Fire/Fuels

Introduction

Presettlement fire strongly influenced the structure, composition and dynamics of most Sierra Nevada ecosystems. Many species and most communities show clear evidence of adaptation to recurrent fire, further demonstrating that fire has long been a regular and frequent occurrence. This is particularly true in the chaparral and mixed conifer communities, where many plant species take advantage of or depend on fire for their reproduction or as a means of competing with other biota. In many areas frequent surface fires are thought to have minimized fuel accumulation, keeping understories relatively free of trees and other vegetation that could form fuel ladders to carry fire into the main canopy (USDA-FS 1996).

Forest structure and species composition in many western U.S. coniferous forests have been altered through fire exclusion, past and on-going harvesting practices, and livestock grazing. The effects of these activities have been most pronounced in seasonally dry, low and mid-elevation, coniferous forests that once experienced frequent, low to moderate intensity fire regimes. Increased stand density, decreased overall tree size, and increased surface fuel loads are well documented for many forests of this type (Stephens, S. et al. 2009). Conifer stands generally have become denser, mainly in small and medium size classes of shade-tolerant and fire-sensitive tree species (USDA-FS 1996). These changes concern fire managers because the increased fuel loads and altered forest structure have made forest vulnerable to fire intensities and severities outside of the desired conditions and outside of historic fire regimes for these ecosystems. Changing climates in the next several decades may further complicate fire management by increasing temperatures and fire season length (Stephens, S. et. al. 2009). Fires now occur less frequently and cover much less area, but are likely to be large and severe when they do occur (USDA-FS 1996).

Fire represents both one of the greatest threats and one of the strongest allies in efforts to protect and sustain human and natural resources in the Sierra Nevada. Residents and visitors alike are well aware of the threats posed by summer wildfires. A growing density of homes and other structures coupled with the increased amount and continuity of fuels resulting from twentieth-century fire suppression have heightened concern about threats to life and property, as well as the health and long-term sustainability of forests, watersheds, and other natural resources. Yet fire has been an integral part of the Sierra Nevada for millennia, influencing the characteristics of ecosystems and landscapes. Today, State, Federal and local agencies put enormous resources into efforts to reduce fire occurrence while at the same time advocating the need to use fire to promote healthy ecosystems. The challenge faced is how to restore some aspects of a more natural fire regime while at the same time minimizing the threat wildfire poses to human and natural resources and values (USDA-FS 1996).

Affected Environment

The Sugar Pine Adaptive Management Project area encompasses five distinctive vegetation complexes. These include: (1) conifer plantations, (2) young (90 to 110 year old) mixed conifer stands, (3) mixed chaparral stands, (4) white and red fir conifer stands and/or (5) a combination of these. These vegetative complexes are results of various processes including wildland fires, effective fire suppression efforts, turn of the century timber harvesting and reforestation efforts.

Fire History

This area has a history of large fire occurrence. On September 10, 1922 a fire starting in the area of Sugar Pine occurred when the Madera Sugar Pine Lumber Company sawmill caught on fire and burned towards the Westfall area. By the time containment was reached, a total of 540 acres had been consumed. In 1924, three fires burned around the Sugar Pine Community. One fire burned just south of present day Westfall Fire Station below Highway 41, this fire was approximately 160 acres in size. To the north and west of Sugar Pine a fire originating in the vicinity of Happy Camp along Highway 41 burned up to the private property of the Yosemite Mountain Ranch. This fire was contained at 800 acres. To the east of Sugar Pine along road 5S18 (Dillon Orchard Road) a fire burned 106 acres before being contained.

Tables 26, 27, and 28 show the Fire History Records (fires >100 Acres) within and outside of the Sugar Pine Adaptive Management Project area (henceforth known as the Sugar Pine Project). Map 1 in Appendix A of this document shows the approximate perimeters of these fires and their proximity to the community of Sugar Pine and the project area.

Table 1. Fire History within the Project Boundary

Year	Size/Acres	General Location
1922	540	Into Sugar Pine Community
1924	800	North West of community/In Yosemite Mtn. Ranch
1924	160	West of Community
1926	106	East of Community

Table 2. Fire History Outside of the Project Boundary (Generally South of Sugar Pine)

Year	Size
1917	139
1920	99
1930	701
1934	304
1942	359

Table 3. Fire History within a 4-mile radius of Sugar Pine

Year	Size
1911	162
1917	2,236
1917	1,159
1924	10,310
1928	21,194
1934	304
1942	359
1958	803
1957	647
1959	11,076
1961	43,330

Logging

Heavy railroad logging entries (1900 through 1931) in the Sugar Pine and Nelder Grove area coupled with fire exclusion since the 1920s have resulted in development of dense fuel ladders. These consist of understory layers of fir and incense cedar beneath young growth stands of ponderosa pine, and sugar pine. Also in many of the pine plantations, incense cedar and white fir and brush have seeded in beneath the canopy, creating significant fuel ladders.

