Scottiago Forest Health and Fuels Reduction Project

Fire & Fuels Report

Prepared by:
J. Plummer
Fuels Specialist
Amador Ranger District
Eldorado National Forest
02/22/2019

Introduction

The Scottiago Forest Health and Fuels Reduction Project includes proposed vegetative treatments designed to reduce wildfire hazard and promote a healthy forested landscape that is fire resilient.

Relevant Laws, Regulations, and Policy

Regulatory Framework

Land and Resource Management Plan

The Eldorado National Forest Land and Resource Management Plan (LRMP) as amended by the Sierra Nevada Forest Plan Amendment Record of Decision (SNFPA ROD, 2004) provides direction for Forest management.

Management Area

In addition to Forest-wide direction, the SNFPA provides programmatic management direction for site-specific projects, including designating Land Allocation areas that fall within the project area.

Wildland Urban Interface (WUI) Threat Zones

Desired Conditions:

- Under high fire weather conditions, wildland fire behavior in treated areas within the threat zone is characterized as follows: (1) flame lengths at the head of the fire are less than 4 feet; (2) the rate of spread at the head of the fire is reduced to at least 50 percent of pre-treatment levels; (3) hazards to firefighters are reduced by managing snag levels in locations likely to be used for control of prescribed fire and fire suppression consistent with safe practices guidelines; (4) production rates for fire line construction are doubled from pre-treatment levels; and (5) tree density has been reduced to a level consistent with the site's ability to sustain forest health during drought conditions.

Applicable Management Intent:

- Threat zones are priority area for fuels treatments.
- Fuels treatments in the threat zone provide a buffer between developed areas and wildlands.
- Fuels treatments protect human communities from wildland fires as well as minimize the spread of fires that might originate in urban areas.
- The highest density and intensity of treatments are located within the WUI.

Applicable Management Objectives:

- Establish and maintain a pattern of fuels treatments that is effective in modifying wildfire behavior.
- Design economically efficient treatments to reduce hazardous fuels.

Wildland Urban Interface Defense Zones

Desired Conditions:

- Stands in defense zones 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.

Management Intent:

- Protect communities from wildfire and prevent the loss of life and property.
- WUI defense zones have highest priority for treatment (along with threat zones).
- The highest density and intensity of treatments are located within the WUI.

Applicable Management Objectives:

- Create defensible space near communities, and provide a safe and effective area for suppressing fire.
- Design economically efficient treatments to reduce hazardous fuels.

California Spotted Owl and Northern Goshawk Protected Activity Centers (PACs)

Desired Conditions:

- Stands in each PAC have: (1) at least two tree canopy layers; (2) dominant and co-dominant trees with average diameters of at least 24 inches dbh; (3) at least 60 to70 percent canopy cover; (4) some very large snags (greater than 45 inches dbh); and (5) snag and down woody material levels that are higher than average.

Management Intent:

- Maintain PACs so that they continue to provide habitat conditions that support successful reproduction of California spotted owls and northern goshawks.

Applicable Management Objectives:

- Avoid vegetation and fuels management activities within PACs to the greatest extent feasible.
- Reduce hazardous fuels in PACs in defense zones when they create an unacceptable fire threat to communities.
- Where PACs cannot be avoided in the strategic placement of treatments, ensure effective treatment of surface, ladder, and crown fuels within treated areas.

California Spotted Owl Home Range Core Areas (HRCAs)

Desired Conditions:

- HRCAs consist of large habitat blocks that have: (1) at least two tree canopy layers; (2) at least 24 inches dbh in dominant and co-dominant trees; (3) a number of very large (greater than 45 inches dbh) old trees; (4) at least 50 to 70 percent canopy cover; and (5) higher than average levels of snags and down woody material.

Old Forest Emphasis Areas

Desired Conditions:

- Forest structure and function across old forest emphasis areas generally resemble pre-settlement conditions. High levels of horizontal and vertical diversity exist at the landscape-scale (roughly 10,000 acres).
- Stands are composed of roughly even-aged vegetation groups, varying in size, species composition, and structure. Individual vegetation groups range from less than 0.5 to more than 5 acres in size. Tree sizes range from seedlings to very large diameter trees. Species composition varies by elevation, site productivity, and related environmental factors. Multi-tiered canopies, particularly in older forests, provide vertical heterogeneity. Dead trees, both standing and fallen, meet habitat needs of old-forest-associated species.
- Where possible, areas treated to reduce fuel levels also provide for the successful establishment of early seral stage vegetation.

Management Intent:

Establish and maintain a pattern of area treatments that is effective in modifying fire behavior.

Applicable Management Objectives:

Establish and maintain a pattern of area treatments that is effective in modifying fire behavior.

Federal Law

As a Federal agency, the Forest Service takes its direction from the United States Congress (Congress). Laws enacted by Congress that provide direction to the agency regarding the management of forest vegetation and the evaluation of environmental impacts include the National Forest Management Act (NFMA) of 1976 (16 United States Code (U.S.C.) 1600 et. seq) and the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et. seq.). Congress also instructs Federal agencies to promulgate regulations that provide specific instructions for implementing the legislation. In this case, National Forest Management Act regulations, also called the "Planning Rule," are found at 36 CFR 219, while the implementing regulations for the National Environmental Policy Act are found at both 40 CFR 1500 (Council on Environmental Quality) and 36 CFR 220 (Forest Service).

