive Crown	4,932 (17%)	7,633 (26%)
Active Crown	1,311 (4%)	1,908 (6%)

Table 11: Fire Behavior Potential on Dominant Vegetation Type for the Project Area for Alternative 2, in Acres

Dominant Vegetation Type	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
Annual Grass	680	199	5	335
Barren	322	0	0	0
Douglas Fir	2,414	297	70	1,316
Mixed Chaparral	3,269	1,692	113	2,182
Montane Chaparral	926	701	90	1,330
Montane Hardwood Conifer	930	265	37	743
Montane Hardwood	973	598	50	1,090
Montane Riparian	51	16	1	30
Perennial Grass	198	107	2	29

Dominant Vegetation Type	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
Ponderosa Pine	785	142	33	180
Sagebrush	41	2	1	1
Sierran Mixed Conifer	4,230	830	154	1,690
White Fir	189	38	10	60
Total	15,008	4,887	566	8,986

Table 12: Fire Behavior Potential on Size Class for the Project Area for Alternative 2 in Acres

Size Class (diameter in inches)	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
1-5.9 inches	684	99	1	76
6-10.9 inches	424	200	20	207
11-23.9 inches	3,370	1,037	134	2,090
Greater than 24 inches	4,645	852	158	2,725
Total	9,123	2,188	313	5,098

After completion of the treatments, there is an increase of 37 percent (55 percent total) of the project area meeting desired conditions for flame lengths less than four feet, and an increase of 15 percent (79 percent total) of the area meeting desired conditions for surface fire type. This is important because these flame lengths and fire types allow the use of the most effective strategies for containing wildfires (including direct attack with hand crews). Also, flame lengths of four feet or less are specified in the Forest Plan as being the threshold for low fire hazard. For this modeling, it was assumed that all of the treatments are implemented in the same year. This may not be possible to achieve; however, there is no way to accurately predict when and in what order treatments will be implemented. Because of this, assuming all treatments are implemented in the same year is the only way to make comparisons across the various alternatives.

In fuel breaks and thinning without product removal units where pile burning would occur, fire would be allowed to underburn within the designated unit at low intensity if there is low risk of burning onto private property. Measures will be included in the prescribed burn plan to minimize the risk of fire escaping designated units. This also applies to the wildland urban interface area which is described below.

Direct and Indirect Effects in the Wildland Urban Interface Area

Since the threat zone includes both defense and home ignition zones, the total number of acres of wildland urban interface that would be affected by the project is about 17,260 acres. Under Alternative 2, 10,600 acres of treatment would help to create resilient forest conditions in the wildland urban interface as displayed in Tables 13 and 14. Having flame lengths of less than four feet is particularly important in the wildland urban interface to allow direct attack of wildfires. In 71 percent of the home ignition zone, 50 percent of the defense zone, and 50 percent of the threat zone will meet desired conditions in the short-term. Over the mid-term, treatment effectiveness for meeting desired conditions declines to 55 percent for the home ignition zone, 38 percent for the defense zone, and 39 percent for the threat zone; however, this is a substantial increase from Alternative 1 in acres meeting desired conditions from the Forest Plan. Due to the Craggy Project

focusing primarily on the defense and threat zones (including areas adjacent to private land and the home ignition zone), this allows work on private lands to build upon the Craggy Project's fuels treatments for community and structure protection from wildfire.

Table 13: Short-term Flame Length Potential within the Wildland Urban Interface under Alternative 2

Flame Lengths	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4 feet)	35	508	8,579
Moderate (4-8 feet)	3	154	2,870
High (8-11 feet)	1	12	330
Very High (greater than 11 feet)	11	361	5,477
Total	49	1,035	17,256

Table 14: Mid-term Flame Length Potential within the Wildland Urban Interface under Alternative 2

Flame Lengths	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4 feet)	27	396	6,685
Moderate (4-8 feet)	12	342	6,625
High (8-11 feet)	1	72	1,051
Very High (greater than 11 feet)	9	225	2,895
Total	49	1,035	17,256

The fuel treatment design (e.g. thinning, mastication, and fuel breaks) along with re-introducing fire to the project area under prescribed conditions will provide the benefits associated with low-to mixed-severity fires (e.g. fuels reduction and vegetation diversity) while minimizing the adverse effects often resulting from uncontrolled high-severity wildfires (e.g. effects to soils, wildlife habitat, structures, infrastructure and air quality).