Fire Behavior in Current Fuel Loading

The Sugar Pine Adaptive Management Project (hence forth known as Sugar Pine Project) area has three dominant arrangements of fuels that influence fire behavior. These are: ground, surface and crown fuels. Ground and surface fuels can be described utilizing the Intermountain Fire Science Laboratory (IFSL) Fuel Models (Anderson 1982) and Scott and Burgan fuel models (2004) for estimating fire behavior. This is used to aid in describing the type and average amount of fuel given a particular vegetation type and the prediction of the type of fire behavior expected under certain weather and topographic conditions. Crown fuels are generally described in relationship to the density of crowns (canopy bulk density) and their height above the surface fuels (canopy base height).

Surface Fuels

Ground and surface fuels within the Sugar Pine Project area can be described by using the IFSL Fuel models, IFSL Fuel Model 6 (intermediate brush) best describes the surface and ground fuels in plantations, mixed conifer stands and mixed chaparral areas.

In areas within plantations where bear clover has re-established itself with minimal amounts of dead natural fuel accumulations, an IFSL Fuel Model 2, Timber (grass and understory) is used.

The ground and surface fuels within the mixed conifer stands that do not have brush as the main understory component fall into three IFSL Fuel Models 9, 10 and 12. The difference between these three fuel models comes from the increasing amounts of ground and surface fuels. IFSL Fuel Model 9 has the lightest amount of ground and surface fuels associated with it and is used to describe the conifer stands in Sugar Pine Project area that have not started to deteriorate from

drought stress and/or over crowding and the trees have not begun to fall on their own. This fuel model would also describe where there are large areas where small saplings and suppressed trees have begun to fill in the understory of larger trees. Surface fuel loadings in the Sugar Pine Project area that are representative of IFSL Fuel Model 9 average between 3 and 10 tons per acre.

IFSL Fuel Model 10 and 12 are used to describe those conifer stands where natural fuel and activity generated accumulations of ground and surface fuels are beginning to increase. These surface fuels are of larger size, mostly 3 or more inches in size and can increase the intensity of surface fires within the area. These fuels include not only the branches and needles of fallen trees, but also include the boles, increasing the tons per acres of natural fuels on the ground rapidly. Surface fuel loadings in the Sugar Pine Project area that are representative of IFSL Fuel Model 10 average between 12 and 25 tons per acre. Surface fuel loadings that are representative of IFSL Fuel Model 12 average between 25 and 40 tons per acre.

Crown Fuels

The crown fuels in the Sugar Pine Project area can be described in two ways; (1) crown fuels that can lead to the propagation of a crown fire and (2) crown fuels available to sustain a crown fire. There are two elements that need to fall into place for a crown fire to start and for it to sustain itself, fuel ladders (vegetation that "stair-steps" up in height and can allow a fire to reach the crowns of trees) and canopy density (in simple terms, how close together individual tree crowns are, usually given as a percentage of space taken up by the tops of trees).

In the Sugar Pine Project area, fuel ladders are heavy and continuous, consisting of natural regeneration of conifers (mainly white fir and incense cedar) and in some areas regeneration of conifers and brush. These fuel ladders start at the surface layer and have grown to the point of having a continuous "stair-step" of available fuels into the bases of the canopy trees.

The canopy fuels in the Sugar Pine Project area are varied from open to heavily closed (approximately 100% canopy closure). Areas where there is a combination of heavy, continuous fuel ladders and canopy closure is closed (interlocking of crowns in the canopy) the potential for initiation and sustainability of a crown fire is the greatest.

Wildland Urban Intermix (WUI)

Communities (wildland urban intermix zones) within and surrounding the project area have been rapidly developing over the last several years. The community of Sugar Pine is encompassed by the project area with scattered residences and businesses along the Highway 41 corridor. To the north is the community of Fish Camp, with Teneya Lodge (popular visitor destination outside of Yosemite National Park) directly adjacent to the project area and Wawona in Yosemite National Park. South of the Sugar Pine Project area lies the community of Cedar Valley. Farther south lays the community of Oakhurst. To the east, lies the Nelder Grove Historical Area of giant sequoia. With the continuity of the fuels within the Sugar Pine project area, a wildland fire originating from along Highway 41 or Cedar Valley area, under the right conditions, has the potential to spread northward or eastward to the communities of Sugar Pine, Fish Camp, Yosemite National Park and/or Nelder Grove.

Desired Condition

The SNFPA ROD, 2004 establishes a desired condition for each land allocation. In particular, the desired condition for each land allocation incorporates how and what type of vegetation complexes are desired for each. These are referenced in short and long term conditions and are influenced by the temporal and spatial influences of fire. With this in mind, the land allocations and their specific desired conditions used in this report include:

Wildland Urban Interface

Defense Zone (USDA-FS 2004; page 40)

- Stands are fairly open and dominated primarily by larger, fire tolerant trees.
- Surface and ladder fuel conditions are such that crown fire ignition is highly unlikely.
- The openness and discontinuity of crown fuels, both horizontally and vertically, result in very low probability of sustained crown fire.