Other Guidance or Recommendations

The Healthy Forests Restoration Act (HFRA) provided communities with an opportunity to influence where and how federal agencies implement fuel reduction projects on federal lands. This is done through the development of a Community wildfire protection plan (CWPP).

National Fire Plan

The Federal Land Assistance, Management and Enhancement Act of 2009

The Federal Land Assistance, Management and Enhancement Act of 2009 (the FLAME Act) was signed by President Obama in November 2009. The Act states, in part, "Not later than one year after the date of the enactment, the Secretary of the Interior and Secretary of Agriculture shall submit to Congress a report that contains a cohesive wildfire management strategy." The FLAME Act directs that a cohesive strategy be developed addressing seven specific topic areas ranging from how best to allocate fire budgets at the Federal level to assessing risk to communities, and prioritizing hazardous fuels project funds. The FLAME Act is the catalyst for bringing fire leadership at all levels together and prompting a new approach to how wildland fire is managed. This new approach will guide the development of a national cohesive strategy that paves the way for developing a national wildland fire management policy.

National Cohesive Wildland Fire Management Strategy

In response to requirements of the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009, the Wildland Fire Leadership Council (WFLC) directed the development of the National Cohesive Wildland Fire Management Strategy (Cohesive Strategy). The Cohesive Strategy is a collaborative process with active involvement of all levels of government and non-governmental organizations, as well as the public, to seek national, all-lands solutions to wildland fire management issues. The Cohesive Strategy will address the nation's wildfire problems by focusing on three key areas: Restore and Maintain Landscapes, Fire Adapted Communities and Response to Fire.

Three primary factors have been identified as presenting the greatest challenges and the greatest opportunities for making a positive difference in addressing the wildland fire problems to achieve this vision. They are:

Restoring and maintaining resilient landscapes. The strategy must recognize the current lack of ecosystem health and variability of this issue from geographic area to geographic area. Because landscape conditions and needs vary depending on local climate and fuel conditions, among other elements, the strategy will address landscapes on a regional and sub-regional scale.

Creating fire-adapted communities. The strategy will offer options and opportunities to engage communities and work with them to become more resistant to wildfire threats.

Responding to Wildfires. This element considers the full spectrum of fire management activities and recognizes the differences in missions among local, state, tribal and Federal agencies. The strategy offers collaboratively developed methodologies to move forward.

The cohesive strategy was designed to commit to this shared national vision for present and future wildland fire and land management activities in the United States. It will build on the foundation of other efforts to establish direction for wildland fire management in America — the 1995 Federal Wildland Fire Policy and Program Review; the documents that comprised the National Fire Plan; A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment: A 10-Year Strategy; both editions of the Quadrennial Fire Review; Mutual Expectations for Preparedness and Suppression in the Interface; A Call to Action; and Wildland Fire Protection and Response in the United States, The Responsibilities, Authorities, and Roles of Federal, State, Local and Tribal Governments.

The Cohesive Strategy is being implemented in three phases, allowing stakeholders to systematically develop a dynamic approach to planning for, responding to, and recovering from wildland fire incidents. This phased approach is designed to promote dialogue between national, regional and local leadership.

Phase I involved the development of two documents: A National Cohesive Wildland Fire Management Strategy and the Federal Land Assistance, Management and Enhancement Act of 2009 Report to Congress. These documents provide the foundation of the Cohesive Strategy.

Phase II will involve utilizing the process outlined in Phase I, regions will identify values, conduct regional risk assessments and develop strategies to effectively meet local, regional and national goals.

During Phase III, the following steps will occur: Conduct the national analysis. Develop a draft national summary of the regional alternatives. The summary will include a description of the decision space available, a description of the activities and priorities associated with the regional alternatives, and a description of the tradeoffs associated among the alternatives. It will also:

- Share the results of the national results and summarization with stakeholders.
- Update and conclude the analysis based on feedback from the stakeholders.
- Establish a 5-year review cycle to provide updates to Congress.

Phase II and III have not yet occurred.

Cohesive Strategy Goals and Performance Measures

Wildfire crosses and affects all lands and resources regardless of jurisdiction and ownership. Each responding organization has a role in working together to protect lives, property and resources. Concise, mutually accepted goals and guiding principles are the foundation of a cohesive strategy. Clear accountability will ultimately promote transparency and aid oversight during the implementation phase. These overarching, broad goals and performance measures will be used as a foundation as regional tasks and actions and performance measures are developed in Phase II.

Restore and Maintain Landscapes

GOAL: Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.

Outcome-based Performance Measure:

- Risk to landscapes is diminished.

Fire-adapted Communities

GOAL: Human populations and infrastructure can withstand a wildfire without loss of life and property.

Outcome-based Performance Measures:

- Risk of wildfire impacts to communities is diminished.
- Individuals and communities accept and act upon their responsibility to prepare their properties for wildfire.
- Jurisdictions assess level of risk and establish roles and responsibilities for mitigating both the threat and the consequences of wildfire.
- Effectiveness of mitigation activities is monitored, collected and shared.

Wildfire Response

GOAL: All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

Outcome-based Performance Measures:

- Injuries and loss of life to the public and firefighters are diminished.
- Response to shared-jurisdiction wildfire is efficient and effective.
- Pre-fire multi-jurisdictional planning occurs.