Actions in Alternative 2 provide a substantial benefit to the wildland urban interface by increasing the number of acres in which low and moderate flame lengths are expected to occur and decreasing substantially the number of acres in which high and very high flame lengths are expected. In addition, this will increase firefighter suppression capability within the wildland urban interface as well as decrease the likelihood in which structures are damaged or destroyed. Treatments near routes that allow firefighters and the public to enter or leave the project area (ingress and egress), especially roadside fuelbreaks, would provide increased safety for firefighters entering the area and allow for safer evacuation if necessary for the public.

Thinning will increase canopy base heights making it more difficult for fire to get into tree crowns and promoting more surface fire type. Mastication, in which units primarily consist of brush, re-arranges the fuel bed from standing brush to finer fuels on the surface floor. Many of the proposed units are fuel reduction maintenance areas from previous projects within the Craggy Project area. In comparing pre- versus post- treatments in these units, fire type in treated and maintained areas are anticipated to stay a surface fire with flame lengths less than four feet. Fuel loads of masticated fuel beds for these previous projects have not shown to be a concern for undesired fire effects in the event of a wildfire or during prescribed fire for the project area.



Figure 3: Mastication of Brush from the Yreka Project in 2002. This Unit is proposed for Maintenance and Re-entry for the Craggy Project and Serves as part of a Key Ridge System for the Fuels Strategy and is within the Wildland Urban Interface.

Cumulative Effects

Adding the effects of the reasonably foreseeable future fuel reduction treatments displayed in Appendix C of the Craggy Environmental Impact Statement, to the effects of this alternative will decrease flame lengths and move toward less crown fire where similar treatments are proposed, but will not produce significant cumulative effects. Some future actions such as fuel reduction treatments on the Bureau of Land Management Lands and timber harvest and fuels reduction on private lands will have some beneficial effects. These projects are anticipated to benefit the analysis indicators as in some locations they tie into work proposed in Alternative 2 and the treatments will complement each other. In addition, treatments reducing fuel loading, fire type, and flame length would benefit the area being treated, including the wildland urban interface. Therefore, there will be some benefit to the analysis indicators from these projects for fire and fuels within the Craggy Project.

Alternative 3

Direct and Indirect Effects in the Project Area

Alternative 3 proposes to treat about 11,310 acres. This alternative has similar effects on flame lengths and fire type to those of Alternative 2 with some differences due to some stands being treated in Alternative 2 that are not treated in Alternative 3, and additional fuels treatments adjacent to private lands in Alternative 3. However, these differences are minor in effects on fire resiliency over the landscape. For these reasons, the direct and indirect effects are similar to Alternative 2 as displayed in Tables 15 through 18.

Table 15: Flame Length Potential for the Project Area for Alternative 3 in Acres and Percent of the Project Area

Flame Length	Short-term Post-Treatment	Mid-term Post-treatment
0-4 feet	17,275 (58%)	16,997 (57%)
4-8 feet	5,704 (19%)	5,969 (20%)
8-11 feet	1,161 (4%)	1,166 (4%)
Greater than 11 feet	5,541 (19%)	5,549 (19%)

Table 16: Fire Type Potential for the Project Area for Alternative 3 in Acres and Percent of the Project Area

Fire Type	Short-term Post-Treatment	Mid-term Post-treatment
Surface	23,605 (80%)	21,107 (71%)
Passive Crown	4,852 (16%)	6,859 (23%)
Active Crown	1,215 (4%)	1,714 (6%)

Table 17: Fire Behavior Potential on Dominant Vegetation Type for the Project Area for Alternative 3, in Acres

Dominant Vegetation Type	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
Annual Grass	774	122	5	319
Barren	322	0	0	0
Douglas Fir	2,513	829	413	342
Mixed Chaparral	3,727	1,313	57	2,159
Montane Chaparral	1,247	921	122	757
Montane Hardwood Conifer	1,080	436	97	362
Montane Hardwood	1,197	682	106	726
Montane Riparian	66	15	0	17
Perennial Grass	252	41	13	30
Ponderosa Pine	878	137	37	88
Sagebrush	43	1	1	0
Sierran Mixed Conifer	4,871	1,026	298	709
White Fir	267	11	8	11

Dominant Vegetation Type	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
Total	17,237	5,534	1,157	5,520

Table 18: Fire Behavior Potential on Size Class for the Project Area for Alternative 3 in Acres