Threat Zone (USDA-FS 2004; page 41)

Under high fire weather conditions, wildland fire behavior in treated areas is characterized as follows:

- Flame lengths at the head of the fire are less than four feet;
- The rate of spread at the head of the fire is reduced to at least 50 percent of pre-treatment levels;
- Hazards to firefighters are reduced by managing snag levels in locations likely to be used for control prescribed fire and fire suppression consistent with safe practices guidelines;
- Production rates for fireline construction are doubled from pre-treatment levels; and
- Tree density has been reduced to a level consistent with the site's ability to sustain forest health during drought conditions.

Fuels treatments outside of the WUI and within other land allocations are to establish and maintain a pattern of area treatments that is effective in modifying wildfire behavior (USDA-FS 2004; pages 45-48). There are specific means and conditions by which treatments can be conducted within some land allocations because of maintaining habitat needs as well as perpetuating such conditions (i.e. old forest emphasis areas).

Alternative 1 – No Action

Under Alternative1, current management plans would continue to guide activities in the project area. This includes all ongoing activities with existing decisions or permits that would not be changed if this alternative were selected including: underburning, plantation maintenance, cattle grazing, recreation, and recreation residences.

Under Alternative 1 there would be no thinning; precommercial, commercial and/or biomass, accomplished. Fuel ladders and competition between trees would not be reduced and/or removed. Forest health in the area will continue to decline. No connection and augmentation of fuel treatments within and adjacent to the Wildland Urban Interface would be completed. No fuelbreak maintenance work would be completed. Aerial fire suppression would not support ground forces due to the inability of retardants to reach ground fuels because of closed canopy cover.

Direct Effects

Natural fuel accumulations would continue to increase as more trees begin to succumb to overcrowding, drought, insect and pathogens. This would increase the amount of ground and surface fuels within the area. This increase in ground and surface fuels would gradually begin to shift the potential fire behavior in the area, to a more severe stature if a wildfire were to start. This increase would be to a more severe surface fire as the type of fuels changed from branches and needles (0 to 1 inch material) to the larger size material (3 or more inches). This change is best represented by fuel model changes or conversions. Brush covered areas would gradually become

older and more decadent, converting from an IFSL Fuel Model 6 into an IFSL Fuel Model 4. Mixed conifer areas that begin as IFSL Fuel Model 9 would convert to IFSL Fuel Model 10. As accumulated natural surface fuel loadings increased, a further conversion from IFSL Fuel Model 10 to IFSL Fuel Model 12, similar to that of a moderate slash fuel loading could occur in some areas. IFSL Fuel Model 2 is used to represent the surface fuel conditions existing in some conifer plantation. Under Alternative 1, this would not change, but additional accumulations of larger diameter branch wood, twigs and perhaps boles of trees could increase the average tons/acre of surface fuels, increasing the fireline intensity and resistance to control. Firefighters with handtools or water from fire engines would become less effective. Crown fire potential would also remain high because none of the elements needed to propagate and sustain a crown fire would be removed (fuel ladders and canopy density). Because of the increased amount of surface fuels and the increased fire behavior associated with them, these potential crown fires would have the potential to propagate over a larger area. Tables 29 and 30 show the indicators for current existing conditions and those associated with the conversions in IFSL Fuel Models under Alternative 1.

Table 4. Indicators for IFSL Fuel Models of Brush Covered Areas

Indicator	Existing	Converted
Fuel Model	6	4
Average Rate of Spread (ch/hr)	24.8	91.6
Average Flame Length (feet)	5.8	22.9
Average Fireline Intensity (Btu/ft/s)	258	5131
Crown Fire Potential (transition and type)	Yes; Crowning	Yes; Crowning
Resistance to Control (low, mod., high)	High	High
Average Fuel Loading (tons/acre)	6.0	13.0
Average Mortality (%)	N/A	N/A

It is assumed that mortality in the brush species would be from stand replacing (100%) or patchy dependent on the percent cover of the brush. For mortality to occur in brush there need only be enough fire to girdle the main stem. With the predicted fire behavior, as shown above, it is anticipated that in Fuel Model 6, as currently exist, there would be mortality, but not as great as in Fuel Model 4, because of the lower amount of dead woody material found on the brush.

Table 5. Indicators for IFSL Fuel Models in Timber Covered Areas

Indicator	Existing	Existing	Converted	Converted
Fuel Model	9	2	10	12
Average Rate of Spread (ch/hr)	10.3	48.3	10.3	16.2
Average Flame Length (feet)	3.5	7.8	6.0	9.6
Average Fireline Intensity (Btu/ft/s)	84	500	282	781
Crown Fire Potential (transition and type)	Yes; Crowning	Yes; Crowning	Yes; Crowning	Yes; Crowning
Resistance to Control (low, mod., high)	Moderate to High	Low to Moderate	High	High
Average Fuel Loading (tons/acre)	3.5	4.0	12.0	34.6
Average Mortality in White Fir / Ponderosa Pine (%)	35 / 22	97 / 94	79 / 65	99 / 97

Tables 29 and 30 above tables give an indication of what type of fire behavior could be expected if a fire were to occur within these fuel beds as they currently exist and in the anticipated fuel beds into the future with no management action taken. Because of the variability in the three facets needed to predict fire behavior; fuel, weather and topography that exist within the Sugar Pine Project area, there would be variations in the conditions and results of wildfire. On northern aspects, conditions would be expected to be cooler than southern aspects, lending to slightly slower and slightly less intense fires. Lower fuel loadings could produce slower rates of spread and intensities than predicted above. There are conditions that could produce higher rates of spread and intensities than in the above tables as well. These would include increased slopes, wind conditions, greater surface fuel loadings (both small and large down-woody debris) and increased density of ladder fuels.