Purpose and Need

Historically, fires burned on this landscape on a frequent basis (Fire Regime I; 0-35 year frequency and low (surface fires most common) to mixed severity (less than 75% of the dominant overstory vegetation replaced) and were of low to mixed severity. Frequent burning in these forests regularly consumed fuels, killed small trees, and pruned the boles of residual trees, maintained a relatively fire-resistant landscape (Agee 1993, 2002). Over time, as fires were suppressed, vegetation became more dense and surface and ladder fuels increased; the fire regime changed to one characterized by infrequent, mixed to high severity fires, with large areas of high mortality, as demonstrated by the recent Power, Rim, King, and Ferguson Fires.

To move the project area toward a frequent fire regime, a fire resilient forest requires the survival and growth of individual trees and forested stands for many years without the occurrence of stand replacing fires. Currently, trees are at high risk of fire-related mortality due to current fuel loading and ladder fuels. Reducing fuels, increasing tree vigor and retaining existing large trees would accelerate the development of key habitat and old forest characteristics and reduce the risk of loss to wildland fire (SNFPA ROD, page 49).

Tree mortality is also affected by both the intensity and size of wildfires that occur in the project area. Treatments that reduce fire intensity, torching and crown fire potential would reduce tree mortality in wildland fire conditions. The ability to utilize more aggressive suppression techniques such as direct attack, improving access, and creating a fuel break network as proposed in this project would limit the size of wildland fires in the area, further reducing tree mortality and allow trees to continue to accelerate their development of old forest conditions.

High-severity wildfire potential is the result of numerous factors present in the project area including:

- Major drainages are aligned with predominant wind direction,
- High surface fuel loading and abundant ladder fuels,
- Canopy density conducive to supporting crown fire,
- High recreation use and vehicle travel (ignition sources)

The risk to emergency responders is a product of:

- Protracted escape routes and poor road conditions,
- Inadequate safety zones and staging areas,
- Lack of vantage points, and
- Absence of recently burned, and/or treated fuel breaks.

Desired Condition

Desired fuels conditions can be achieved by:

- Creating and maintaining a fuel treatment network to reduce extent and severity of wildfires based on the below listed locations:
    - Barney Ridge/Omo Ranch Road and Roads 8N61 and 8N62
    - Goldnote Ridge/ Roads 8N55 and 8N48
    - Big Mountain Ridge/ Road 8N49
    - North-South Road

- Using these locations, create evacuation routes for public egress and emergency responder safety by thinning trees less than 30"dbh within 35' of the centerline of roads. Trees would be selectively removed that are currently impeding the ability for safe access as well as fire suppression activities. (107 acres)

- Beyond the 35' and extending out to 200' from above listed strategic locations, trees up to 18" will be thinned and surface and ladder fuels will be removed. (749 acres) Post-treatment, these stands will retain their larger trees with minimal modification to overstory canopy. Plantations contained within and adjacent to the above-described fuel break would be treated as part of the fuel break design.

- Conduct additional treatments in 200' roadside areas, including grapple or tractor piling of existing and activity fuels, prescribed fire, including both broadcast burning and lighting of piles.

- On an additional approximately 2,132 acres, low intensity prescribed fire will be implemented at any time of year when conditions allow for consumption of surface fuels and low (<15% averaged across the unit; 5-10% averaged in PACs) overstory tree mortality. Reduction or rearrangement of fuel concentrations using hand cutting, piling, chipping and/or other mechanical treatment may also occur on these acres to supplement or complement prescribed burning.

- Install hand or dozer line to limit the extent of prescribed burns

- Use hand and aerial ignition techniques for pile and understory burning
- Reduce fuels and fire hazard 300 feet from key OHV staging areas (Barney, Five Corners, Goldnote, Goldnote East, 36 Tie). Trees up to 18" will be thinned and surface and ladder fuels will be removed to increase utility of these areas for fire suppression and staging of equipment.
- Reoccurring maintenance of treatments listed above using fire, hand or mechanical methods.
- Following harvest or fuel reduction activities, the desired surface fuel loading would be less than 20 tons per acre.
- Thinning of stands near Armstrong Hill lookout tower to enable detection and management of wild and prescribed fires in the Cosumnes and North Fork Mokelumne River watersheds. Thinning will be focused on providing a clear view and will include removal of tall trees. Some trees may exceed 30" dbh. Install a fire detection camera in the existing fire detection lookout tower. Reoccurring maintenance of trees and vegetation (promoting oaks for example) to allow continued effective fire detection.

Treatments for Protection of California Spotted Owl Habitat
Fuels treatments listed in the "Fuels Reduction and Management Strategy" section (above) would occur in portions of spotted owl and goshawk PACs. These areas are designated Wildland Urban Intermix (WUI) Defense and Threat Zones. Treatments would be designed to facilitate prescribed burning, reduce stand mortality effects from both prescribed and wildland fire, and would be expected to improve efficiency of suppression of wildfires. Effective management of prescribed fire and wildfire may help reduce loss of or damage to key CSO and northern goshawk habitat. PACs were selected for treatment based on necessity to ensure the overall effectiveness of the landscape fire and fuel strategy. Design features to protect habitat and nesting status are listed below.
Fire hazard can be reduced through prescribed burning and management of the fuels available for burning. Desired fuels conditions include reduction of fuels to lower the potential for large or severe fires that can result in damage to natural resources or habitat. Forested areas would be converted from high fire hazard to low or moderate, where surface fuels are light, ladder fuels are not widespread, and canopy base height is increased. Fuel loading would be reduced in fire-prone forests to protect people and sustain resources as directed by the FLAME act and the cohesive strategy. This would result in flame lengths less than 4 feet and reduced rate of spread.