Size Class (diameter in inches)	Low (0-4 feet)	Moderate (4-8 feet)	High (8-11 feet)	Very High (greater than 11 feet)
1-5.9 inches	685	116	13	46
6-10.9 inches	510	207	13	121
11-23.9 inches	3,942	1,249	259	1,181
Greater than 24 inches	5,489	1,456	567	868
Total	10,626	3,028	852	2,216

After completion of the treatments, there is an increase of 40 percent (58 percent total) of the project area meeting desired conditions for flame lengths less than four feet, and an increase of 16 percent (80 percent total) of the area meeting desired conditions for surface fire type. This is important because this is the flame length and fire type that allows for the use of direct attack of a wildfire with hand crews and the most effective strategy for containing wildfires. Also, flame lengths of four feet or less are specified in the Forest Plan as being the threshold for low fire hazard. For this modeling, it was assumed that all of the treatments are implemented in the same year. This may not be possible to achieve; however, there is no way to accurately predict when and in what order treatments will be implemented. Because of this, assuming all treatments are implemented in the same year is the only way to make comparisons across the various alternatives.

Direct and Indirect Effects in the Wildland Urban Interface Area

Under Alternative 3, 11,310 acres of treatment would help to create resilient forest conditions in the wildland urban interface as displayed in Tables 19 and 20. As noted for Alternative 2, having flame lengths of less than four feet is particularly important in the wildland urban interface to allow direct attack of wildfires. In 92 percent of the home ignition zone, 75 percent of the defense zone, and 61 percent of the threat zone will meet desired conditions in the short and mid-term. This is a substantial increase from Alternative 1 in acres meeting desired conditions from the Forest Plan but very similar to the effects of Alternative 2.

Table 19: Short-term Flame Length Potential within the Wildland Urban Interface under Alternative 3

Flame Lengths	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4 feet)	45	770	10,540
Moderate (4-8 feet)	1	95	3,111
High (8-11 feet)	0	28	722
Very High (greater than 11 feet)	3	142	2,883
Total	49	1,035	17,256

Table 20: Mid-term Flame Length Potential within the Wildland Urban Interface under Alternative 3

Flame Lengths	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4 feet)	43	757	10,406
Moderate (4-8 feet)	3	107	3,238
High (8-11 feet)	0	28	724
Very High (greater than 11 feet)	3	143	2,888
Total	49	1,035	17,256

Cumulative Effects

Adding the effects of the reasonably foreseeable future fuel reduction treatments to the effects of this alternative will be similar to those described for Alternative 2.

Comparison of Alternatives

Alternatives are compared below for the project area and for the wildland urban interface area.

Comparison of Alternatives for the Project Area

Table 21 and Table 22 (short-term) and Table 23 and table 24 (mid-term) compare the potential flame length and fire type for the project area by alternative.

Table 21: Flame Length Potential (short-term) in the Project Area for Alternative 1 Compared to Action Alternatives

Flame Length	Alternative 1	Alternative 2	Alternative 3
0-4 feet	5,262 (18%)	16,329 (55%)	17,275 (58%)
4-8 feet	5,497 (19%)	6,264 (21%)	5,704 (19%)
8-11 feet	7,413 (25%)	1,204 (4%)	1,161 (4%)
Greater than 11 feet	11,544 (39%)	5,884 (20%)	5,541 (19%)

Table 22: Fire Type Potential (short-term) in the Project Area for Alternative 1 Compared to Action Alternatives

Fire Type	Alternative 1	Alternative 2	Alternative 3
Surface	18,987 (64%)	22,437 (79%)	23,605 (80%)
Passive Crown	8,111 (27%)	4,932 (17%)	4,852 (16%)
Active Crown	2,618 (9%)	1,311 (4%)	1215 (4%)

Table 23: Flame Length Potential (mid-term) in the Project Area for Alternative 1 Compared to Action Alternatives

Flame Length	Alternative 1	Alternative 2	Alternative 3
0-4 feet	5,262 (18%)	11,187 (38%)	16,997 (57%)
4-8 feet	5,497 (19%)	9,755 (33%)	5,969 (20%)

Flame Length	Alternative 1	Alternative 2	Alternative 3
8-11 feet	7,413 (25%)	1,718 (5%)	1,166 (4%)
Greater than 11 feet	11,544 (39%)	7,029 (24%)	5,549 (19%)

Table 24: Fire Type Potential (mid-term) in the Project Area for Alternative 1 Compared to Action Alternatives

Fire Type	Alternative 1	Alternative 2	Alternative 3
Surface	18,987 (64%)	20,140 (68%)	21,107 (71%)
Passive Crown	8,111 (27%)	7,633 (26%)	6,859 (23%)
Active Crown	2,618 (9%)	1,708 (6%)	1,714 (6%)

Table 25 and Table 26 compare the fire behavior potential on dominant vegetation type and size class for the project area under Alternative 1, and post-treatment for Alternatives 2 and 3.