Indirect and Cumulative Effects

Past, present and reasonably foreseeable actions, as listed in the project file for the Sugar Pine Project area, along with fire management policy of full suppression at the smallest size (97 percent of all fires will be controlled at 10 acres or less from Sierra NF LRMP (USDA-FS 1991, 1996) have contributed to the current existing condition for the Sugar Pine Project area and are used to depict the existing condition and the resultant fire behavior within the project area.

Fire Suppression / Fire Use

As surface fuels continue to accumulate naturally, with no additional management actions, suppression efforts will gradually become more difficult, whereby direct attack could no longer be used in suppressing a fire, but have to be changed to more indirect tactics, whereby more area has the potential to be affected by fire, in some cases high intensity and more severe fire. With the increases in fire behavior generated by these surface fuel changes, fire suppression forces would have higher resistance to control (the relative difficulty of constructing and holding a control line as affected by resistance to constructing line due to fuel loading and by fire behavior), and aerial retardants would be less effective due to closed continuous canopy. If fire were to start in or burn into the Sugar Pine Project area, ground and aerial initial attack operations as well as extended attack would become less effective and firefighter and public safety would be difficult to ensure.

Under Alternative 1, full suppression would continue to be the management direction for the Sugar Pine Project area. Because of the continued and potential increased threat to life and

property, under Alternative 1, firefighting resources would focus strategies and tactics on reducing the impacts on communities, protecting infrastructure and private property as the highest priority followed by protection of natural resources.

Under Alternative 1, there would be very limited to no potential to allow fire to play its natural role on the landscape. The risk of escape and the consequential effects associated with utilizing fire without some form of management activity to reduce current surface fuel loadings and ladder fuels would be too great. Although prescribed fire could be implemented under more controlled conditions than those conceivably present during the summer fire season, it would be a very narrow prescription window that could produce reasonable outcomes that would be beneficial versus detrimental. Just like wildfire, prescribed fire produces air quality concerns, risk of escape, potential negative impacts to resources (from control lines and fire itself), resource commitments and political and social impacts.

Fire Effects

Fire influences many portions of a fire dependent ecosystem by either its presence or even its absence. Forest stand structures, wildlife habitat, aquatic communities, watersheds, plant communities and soil conditions, to name a few can be influenced. Without frequent fire to clean the understory of stands, excessively dense stands lead to drought stress and bark beetle outbreaks, resulting in wide spread mortality of trees in many areas and the potential for extensive mortality. This leads to a large increase in the amount and continuity of both live and dead forest fuels, resulting in a substantial increase in the probability of large, severe wildfires (Weatherspoon, C.P. 1996). These are directly correlated to the conversions of IFSL Fuel Models discussed in the direct effects section.

With increased rates of spread, flame lengths, and fireline intensities there is potential for greater fire effects to occur. Because of existing changes in tree species composition, from fire resistant to fire susceptible, tree mortalities would increase with small incremental changes in wildfire intensity. This, in combination with drought or insect/pathogen induced mortality in overstocked stands, could greatly increase the amount of surface fuel loading, thus increasing fire behavior and intensity of subsequent wildfires. Under Alternative 1, there would be no reduction in surface and ladder fuels, to raise mean canopy base heights and/or decrease canopy bulk densities as has been suggested in the desired condition for creating fire resilient stands. Vertical continuity of fuels from the forest floor to the crowns of overstory trees would be present and with sufficient radiant/convective heat could produce crown fire. Some studies and models, however, suggest a crown fire entering a stand is rarely sustained (i.e., sustained only under extreme weather conditions) (North, M., et. al. 2009). Calculated and predicted crown fire potential (see Tables 29 and 30) show that conditions are present in the Sugar Pine Project area to produce the potential for crown fire. This could be in the form of torching single trees, groups of trees and/or active crown fire dependent on weather, fuels and topography of where the fire were to occur.

Crown fires remove much or the entire tree canopy in a particular area, essentially resetting the successional and growth processes of stand and forests. These fires typically, but not always kill or temporarily reduce the abundance of understory shrubs and trees. Crown fires have the largest immediate and long-term ecological effects and the greatest potential to threaten human settlements near wildland areas (Graham, R., et. al. 2004). For wildlife species dependent on diverse forested landscapes (heterogeneity) and old forest characteristics for habitat, this successional “set-back” could pose negative consequences.