The BEHAVE Plus 5 Fire Model

This modeling program for personal computers is a collection of mathematical models that describe fire and the fire environment. It can be used for a multitude of fire management applications including projecting the behavior of an ongoing fire, planning prescribed fire, and training. Primary modeling capabilities include surface fire spread and intensity, crown fire spread and intensity, safety zone size, size of point source fire, fire containment, spotting distance, crown scorch height, tree mortality, wind adjustment factors, and probability of ignition. The user's guide describes operation of the program.

Fire behavior characteristics and hazard were derived for a sample of the proposed treatment areas by assigning nationally accepted fire fuel model groups that describe the potential fire behavior within defined weather variables and the fuel model groups were used as a measure to estimate changes in fuel profile by alternative. Fuel models are simulated fuel complex (or combination of vegetation types) for which all fuel descriptors required for the solution of a mathematical rate of spread model have been specified. These fuel models were utilized in the fire behavior modeling software package Behave +5. Given the uncertainty of any modeling exercise, the results are best used to compare the relative effects of the alternatives, rather than as an indicator of absolute effects. Interpretation, professional judgment, and local knowledge of fire behavior were used to evaluate the outputs from the models and adjustments made as necessary to refine the predictions. Modeling was done utilizing fuel models (Anderson 1982, Scott and Burgan 2005).

Information Sources

Assumptions and variables used in modeling

Weather parameters used in the models represent the 90th percentile weather conditions for the area from 1961-2018. These values were derived from Beaver Camp Remote Automated Weather Station located on the Amador Ranger District.

Fire behavior outputs generated from modeling exercises only reflect static conditions and do not take into account changing weather conditions. Any change in these factors could drastically affect fire behavior. Given the uncertainty of any modeling exercise, the results are best used to compare the relative effects of the alternatives, rather than as an indicator of absolute effects. Interpretation, professional judgment, and local knowledge of fire behavior were used to evaluate the outputs from the models and adjustments made as necessary to refine the predictions

Limitations of the Models

It should be noted a model is a simplification or approximation of reality and hence will not reflect all of reality (Stratton 2006). The use of models such as Behave Plus depends upon sample data, validity of the model itself, and assumptions made by the modeler. All three affect the results. The use of Behave plus in this analysis is to generally characterize and display existing conditions and the nature and magnitude of treatment effects to inform decisions to be made. The modeling results are not to be taken as absolute.

Fire models are tools to help depict relative change in fire behavior and growth across the landscape. Although there are limitations to fire behavior modeling, the model outputs provide useful information for planning, assessing and prioritizing fuel treatments (Stratton 2004 and Stratton 2006). Interpretation, professional judgment and local knowledge of fire behavior were used to evaluate the outputs from the models.

Spatial and Temporal Context for Effects Analysis

Potential effects to fire and fuels are analyzed across National Forest System lands proposed for treatment within the proposed treatment area. The cumulative effects area was determined to be the project analysis boundary because collective activities within this area can modify fire behavior in such a way as to affect fuel loading and fire hazard. Although the activities outside this boundary could possibly influence fire spreading into the project area, they would not likely have a substantial effect on fire behavior within the project area. Because of this, the spatial magnitude (size) of this boundary was determined adequate from a fire management perspective.

Existing conditions are those present in year 2019. Mechanical treatments are modeled to occur in 2019.

Activities and events considered in this analysis include those that occurred within the past 15 years and those that are expected to occur within the next 15 years. Most long-term studies of forest vegetation condition indicate that time periods of this length are sufficient for evaluating the effect of silvicultural treatments (Hornbeck et al. 1993). Since the treatment of the overstory has a substantial impact on fire management, this is the time frame selected for the fuels analysis.

Affected Environment

Existing Condition

Fire History and Occurrence

Both natural and human caused fires occur in the project area. The abundance of human and natural ignition sources and the elevated fuel loading in the area increase the likelihood of large wildland fire. Fire has played a significant role in the historical development of the vegetation in Sopiago Creek, Middle Fork Cosumnes River, and Scott Creek watersheds, however more recently the last large fire occurred in 1928. The dominant forest type in the project area is Sierra Nevada mixed conifer.

Aggressive fire suppression action has kept most fires in the area small. Small fire occurrences (fires less than 10 acres) in the project area are largely attributed to lightning and human causes. Without suppression these fires could have burned through large areas of the project area over days, weeks or even months until they burned into non-fuel areas or received enough precipitation to extinguish the fire.

Fire Weather

Historic weather data from local Remote Automated Weather Stations (RAWS) were obtained for fire behavior modeling. The 90th percentile weather was chosen because it is the normally accepted weather parameters used for fuels planning. Modeling at the most extreme end of atmospheric and fuel moisture conditions are not normally used for fuels planning. The 90th percentile is considered as the "average worst" conditions and therefore is used to represent conditions when fires have the potential to grow rapidly. The weather parameters used for modeling potential fire behavior and determining the associated fire hazard using weather parameters that represent the "average worst" conditions that can be expected on 90 percent of all the days that fires occur. More severe conditions would likely result in more severe fire behavior and fire effects to the site. This weather data was used to model potential fire behavior for the project area for both existing and post treatments vegetation and fuels.