Table 25: Fire Behavior Potential (flame length) on Dominant Vegetation Types in Acres, Comparing Short-term Effects for Alternatives

Alternatives	Alternative 1				Alternative 2				Alternative 3			
Dominant Vegetation Type	Low (0-4')	Moderate (4-8')	High (8-11')	Very High (> 11')	Low (0-4')	Moderate (4-8')	High (8-11')	Very High (> 11')	Low (0-4')	Moderate (4-8')	High (8-11')	Very High (> 11')
Annual Grass	235	213	216	556	680	199	5	335	774	122	5	319
Barren	322	0	0	0	322	0	0	0	322	0	0	0
Douglas Fir	848	701	982	1,566	2,414	297	70	1,316	2,513	829	413	342
Mixed Chaparral	824	1,867	1,614	2,950	3,269	1,692	113	2,182	3,727	1,313	57	2,159
Montane Chaparral	319	441	937	1,350	926	701	90	1,330	1,247	921	122	757
Montane Hardwood Conifer	324	327	454	870	930	265	37	743	1,080	436	97	362
Montane Hardwood	464	416	746	1,091	973	598	50	1,090	1,197	682	106	726
Montane Riparian	30	24	14	29	51	16	1	30	66	15	0	17
Perennial Grass	80	126	56	74	198	107	2	29	252	41	13	30
Ponderosa Pine	302	279	237	322	785	142	33	180	878	137	37	88
Sagebrush	19	12	7	7	41	2	1	1	43	1	1	0
Sierran Mixed Conifer	1,455	896	1,922	2,633	4,230	830	154	1,690	4,871	1,026	298	709
White Fir	164	43	40	51	189	38	10	60	267	11	8	11
Total	5,386	5,345	7,225	11,499	15,008	4,887	566	8,986	17,237	5,534	1,157	5,520

Table 26: Fire Behavior Potential on Vegetation Size Class for Current Condition as Displayed for Alternative 1 Compared to Action Alternatives in the Short Term

Alternatives	Alternative 1				Alternative 2				Alternative 3			
Size Class (diameter)	Low (0-4')	Moderate (4-8')	High (8-11')	Very High (> 11')	Low (0-4')	Moderate (4-8')	High (8-11')	Very High (> 11')	Low (0-4')	Moderate (4-8')	High (8-11')	Very High (> 11')
1-5.9 inches	226	357	154	123	684	99	1	76	685	116	13	46
6-10.9 inches	119	221	222	289	424	200	20	207	510	207	13	121
11-23.9 inches	1,146	1,069	1,842	2,574	3,370	1,037	134	2,090	3,942	1,249	259	1,181
Greater than 24 inches	1,882	1,180	2,074	3,244	4,645	852	158	2,725	5,489	1,456	567	868
Total	3,373	2,827	4,292	6,230	9,123	2,188	313	5,098	10,626	3,028	852	2,216

For the action alternatives, the fuel treatment design (e.g. thinning, mastication, and fuel breaks) along with the re-introducing fire to the project area under prescribed conditions will provide the benefits associated with low- to mixed-severity fires (e.g. fuels reduction and vegetation diversity) while minimizing the adverse effects often resulting from uncontrolled high-severity wildfires (e.g. effects to soils, wildlife habitat, infrastructure and air quality). While Alternative 3 provides more acres of low flame lengths and surface fire type than does Alternative 2, the greatest differences in benefits are between Alternative 1 and the action alternatives.

Comparison of Alternatives for the Wildland Urban Interface

Table 27 (short-term) and Table 28 (mid-term) compare the flame length potential within the wildland urban interface under the Alternative 1 and post-treatment for action alternatives.