Although crown fires would be considered of higher consequence of negative effects, surface and ground fires with higher intensities similar to those predicted and anticipated in this alternative, can also have negative impacts. While surface fires can reduce vegetation and woody, moss, lichens and litter strata, ground fires that consume large amounts of woody fuels and organic soil

horizons can produce disproportionately large amounts of smoke. Ground fires reduce the accumulation of organic matter and carbon storage and contribute to smoke production during active fires and long after flaming combustion has ended. These fires can also damage and kill large trees by killing their roots and the lower stem cambium. Because ground fires are often of long duration, they may result in greater soil heating than surface or crown fires, with the potential for reducing organic matter, volatilizing nutrients, and creating a hydrophobic layer that contributes to erosion. Areas where the ground cover is removed and severely burned will likely see decreased infiltration of water, increased surface runoff and peak flows, and the formation of pedestals, rills and gullies (Graham, R., et. al. 2004).

Depending on the setting (in particular topography and soil), perennial streams downstream from fires can be impacted by large volumes of sediment. Depending on the recovery of the hillslopes, these fire effects can be long lasting, and relatively little can be done to stop the problem. Large amounts of sediment can be delivered to reservoirs, reducing water storage capacity and potentially affecting fish and macroinvertebrate habitat (Graham, R., et. al. 2004).

Alternative 2 – Proposed Action

Under Alternative 2, the development of Strategically Placed Area Treatments (SPLATs) would occur. Additional areas would be treated to provide a defensible fuels profile near key transportation corridors and within the defense zone of the wildland urban intermix. In addition to those treatments needed to meet fire and fuels objectives, treatments would be created to reduce stand densities (basal area) to such a level as to improve the growth and vigor of remaining trees. Treatments included in this alternative are: thinning from below in conifer stands, either by pre-commercially, commercially, biomassing and/or mastication of vegetation (conifers) to reduce lower and mid- level canopy stand densities; mastication of brush and shrub patches; prescribed burning, both understory and piles; manual reduction and/or prescribed burning of noxious weed infestations; and prepare and plant failed conifer plantations.

Creating Fire Resistant Forests

Fire resistant forests combine fire resistant tree species suitable to a site in a spatial arrangement that discourages surface fires from moving to the crowns. Crowns are made more resistant to fire by reducing surface and ladder fuels as well as increasing the height of the base of the canopy.

Canopy Base Height (CBH):

- Is the lowest height above the ground at which there is sufficient canopy fuel to propagate fire (Van Wagner 1993);
- Is the average crown base height for the stand;
- Is the lowest 20th percentile of all crown base heights in the stand (Hoffman 2005, Fulé et al. 2001, 2002);
- The height at which a minimum bulk density of fine fuel (30 lb/acre/ft, 0.011 kg/m3) is found (Beukema et al,1997); and
- CBH is the lowest height above the ground at which there is sufficient canopy fuels to propagate fire vertically through the canopy (Scott and Reinhardt 2001).

Also decreasing the crown density and removing smaller trees while retaining larger more fire resistant trees reduces the risk of crown fire.

Table 6. Principles of Fire Resistant Forests

Recommendation	Physical Effects	Fire Advantage	Concerns
Reduce surface and ladder fuel	Reduces potential flame length	Fire control easier, less torching	Surface disturbance less with fire than other techniques
Increase canopy base height	Requires longer flame length to ignite tree crowns	Less torching	Opens under story, may allow surface wind to increase
Decrease crown density	Makes independent crown fire less probable	Reduces crown fire propagation	Surface wind may increase, surface fuel may be drier
Retain larger trees	Thicker bark and taller crowns	Increases survivability of trees	Removing only smaller trees is economically less feasible
Retain fire resistant tree species	Promotes trees most likely to survive fires	Reduces mortality from future fires	Repeated treatments may be necessary to promote desired trees

Source: Adapted from Agee 2002 by Graham et. al. 2004

The table above is displayed in this report to assist in demonstrating the types of treatments proposed to achieve the purpose and need of the Sugar Pine Project, the physical effects, fire advantage and concerns associated with each recommended means to affect fire behavior. The following associates the predicted fire behavior results of each level of treatment proposed by this and all action alternatives.

Direct Effects

Under this alternative, thinning from below, through biomass, precommercial and/or commercial means would focus first on the smaller trees for removal gradually moving through the lower canopy levels with the potential to remove trees within the mid-level canopy to reach a silviculturally-prescribed basal area and stocking level. Through the treatments in Alternative 2, the recommendations in Table 31 are accomplished by reducing surface and ladder fuels, increasing canopy base height, decreasing crown density, retaining larger trees and retaining fire resistant tree species.

Fuel Model Changes

Under Alternative 2, existing fuel model would be converted to another fuel model, typically a fuel model with lower surface fuel loadings and reduced fire behavior. In areas currently represented by IFSL Fuel Model 6, mastication would be used to convert it to an IFSL Fuel Model Timber/Understory (TU) 1. Mastication in effect does not remove the fuel from the site, but changes the structure of the fuel from a vertical orientation to a horizontal orientation. Small chips, shredded material and/or crushed fuels (dependent on masticator head) are left on site. A fuel model that represents an increase in fuel loading in the 10 and 100-hour time lag categories is needed to show this. TU1 is used as the base fuel model with increases in 10 and 100-hour fuel loadings to approximately 2 tons per acre each and the removal of live woody fuel loading to approximate this conversion.