Table 1. Fuel moisture values generated from Beaver Camp RAWS. Summarized using FireFamilyPlus into 90th and 97th percentile weather conditions:

90th percentile weather	
1 hour time lag	4%
10 hour time lag	5%
100 hour time lag	8%
Slope	30%
20 foot wind gusts	12 mph
Air temperature	91 degrees F
Herbaceous moisture	9%
Woody moisture	76%

97th percentile weather	
1 hour time lag	3%
10 hour time lag	5%
100 hour time lag	6%
Slope	30%
20 foot wind gusts	14 mph
Air temperature	93 degrees F
Herbaceous moisture	3%
Woody moisture	70%

Fire Behavior

Fire resilience refers to the potential effects of a fire in the project area. An important factor in reducing the adverse effects of a fire is reducing the potential fire intensity and resulting severity. Fire behavior is the manner in which a fire reacts to available fuels, weather, and topography. A change in any of these components results in a change in fire behavior (DeBano et al 1998). Fire behavior is complex, with many contributing factors in the categories of topography (slope, aspect, elevation), weather (climate, air temperature, wind, relative humidity, atmospheric stability) and fuels (size, type, moisture content, total loading, arrangement; Agee 1993). These three elements comprise the fire environment, surrounding conditions, influences, and modifying forces that determine fire behavior.

Topography and weather at a given location are beyond the ability of management to control. The fuel portion of fire behavior is the only controllable factor and is therefore the one factor that managers can use to manage fire hazard. Weather conditions such as drought, high temperature, low humidity, and high wind play a major role in the spread of wildfires and are influenced by topography and location of mountains as well as global influences. Weather conditions are a major factor in the initiation and spread of all wildfires, but Omi and Martinson (2002) found that stands with prior fuel treatments experienced lower wildfire severity than untreated stands burning under the same weather and topographic conditions. Fuel management modifies fire behavior, ameliorates fire effects, and reduces fire suppression costs and danger (DeBano et al 1998). Manipulating fuels reduces fire intensity and severity, allowing firefighters and land managers more control of wildland fires by modifying fire behavior in the fire environment (Pollet and Omi 2000).

Fuel management can include reducing the loading of available fuels, lowering fuel flammability, or isolating or breaking up large continuous bodies of fuels (DeBano et al 1998). Fuels contribute to the rate of spread of a fire, intensity/flame length, fire residence time, and the size of the burned area (Rothermel 1983, Agee et al. 2000).

Flame length has significance for suppression strategy and tactics, and is a good visual indicator of fireline intensity at the head of the fire (DeBano et al. 1998). There are several ways of expressing fireline intensity. A visual indicator of fireline intensity is flame length (Rothermel 1983). Table compares fireline intensity, flame length, and fire suppression difficulty interpretations.

Fire type classifications (surface fire, passive crown fire, and active crown fire) are also widely used to determine general strategies and tactics to maximize the safety of both fire fighters and the public. In generally flame lengths of less than 4 feet are often considered a benchmark for effective fire control operations because they can be attacked directly by hand crews (Rothermel 1983). Low intensity fires (<4-foot flame lengths) do not normally burn through the canopy or result in severe fire effects.

Table 2. Fireline intensity interpretations. Table based on Rothermel (1983)

Fireline Intensity	Flame Length	Interpretations
Low	< 4 feet	Direct attack at the head and flanks with hand crews; handlines should stop spread of fire
Moderate	4-8 feet	Fires are too intense for direct attack on the head by persons using handtools. Handline cannot be relied on to stop fire spread. Equipment such as dozers, engines, and retardant aircraft can be effective.
High	8-11 feet	Fires may present serious control problems-torching, crowning, and spotting. Control efforts at the fire head likely ineffective. This fire would require indirect attack methods
Very High	> 11 feet	Crowning, spotting, and major fire runs are probable; control efforts at the head are likely ineffective. This fire would require indirect attack methods

Higher intensity fires have greater potential to kill existing trees by scorching or burning into the tree crowns. Crown fires can be either passive (commonly called torching) or active. Both types can contribute significantly to spotting which increases spread rates and makes control efforts more difficult. During the 2004 Power fire on the Amador Ranger District, spotting was a significant factor in fire spread and containment difficulties, with spotting observed up to 1 mile from the main fire. Crown fires normally are highly destructive, difficult to control, and present the greatest safety hazard to firefighters and the public. Crown fires burn hotter and result in more severe effects than surface fires. Crown fires generally spread at least two to four times faster than surface fires (Rothermel 1983), and occurred on many recent, local large fires. Fires that spread quickly and at higher intensities can pose a greater risk to firefighters, the public, and ecosystems when they occur. Agee (1996) states that crown fire potential can be managed through prevention of the conditions that initiate crown fires and allow crown fires to spread. Three main factors contributing to crown fire behavior can be addressed through fuels management: initial surface fire behavior, canopy base height, and canopy bulk density. Omi and Martinson (2002) note that that their study of fuel treatments provides strong evidence of fuel treatment efficacy, and that their results "appear quite similar to those provided by previous authors".