Table 27: Flame Length Potential (short-term) in the Wildland Urban Interface for Alternative 1 Compared to Action Alternatives

Alternatives	Alternative 1			Alternative 2			Alternative 3		
Flame Lengths (Feet)	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4')	12	207	2,874	35	508	8,579	45	770	10,540
Moderate (4-8')	6	126	3,183	3	154	2,870	1	95	3,111
High (8-11')	9	297	4,387	1	12	330	0	28	722
Very High (>11')	22	405	6,812	10	361	5,477	3	142	2,883
Total	49	1,035	17,256	49	1035	17,256	49	1,035	17,256

Table 28: Flame Length Potential (mid-term) in the Wildland Urban Interface for Alternative 1 Compared to Action Alternatives

Alternatives	Alternative 1			Alternative 2			Alternative 3		
Flame Lengths (Feet)	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)	Home Ignition Zone (Acres)	Defense Zone (Acres)	Threat Zone (Acres)
Low (0-4')	12	207	2,874	27	396	6,685	43	757	10,406
Moderate (4-8')	6	126	3,183	12	342	6,625	3	107	3,238
High (8-11')	9	297	4,387	1	72	1,051	0	28	724
Very High (>11')	22	405	6,812	19	225	2,895	3	143	2,888
Total	49	1,035	17,256	49	1035	17,256	49	1,035	17,256

Action alternatives provide a substantial benefit to the wildland urban interface by increasing the number of acres in which low and moderate flame lengths are expected to occur and decreasing substantially the number of acres in which high and very high flame lengths are expected. In addition, this will increase firefighter suppression capability within the wildland urban interface as well as decrease the likelihood in which structures are damaged or destroyed. For the wildland urban interface, some of the most important work adjacent to homes is currently being planned as displayed in Appendix C of the Craggy Environmental Impact Statement. Combined strategically-placed treatments on both private and public lands would ultimately reduce the probability of devastating effects from wildfire on homes, infrastructure, and resources.

Compliance with law, regulation, policy, and the Forest Plan

All alternatives are consistent with the Forest Plan standards and guidelines related to fire and fuels as noted on the Forest Plan consistency checklist, available on [the project website](#). All alternatives are also consistent with the law, regulation and policy referenced in the methodology section of this report.

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Appendix A – Climate and Climate Change

The climate of the project area is best described as Mediterranean, characterized by wet and, cool winters; and dry and; warm summers (Skinner et al. 2006). The project area is in a transition zone between Happy Camp, California, which receives a mean annual precipitation of approximately 53 inches, and Oak Knoll, California, which receives a mean annual precipitation of approximately 25 inches. Precipitation primarily occurs from November 1 through April 30, however, summer thunderstorms are common and can release significant localized rain. Thunderstorms can also be dry with conditions that encourage fire ignition and spread from lightning strikes, with the summer of 2015 being the latest example of this pattern near the project area.

Local data derived from five weather stations in the Klamath Mountains were used to evaluate climate trends over an approximate 100 year period (Butz and Safford, 2011). The data suggests that mean annual temperature has increased by approximately two degrees Fahrenheit and precipitation is near the transition zone between areas of higher and lower precipitation (see figure 1 of Butz and Safford 2011).

Fire and Fuels under Climate Change

Data on forest fire frequency, size, total area burned, and severity all show strong increases in California over the last two to three decades. Westerling et al. (2006) showed that increasing frequencies of large fires (greater than 1000 acres) across the western United States since the 1980's were strongly linked to increasing temperatures and earlier spring snowmelt. Northern California forests have had substantially increased wildfire activity, with most wildfires occurring in years with early springs (Westerling et al. 2006). This increase is likely attributable to both climate and land-use effects. Large percentage changes in moisture deficits in Northern California forests, according to Westerling et al. (2006), were strongly associated with advances in the timing of spring, but this area also includes substantial forested area where fire exclusion, timber harvesting, and succession after mining activities have led to increased forest densities and fire risks (McKelvey et al. 1996).

Miller et al. (2012) found no temporal trend in the annual proportion of fire area burning at high-severity within fires greater than 400 hectares (almost 1,000 acres) occurring on the four National Forests of Northwestern California during the period of 1987 to 2008. However, mean and maximum fire size and total annual area burned all increased over the period from 1910 to 2008 and regional fire rotation fell to 95 years by 2008. During 1987 to 2008, Miller et al. (2012) found that the percentage of high-severity fire in conifer-dominated forests of smaller average diameter and lower percent cover was generally higher than in forests of larger diameter and higher cover. For areas that burned more than once during this period, severity (a measure of the effect of fire on vegetation) in conifer and hardwood forests was higher the second time burned versus the first time burned, regardless of tree density and size class. Closed forests of medium and large diameter trees that had previously burned between 1921 and 1986 burned at lower severities than similar forests that had last burned before 1921. Miller et al.'s (2012) data showed that years with larger fires and greatest area burned were produced by region-wide lightning events, and characterized by less winter and spring precipitation than in years dominated by smaller human ignited fires, but the percentage of high-severity fire was generally less in region-wide lightning events (Butz and Safford 2011).