In timbered stands represented as IFSL Fuel Model 9, there would be or no conversion to a different fuel model. In stands represented by IFSL Fuel Model 10, biomass and thinning from below would convert them to an IFSL Fuel Model 8 or 9, dependent on the overstory and surface fuels remaining. In some cases, a short-term conversion to an IFSL Fuel Model 12 may occur

until post activity treatments were completed, then a conversion to an IFSL Fuel Model 8 or 9 would result.

The fuel model conversions shown are used to depict the conditions anticipated in the surface fuel bed changes as a result of the treatments proposed in this alternative. This alternative is also anticipated to raise canopy base heights, with the thinning or removal of ladder fuels from an average of 0 to 10 feet to an average of 20 feet. Canopy bulk density will also be decreased through the thinning of lower and mid-level canopies. It is estimated that, on average the canopy bulk density will be changed from 0.19 kg/m3 to 0.14 kg/m3 under Alternative 2.

Surface and Ladder Fuels

The removal and/or thinning of the lower canopy in effect removes the ladder fuels that can provide the means for surface fires to "climb" into the overstory canopy. In areas where there is a significant amount of ladder fuels present, biomass operations will be used to remove excess material. It is anticipated there would be small amounts of additional fuels added to the current surface fuel loading through this type of operation because the material would be taken in whole tree form to a landing for removal versus limbs/tops cut off and left within the stand (known as lop and scatter). In areas where brush species are the dominant vegetation cover, masticators will be used to in effect change the vertical continuity of the fuel. While mastication does not actually remove fuel from the area, it does change the structure from a vertically oriented fuel (ladder fuel) to a horizontal fuel potentially making fire suppression resistance to control lower and fire effects less in most cases. In areas where there are lower amounts of ladder fuels and/or smaller areas, mastication and/or hand cutting will be used to open or separate the lower canopy from the mid to upper level canopy. Typically, these areas have lower levels of surface fuels existing (smaller amount of trees/vegetation, less amounts of naturally accumulated or activity generated surface fuels).

Dependent on the type of harvest system used for removal of excess commercial-sized material, it is anticipated there may be a short-term increase in surface fuel loading or no significant increase. Whole-tree yarding, used as a harvesting system, can minimize the amount of activity generated fuels (Stephens, S. 2009). If whole tree yarding is not used, additional post harvest treatments will be needed to reduce surface fuel loadings that are in excess of 20 tons/acre (USDA-FS 2004). These post activity treatments would include dozer and/or hand piling and burning and/or broadcast/jackpot burning.

Fire Behavior / Fire Effects

Table 32 shows the predicted results of fuel model conversions anticipated with this alternative.

Table 7. Indicators for IFSL Fuel Models of Brush and Timber Covered Areas

Indicator	Existing	Existing	Existing	Converted	Converted	Converted
Fuel Model	6	9	10	12	TU1	9
Average Rate of Spread (ch/hr)	24.8	10.3	10.3	11.0	7.5	5.8
Average Flame Length (feet)	5.8	3.5	6.0	8.1	3.0	2.7
Average Fireline Intensity (Btu/ft/s)	258	84	282	531	63	47
Crown Fire Potential (transition and type)	Yes; Crowning	Yes; Crowing	Yes; Crowning	Yes; Torching	No; Surface	No; Surface
Resistance to Control (low, mod., high)	High	Low to Moderate	High	High	Low	Low
Average Fuel Loading (tons/acre)	6.0	3.5	12.0	34.6	6.0	3.5
Average Mortality in White Fir / Ponderosa Pine (%)	N/A	35 / 22	79 / 65	96 / 93	N/A	15 / 8

The above table gives an indication of what type of fire behavior could be expected if a fire were to occur within these fuel beds as they currently exist and in the anticipated fuel beds after treatments were to occur. Because of the variability in the three facets needed to predict fire behavior; fuel, weather and topography within the Sugar Pine Project area, there would be variations in the conditions and results of wildfire. On northern aspects, conditions would be expected to be cooler than southern aspects, lending to slower and less intense fires. Lower fuel loadings could produce slower rates of spread and intensities than predicted above. There are conditions that could produce higher rates of spread and intensities than in the above tables. These would include increased slopes, wind conditions, greater surface fuel loadings (both small and large down-woody debris) and increased density of ladder fuels.

Indirect and Cumulative Effects

Past, present and reasonably foreseeable actions, as listed in the project file for the Sugar Pine Project area, along with fire management policy of full suppression at the smallest size (97 percent of all fires will be controlled at 10 acres or less from Sierra NF LRMP (USDA-FS 1991, 1996) have contributed to the current existing condition for the Sugar Pine Project area and are used to depict the existing condition and the resultant fire behavior within the project area.