There is a large body of literature that makes the case for treating the various strata (surface, ladder, and canopy) of fuels. According to Graham et al (2004) "Qualitative observations, limited empirical data, and modeling provide the scientific basis for identifying how forest structure can be modified to reduce fire hazard and modify fire behavior. Additionally, research shows that when activities reduce surface fuels (low vegetation, woody fuel, shrub layer), those activities decrease the chances that surface fires will be able to ignite ladder fuels and canopy fuels (Pollet and Omi 2002). The most effective strategy for reducing crown fire occurrence and severity is to (1) reduce surface fuels, (2) increase height to live crown, (3) reduce canopy bulk density, and (4) reduce continuity of the forest canopy (Van Wagner 1977, Agee 1996, Graham et. al 1999, Scott and Reinhardt 2001, Cruz et. al. 2002)."

Surface Fuels

Fire behavior is described by flame length, rate of spread, and fireline intensity (Rothermel 1983; Scott and Burgan 2005). Surface fuels are an important factor in determining how fast a surface fire will spread and how hot it will burn. Surface fuels consist of needles, leaves, grass, forbs, branches, logs, stumps, shrubs, and small trees. Surface fire factors are also important to the initiation and spread of crown fires.

Anderson (1982) identifies surface fuels that are up to 3 inches in diameter as those that are used in the Fire Behavior Model. Surface fuels greater than 3 inches contribute towards intensity, resistance to control and spotting but are not part of the fire behavior model. Fuel models as defined by Anderson (1982) were used to model general changes in fuel profiles by vegetative cover type. Fuel models were chosen after site visits in order to most accurately represent fuels for the project area.

Canopy Fuels

Crown fire and crown fire initiation is related to several conditions that must be met. First the intensity (flame length) of the surface fire must be high, the foliar moisture content of the live vegetation must be low, crown base heights must be low enough to interact with the surface fire and for active fire spread, and the crown bulk density must be high enough to sustain the fire once it gets into the crowns. Canopy base height (CBH) is the lowest height above the ground at which there is a sufficient amount of canopy fuel to propagate fire vertically into the canopy (Scott and Reinhardt 2001). CBH incorporates ladder fuels such as shrubs, brush and understory trees as well as the lower branches of mature trees. The lower the canopy base height, the easier it is for a given surface fire to initiate a crown fire. Low canopy base heights provide the "ladder" which allows a surface fire to become a crown fire.

In order for a crown fire to initiate, a surface fire must be intense enough, with long enough flame lengths, to ignite the lowest level of branches that will propagate fire to the upper levels of the canopy. When the height from the surface fuels to the bottom of the tree crown is low, for example only 5 feet, a relatively short flame length will ignite the crown. A greater height from the ground would require a larger flame length to ignite. At the same time, higher surface flame lengths will catch canopy fuels on fire even when they are higher up above the ground.

Once a fire begins burning in the crowns of the trees, whether that crown fire ignition is sustained or not is determined by surface fire rate of spread, and crown bulk density (Alexander 1988, Van Wagner 1977). Wind and slope are important factors in potential crown fire spread (Rothermel 1991), and species composition and structure determine crown bulk density.

In general, treated fuels result in less intense surface fires. Lower surface fire intensity means that fires are less likely to scorch or burn the canopy, resulting in decreased mortality to desired tree species. Given the anticipated weather conditions, the fuel model and the associated flame length for the areas proposed for treatment can be used to compare the likelihood that the treatments would result in areas that are more resistant and resilient to fires.

Managing Risk to Wildland-Urban Interface (WUI)

This Project area is almost entirely classified as Wildland Urban Interface Threat or Defense Zone. The wildland-urban interface refers to areas where wildland vegetation meets urban developments, or where forest fuels meet urban fuels such as houses or other man-made structures. Research by (Cohen and Butler 1998) has shown that structures with typical ignition characteristics (wood sided, wood framed, asphalt composition roof) are at risk of catching on fire from one of three sources. The first method is direct flame contact to the structure. Another method is aerial transport of burning materials to a structure from vegetation or other burning sources. The third is exposure to intense flames from a nearby source, which could be intensely burning vegetation or another structure. His research shows that the structures may be at risk if the flame front is less than approximately 100 feet away. Structures may also be ignited from less intense sources against or close to the side of the structure. This can occur if firewood or other flammable material next to the structure is ignited by a ground fire or firebrands. In addition, firebrands falling directly on roofs can ignite the structure if the roof is flammable, or if flammable debris is present.

There is some scientific controversy on treating forest fuels at distances more than 100 feet away from the structure itself, ongoing research by Cohen (2008) advocates that the home ignition zone primarily falls within private ownership, and therefore the responsibility for preventing home ignitions largely falls within the authority of the property owner. However he also states that during WUI disasters wildland fires are burning under conditions that are difficult to control. “The combination of vegetation, weather conditions, and topography produces fast-spreading, intensely burning fire behavior that overwhelms suppression efforts. If the extreme wildfire spreads close enough to residential development with its flames and firebrands (lofted burning embers), hundreds of ignitable homes can be simultaneously exposed. Although protection may be effective for some homes, an extreme wildfire’s high intensities and high rate of area growth (rapid spread and spot ignitions) ignites too many houses and threatens firefighters’ safety, preventing them from protecting all structures. With homeowners likely evacuated and firefighters unable to protect every house, initially small, easy-to-extinguish ignitions can result in total home destruction.”