Appendix B - Fire Regime and Historical Reference Conditions (Condition Class)

A natural fire regime is a general classification of how fire played a role in an ecosystem in the absence of modern human intervention but including the influence of aboriginal burning (Agee, 1993, Brown, 1995). Coarse-scale definitions of fire regimes have been provided by Hardy et al. 2001 and Schmidt et al. 2002 and interpreted for management of fire and fuels (Hann and Bunnell, 2001). The five natural (historical) fire regimes as described by historical fire frequency (average number of years between fires) and historical fire severity (the effect of the fire on dominant overstory species) are described in the following table.

Table B-1: Description of Historic Natural Fire Regimes

Historical Natural Fire Regimes	
Code	Description
I	0–35-year frequency ^a , low and mixed severity ^b
II	0–35-year frequency, stand-replacement severity
III	35–100+ year frequency, low and mixed severity
IV	35–100+ year frequency, stand-replacement severity
V	200+ year frequency, stand-replacement severity
a- Fire frequency is the average number of years between fires.	
b- Severity is the effect of the fire on the dominant overstory vegetation.	

Historical and current vegetation classes are primarily conifer, mixed-conifer, and mixed-conifer and hardwood; however, differences in seral stage distribution have changed through time. The mean historical fire return interval within the Craggy project boundary ranges from approximately 11 years to 55 years, depending on biophysical setting. A biophysical setting is defined as a combination of vegetation and topographic features, soils, and climate variables that influence vegetation development. As depicted below, approximately 76 percent of the landscape supported vegetation at or below a fire return interval of 30 years.

Table B-2: Historic Fire Return Intervals in the Project Area

Historic Fire Return Intervals in years	Acres	Percent of Area
Less than or equal to 15	14,277	48
Greater than 15 and less than or equal to 30	8,343	28

Historic Fire Return Intervals in years	Acres	Percent of Area
Greater than 30	7,096	24
Total	29,716	100

An analysis was conducted to compare historical fire return intervals (pre-suppression) to contemporary fire return intervals (suppression era) over the analysis area. This analysis is known as condition class based on departure from the historic fire return interval.

The following equation is used to determine the departure of fire return intervals:

$\{1 \text{ minus (reference fire return interval divided by current fire return interval)}\} \text{ times } 100$

The value obtained is a percent difference, and condition class is determined using the LANDFIRE national scale (i.e., zero to less than 33 percent departure equals condition class 1, 33 to less than 67 percent departure equals condition class 2, and greater than 67 percent departure equals condition class 3. Other assumptions come from Safford and Schmidt, 2006. Figure 3 below depicts condition class by approximate acres of fire return interval departure. Approximately 80 percent of the project area is moderately to severely departed from historic fire return intervals.

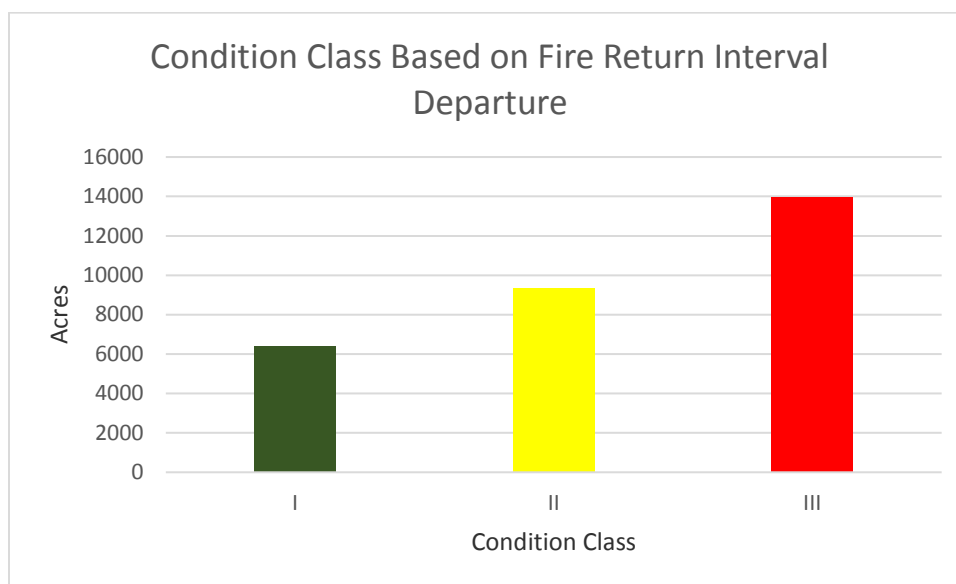


Figure B-1: Historical Reference Vonditions (Condition Class) Based Fire Return Interval Departure