Fire Suppression and Fire Use

Alternative 2 in effect reduces ladder fuels which in turn increases canopy base height. Canopy density (in the form of canopy bulk density) is decreased through the thinning of the mid-level

canopy, but to a small extent through the reduction in fuel ladders. These, in combination, reduce rates of spread, flame length, fireline intensity, resistance to control and the potential for a fire to transition into crown fires. If full fire suppression continues as the management strategy for unplanned ignitions within the project area, fire suppression resources will have an increased capacity to control fires at initial attack with minimized risk to their safety (and the public) and increased ability to keep these fires small in size with the use of direct attack tactics versus indirect tactics. Fires would typically drop from the crowns to the forest floor. Aerial fire fighting resources would be better able to penetrate the canopy to aid ground resources with reduced canopy density, even moderate amounts as an indirect effect of treatments in Alternative 2.

Design features used to minimize effects and/or retain habitat structures preferred by wildlife species such as; grouping of larger trees, oak retention with ladder fuels retained under them and Old Forest Linkages with limited treatments will have lower potential for loss since there will be treated areas between them and are not continuous. This would be similar to the variability in forest conditions produced by frequent fire (North 2009).

In utilizing mechanical treatments, as in Alternative 2, stand structures are modified quickly and more precisely than with prescribed fire alone (North 2009). Under this alternative, treatments are effective in breaking up the horizontal and vertical continuity of live fuels in the lower canopy layers and/or in effect pre-treating the stands to more readily allow prescribed fire to be re-introduced. Silvicultural cuttings can only partially substitute for fire (Weatherspoon 1996). This alternative allows increased potential to utilize prescribed fire as either a maintenance treatment and/or in conjunction with mechanical treatments as a follow-up process to achieve forest resilience. Fire could mimic the natural ecosystem functions of frequent low-to-moderate severity fire. Under this alternative, prescribed fire, whether burning of piles and/or broadcast burns can be implemented with less risk of escape, with a broader range of acceptable conditions and in some cases less impacts to air quality (Weatherspoon 1996).

Fire Effects

With the removal of what is considered the suppressed, intermediate and some co-dominates within a stand, the vegetation considered ladder fuels would be removed. Conifer species such as Ponderosa Pine and Sugar Pine, which are considered more fire resistant, would be favored to remain in a stand over shade tolerant and fire sensitive species, such as incense cedar and white fir. Incense cedar and white fir make up the largest percentage of conifers found in the understory of stands in the Sugar Pine Project area (based on sampled plot data). These species also tend to have increased susceptibility to wildfire as well tend to have limbs that stay closer to the ground providing increased ability to take surface fires into the crowns in the form of single tree torching or group torching. With species composition favored towards the more fire resistant, shade intolerant species and fire behavior modified, effects to stands (mortality) would be decreased.

As part of this alternative, treatments would be implemented to reduce surface fuels, where needed. In most cases, as been experienced in past projects similar to this alternative, these areas are not continuous over the entire treatment area. If a fire was to start in an area where these surface fuels have not been reduced, fire behavior would be increased (as represented by IFSL Fuel Model 12). The results of wildfire impacts on areas treated only with mechanical methods are mixed. Some burned with higher intensity, than those where mechanical treatments were followed by prescribed burning, though with lower severity than untreated control areas (Stephens, S. 2009). The timing and sequence of these “clean-up” treatments are dependent on several factors, such as adequate funding and completion of harvesting operations. Those treatment areas closest to WUI will be treated first and then will progress into other areas from there. As stated earlier the surface fuel load changes would be largely based on harvesting system used. If whole-tree yarding is used, post treatment areas where natural fuel accumulations are

above 20 tons/acre would be the areas where secondary treatment would be used. These are areas expected to be less (acres) in need of surface fuel reduction.

With reduction in fire behavior, the effects of fire on other ecosystem components would be reduced and perhaps enhanced. Many are resistant or often have favorable responses to low to moderate fire intensity and severity. The idea of preemptive work that restores historic fire regimes has not been widely discussed, considered, or used to address both the ecological and social issues surrounding fires and watershed resources. The same can be said for many of the wildlife species that live and depend on the forested ecosystem. At risk species, and the ecological functioning systems they depend on, cannot be sustained or recovered without the immediate and longer-term ecological functioning provided by fire. In Alternative 2, integrating fire and fuels management objectives and forest health restoration with at-risk species conservation and protection are made. This is needed to provide both the viability of human communities and at-risk species where both overlap (Sugihara, N., et.al. 2006).

Climate Change and Fire Severity Relationships

As stated earlier, weather (climate) has a large influence on fire behavior and is also the most difficult to predict. Associated with the purpose and need to reduce stand densities to levels where trees would be more resilient to drought conditions, reducing surface and ladder fuels to reduce wildfire intensity and spread, can also produce benefits in drought conditions. Research suggests global mean minimum temperatures may have already begun to rise. One effect of this change for western forests would be earlier spring melt of mountain snow packs. An analysis of western U.S. fire season length over the last 50 years suggests that during the last two decades, fires begin earlier in the spring and occur later in the fall possibly due to this trend in elevated nighttime minimum temperatures. Though there are variations in predictions and models, one point of consensus is that most agree the climate will become more extreme, suggesting oscillations between wet and drought conditions will be more common (North 2009).