Existing Fuels Conditions

Field reconnaissance of the proposed treatment areas found high-severity wildfire potential existed and is the result of numerous factors including:

- Major drainages are aligned with predominant wind direction,
- High surface fuel loading and abundant ladder fuels,
- Canopy density conducive to supporting crown fire,
- High recreation use and vehicle travel (ignition sources)

Significant hazard to emergency responders is a product of:

- Protracted escape routes and poor road conditions,
- Inadequate safety zones and staging areas,
- Lack of vantage points, and
- Absence of recently burned areas, and/or treated fuel breaks.

Computer modeling, expert opinion, and recent nearby wildfires suggest future wildfires' rate of spread and fire intensity ranges from moderate to very high, with very high mortality to existing trees and potential loss of habitat.

Most of the stands proposed for treatment in this project can be grouped into two categories, as stands that have been treated in the last 15 to 20 years and untreated stands. In general, the stands that received thinning and/or prescribed burning in the last 15 years (initially post-treatment these stands resembled an fuel model 9, but they currently possess elevated dead fuel loadings and significant amounts of brush/undergrowth, more closely resemble a blend of fuel model 9 and 10). In untreated stands, fuel model 10 is currently the most representative (Anderson 1982).

Environmental Consequences

Post Treatment Fire Behavior and Fuel Models

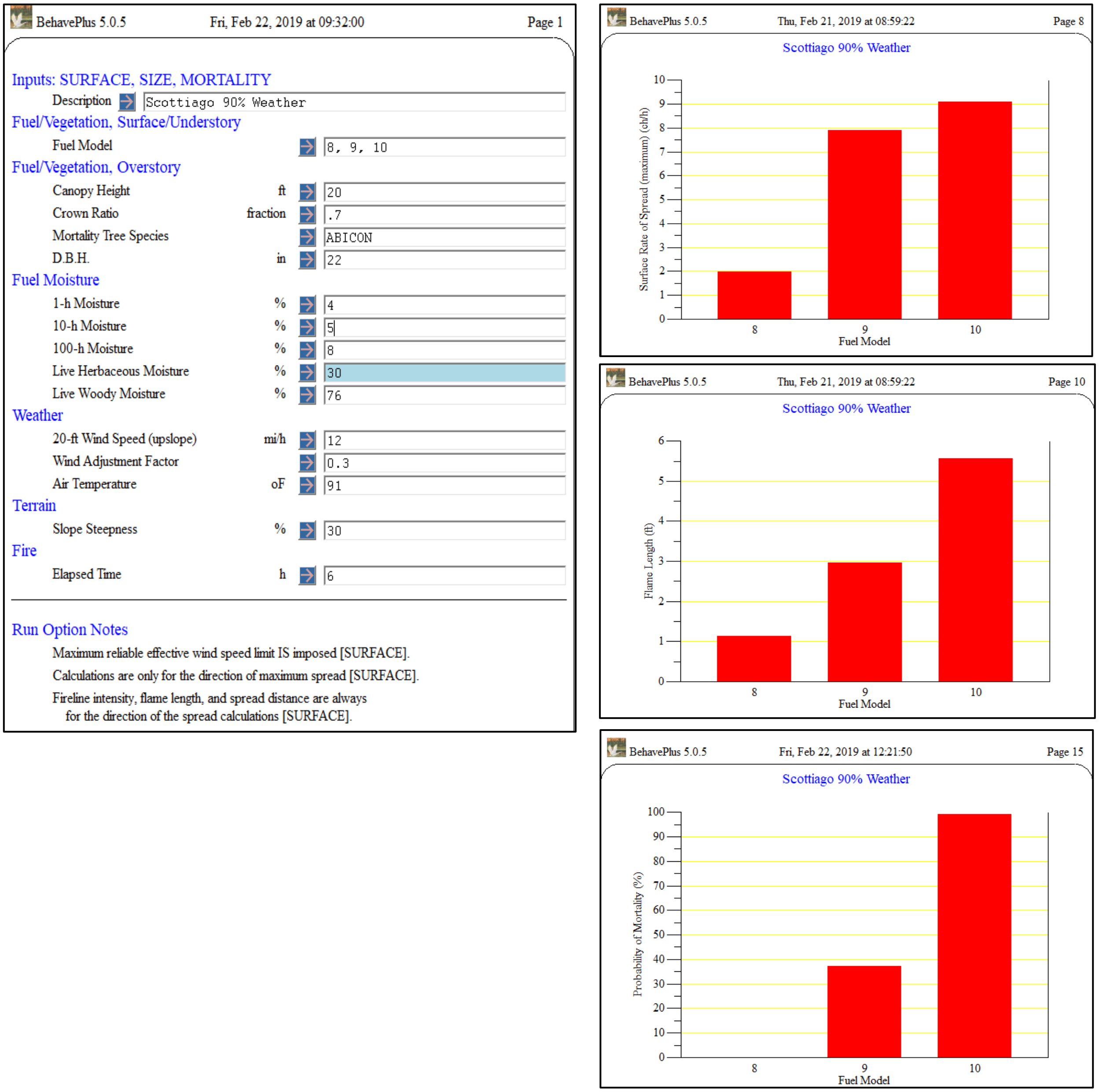
In proposed treatment areas the predicted fuel model and associated flame length, spread rate and likely fire size and tree mortality would drop substantially. This is due mostly to the reduction in surface fuels and the creation of a roadside fuel break network. Reduction of surface and ladder fuels as well as thinning of tree canopy near key roads would also reduce the spotting potential that can lead to significant fire control issues separate from the anticipated surface fire spread rates. Projected fuel models are based upon input from local fire and vegetation manager's experience as well as fuel model selection guides and the current condition is best described by Fuel Model 10. The desired post treatment representative fuel model is an 8 or 9 achieved through maintenance burning and/or mechanical fuel reduction.