Appendix C – Fuels and Fuel Modeling

Fuels

To model and predict fire behavior, fuels are often broken into fuel models that are mathematically put into a fire spread calculation (Rothermel 1972). Geographic information system layers of the Landfire Landscape (i.e., fuel models derived from the vegetation layer) were obtained to analyze current fuel models within the project boundary. The fuel models (Scott and Burgan, 2005) within the project boundary are described in Table C-1.

Table C-1: Fuel Model Descriptions within the Project Area by Acres and Percentage of Area

Fuel Model Category	Fuel Model Name	Description	Acres of fuel model in project area	Percent within project area
91, 97, 98, 99	Non-Flammable Fuel Models	Non-flammable. For example, open water, urban development, or bare ground	688	2%
101 – GR1, 102 – GR2	Grass Fuel Models	The primary carrier for GR1 is sparse grass. The grass is generally short and may be sparse or discontinuous. Rates of spread and flame lengths are low. The primary carrier for GR2 is grass, though small amounts of fine dead material may be present. Load is greater than GR1, and fuelbed more continuous. Spread rates are high and flame lengths moderate.	242	<1%
121 – GS1, 122 – GS2	Grass-Shrub Fuel Models	The primary carrier of fire in GS1 and GS 2 is grass and shrubs combined. Spread rate is high; flame length moderate.	6,260	21%
142 – SH2	Shrub Fuel Models	The primary carrier of fire in SH2 is woody shrubs and shrub litter. Moderate fuel load (higher than SH1), depth about 1 foot, no grass fuel present. Spread rate is moderate; flame length moderate.	2,877	9%
145 – SH5	Shrub Fuel Models	The primary carrier of fire in SH5 is woody shrubs and shrub litter. Heavy shrub load, depth 4-6 feet. Spread rate is very high; flame length very high.	2347	8%
147 – SH7	Shrub Fuel Models	The primary carrier of fire in SH7 is woody shrub litter. Very heavy shrub load, depth 4 to 6 feet. Spread rate is high; flame length very high.	6,230	21%
165 – TU5	Timber-Understory Fuel Models	The primary carrier of fire in TU5 is heavy forest litter with a shrub or small tree understory. Spread rate is moderate; flame length high.	5,232	18%
183 – TL3	Timber-Litter Fuel Models	The primary carrier of fire in TL3 is moderate load conifer litter, light load of coarse fuels. Spread rate is very low; flame length very low.	394	1%
186 – TL6	Timber-Litter Fuel Models	The primary carrier of fire in TL6 is moderate load broadleaf litter, less compact than TL2. Spread rate is moderate; flame length low.	252	1%
188 – TL8	Timber-Litter Fuel Models	The primary carrier of fire in TL8 is moderate load long-needle pine litter, may include small amount of herbaceous load. Spread rate is moderate; flame length low.	2,914	10%

Fuel Model Category	Fuel Model Name	Description	Acres of fuel model in project area	Percent within project area
189 – TL9	Timber-Litter Fuel Models	The primary carrier of fire in TL9 is very high load, fluffy broadleaf litter. TL9 can also be used to represent heavy needle-drape. Spread rate is moderate; flame length moderate.	1,593	5%
Other	Other Fuel Models	Other fuel models within the analysis boundary less than 400 Acres and make up a small percentage of the total area.	687	2%
Descriptions based on Anderson 1982 and Scott and Burgan 2005. Fuel models derived from Landfire and clipped to the analysis area in GIS.				

Fire Risk

Fire risk is defined in the Forest Plan as the probability of a fire start occurring over a ten year period for a given thousand acre area. Fire risk is based on the Forest geographic information system layers for fire occurrence records within the analysis area. The risk classification within the Forest Plan is as follows:

- Low Risk = 0 to 0.49: Less than 0.5 fires expected to occur per decade for every thousand acres in the area being analyzed.
- Moderate Risk = 0.50 to 0.99: Between 0.5 and 0.99 fires expected to occur per decade for every thousand acres in the area being analyzed.
- High Risk = At least one fire expected to occur per decade for every thousand acres in the area being analyzed.