Managing forests under these conditions will be challenging. In the face of uncertainty, adaptive strategies should focus on three responses; resistance (forestall impacts and protect highly valued resources), resilience (improve the capacity of ecosystems to return to desired conditions after disturbance), and response (facilitate transition of ecosystems from current to new conditions) (North 2009). All of these are focuses that Alternative 2 is attempting to address through its purpose and need for changes in forest structure capable of surviving climate changes and reduction in fuels to adapt fire behavior that occurs under current climate and ignition conditions (North 2009).

Alternative 3

Under Alternative 3, all treatment areas would be carried forward from Alternative 2, but in areas where there are known Pacific fisher den sites, treatments within associated den site buffer would include only those treatments needed to achieve fire and fuels objectives (treatment of surface and ladder fuels). All other treatment areas would continue to treat for both fire/fuels and forest health (stand density) objectives.

Direct Effects

Under Alternative 3, there would be no significant change in the direct effects from those listed under Alternative 2. There is a potential for a decreased amounts additive surface fuel loading within the known fisher den site area resulting from less conifers being removed. As stated in Alternative 2, resultant increases or decreases in surface loadings from harvesting operations are dependent on the type of harvesting operations that are used. By increasing canopy base heights and reducing surface fuel loadings, fire and fuels objectives are met.

Indirect and Cumulative Effects

Under Alternative 3, there would be no significant change in the indirect and cumulative effects from those listed under Alternative 2. There is a potential for aerial firefighting resources to be less effective in the Pacific fisher den site area with no reduction in mid-level canopy densities. Increased crown densities in the den site area would make it difficult for retardant and/or water dropping from helicopters to penetrate to the ground. In assuring the reduction in ladder fuels to raise canopy base heights from 0 to 10 to 20 feet and reducing surface fuel loadings, fire intensity and spread are reduced to desired condition levels and meet the fire and fuels objectives stated in the purpose and need of the project.

There is little to nothing is done to reduce forest stand densities within the Pacific Fisher den site area though with this alternative and could produce losses from drought induced mortality, insect and disease. Long term, these types of disturbances could induce increases in surface fuel loadings and/or increased snag levels producing conditions similar to those already existing in the project area with resultant fire behavior (intensity and spread rates) similar to those predicted in Alternative 1, with the exception of crown fire potential. It is assumed that with the reduction in ladder fuels, there would be increases in rates of spread, increase flame lengths, increased fireline intensity, and increased resistance to control, similar to that seen in IFSL Fuel Model 9 and/or 10 in Alternative 1, but this would be as a surface fire with potential for crown fire reduced and/or eliminated. Fire intensities could cause the potential for single or group tree torching because of the increased number of fire susceptible trees such as white fir and incense cedar left in the stand, but this is expected to be less than in Alternative 1.

Alternative 4

Under Alternative 4, all treatment areas would be carried forward from Alternative 2, but treatments would include only those needed to achieve fire and fuels objectives (treatment of surface and ladder fuels).

Direct Effects

Under Alternative 4, there would be no significant change in the direct effects from those listed under Alternative 2. As in Alternative 3 direct effects, there is a potential for a decreased amounts additive surface fuel loading within all “T” treatment areas resulting from less conifers being removed. As stated in Alternative 2, resultant increases or decreases in surface loadings from harvesting operations are dependent on the type of harvesting operations that are used. By increasing canopy base heights and reducing surface fuel loadings, fire and fuels objectives are met.

Indirect and Cumulative Effects

Under Alternative 4, there would be no significant change in the indirect and cumulative effects from those listed under Alternative 2. There is a potential for aerial firefighting resources to be less effective in all “T” treatment areas with no reduction in mid-level canopy densities. Increased crown densities in the den site area would make it difficult for retardant and/or water dropping from helicopters to penetrate to the ground. In assuring the reduction in ladder fuels to raise canopy base heights from 0 to 10 to 20 feet and reducing surface fuel loadings, fire intensity and spread are reduced to desired condition levels and meet the fire and fuels objectives stated in the purpose and need of the project.

There is little to nothing done to reduce forest stand densities within the Pacific fisher den site area. This alternative could produce losses from drought induced mortality, insect and disease. Long term, these types of disturbances could induce increases in surface fuel loadings and/or

increased snag levels producing conditions similar to those already existing in the project area with resultant fire behavior (intensity and spread rates) similar to those predicted in Alternative 1, with the exception of crown fire potential. It is assumed that with the reduction in ladder fuels, there would be increases in rates of spread, increase flame lengths, increased fireline intensity, and increased resistance to control, similar to that seen in IFSL Fuel Model 9 and/or 10 in Alternative 1, but this would be as a surface fire with potential for crown fire reduced and/or eliminated. Fire intensities could cause the potential for single or group tree torching because of the increased number of fire susceptible trees such as white fir and incense cedar left in the stand, but this is expected to be less than in Alternative 1.