Within the project boundary (29,693 acres) 72 fire starts occurred over a 30-year period analyzed (1986 to 2015). The risk value formula is $R = \{(x/y) 10\}/z$

Where:

x = fire starts (72)

y = period analyzed (30 years)

z = number of acres analyzed (29,693 displayed in thousands = 29.7)

Risk rating = $\{(72/30) 10\}/29.7 = .80$ (Moderate Risk)

The project area has a moderate fire risk value. The primary source of ignition (approximately 81 percent) is lightning caused while approximately 19 percent was human caused ignitions.

Appendix D – Wildland Urban Interface Zones within Craggy Project Area

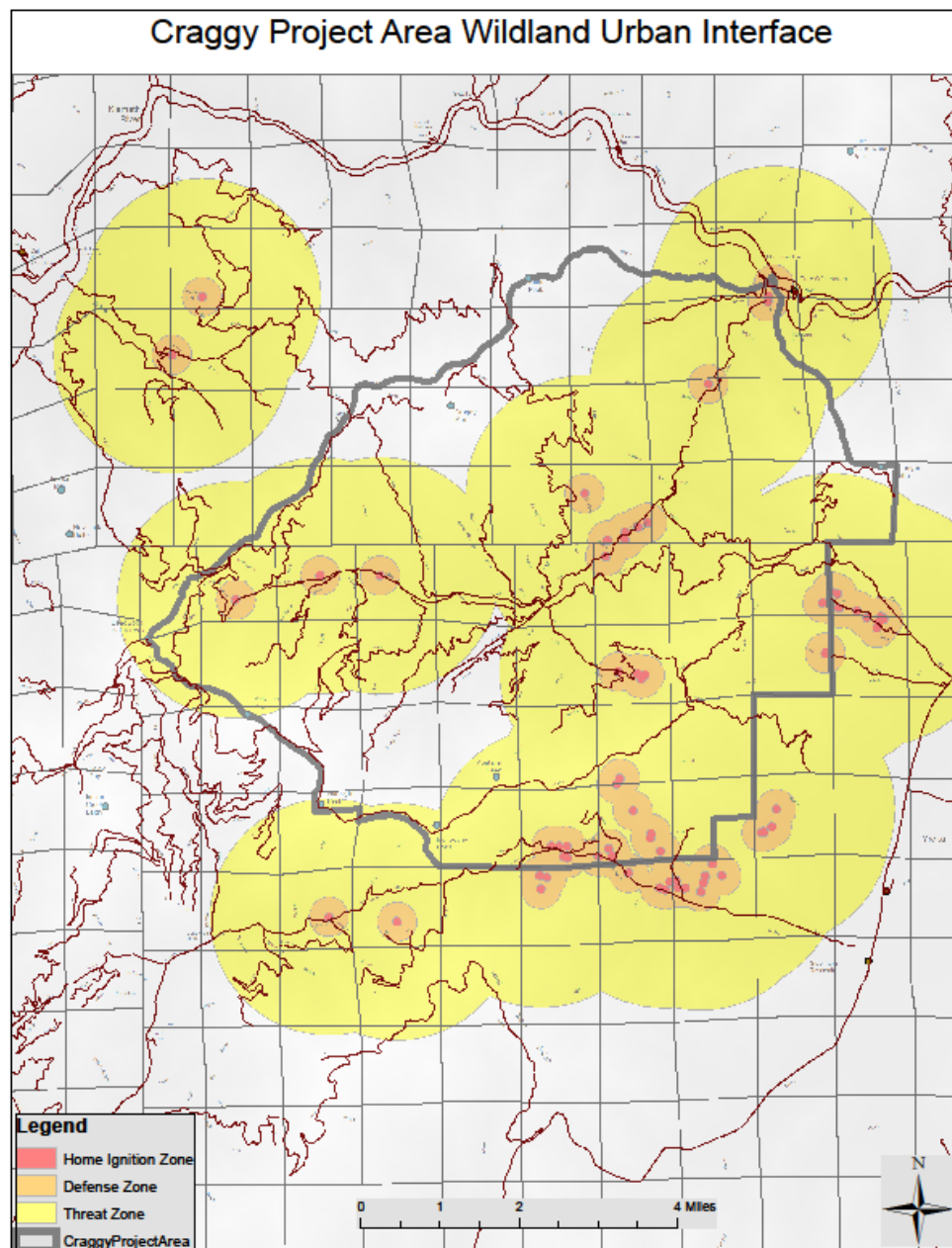


Figure D-1: Wildland Urban Interface Zones within Craggy Project Area