Table 3. Modeled and predicted Fire Behavior by Anderson (1982) under moderate conditions: "The fire intensities and spread rates of these timber litter fuel models are indicated by the following values when the dead fuel moisture content is 8 percent, live fuel moisture is 100 percent, and the effective windspeed at midflame height is 5 mi/h (8 km/h)":

Model	Rate of spread *Chains/hour*	Flame length *Feet*
8	1.6	1.0
9	7.5	2.6
10	7.9	4.8

As shown in Table 3, altering fuels from a fuel model 10 to a fuel model 8 reduces the flame length from 4.8 feet to 1.0 feet, and slows the rate of spread from 7.9 chains per hour to 1.6 chains per hour.

Figure 1. Fire behavior modeling inputs and outputs



The effect of the treatment areas would be to reduce the potential for fires to escape initial attack, and would give firefighters areas of lower hazard from which to attack a larger fire. These treatments enable prescribed burning which will further improve fire management options. The projected flame length for treated areas would be moderate, allowing crews to be much more aggressive in their tactics to suppress them. The lighter fuels would improve crews' ability to burn out and improve production rates prepping fire control lines as well as reduce fireline intensity near the Wildland Urban Interface.

Cumulative Effects

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

Existing conditions, which serve as a proxy for the effects of past actions, are discussed above in the Existing Condition section. Aggregate effects of past projects are outlined for the Silviculture report. In general, past treatments probably increased suppression ability and reduced fire hazard in residual stands (by reducing density and fuels) and led to some regeneration, depending on the treatment and intensity of that treatment. Within the analysis area, past treatments play a role in shaping the existing vegetation condition and influencing proposed treatments especially where timber harvest and/or prescribed burning has occurred in the last 15 years. Cumulative effects of past, present, and reasonably foreseeable future actions are minor with respect to forest vegetation and fuels within the Project area.

Summary

The proposed treatments in Scottiago Wildfire Resilience Project, and the Scottiago Forest Health Project complies with the Forest Plan and other relevant laws, regulations, policies, and plans. No adverse significant impacts would occur under this plan with respect to fire management. The project would increase the fire resiliency of the forest stands, reduce hazards for both the public and firefighters in the event of a wildfire, and improve fire suppression capabilities while reducing wildfire related costs.

Literature Cited

Agee, J.K. 1993. Fire ecology of Pacific Northwest Forests. Island Press, Wash. DC.

Agee, James K. 1996. The influence of forest structure on fire behavior. In: Proceedings, 17th Annual Forest Vegetation Management Conference, Redding, CA. January 16-18, 1996: 52-68.

Agee, J.K., Bahro, B., Finney, M.A., Omi, P.N., Sapsis, D.B., van Wagtendonk, J.W., Skinner, C.N., Weatherspoon, C.P., 2000. The use of shaded fuelbreaks in landscape fire management.Forest Ecol. Manage. 127, 55–66.

Agee, J.K. 2002. The fallacy of passive management. Conservation Biology in Practice 3(1):18-25 Agee, J. K., Wright, C.S., Williamson,N., and Huff, M.H. 2002. Foliar moisture content of Pacific Northwest vegetation and its relation to wildland fire behavior. For. Ecol. Mgt. 167:57-66.

Alexander, M. E. 1988. Help with making Crown Fire hazard assessments. Paper presented at the Symposium Workshop on Protecting People and Home from Wildfire on the Interior West, Missoula, MT.

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. Gen Tech. Rep. INT-122, USDA, FS, Intermountain Forest and Range Experiment Station. Ogden, UT. A publication of the National Wildfire Coordinating Group., 22 pp.

Cohen, Jack D.; Butler, Bret W. 1998. Modeling potential ignitions from flame radiation exposure with implications for wildland/urban interface fire management. In: proceedings of the 13th conference on fire and forest meteorology, vol. 1; 1996 October 27–31; Lorne, Victoria, Australia. Fairfield, WA: International Association of Wildland Fire: 81-86.

Cohen, Jack. 2008. The wildland-urban interface fire problem: A consequence of the fire exclusion paradigm. Forest History Today. Fall: 20-26.

Cruz, M.G.; Alexander, M.E.; Wakimoto, R.H. 2002. Predicting crown fire behavior to support forest fire management. Pages 1-11 in D.X. Viegas, editor. Forest Fire Research & Wildland Fire Safety, Proceedings: IV International Conference on Forest Fire Research/2002 Wildland Fire Safety Summit. November 18-23, 2002, Luso-Coimbra, Portugal. Millpress Science Publications, Rotterdam, Netherlands. 11 p.

Debano, L.F., D.G. Neary, and P. F. Folliott. 1998. Fire's effects on ecosystems. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012. p 331

Fites-Kaufman, J.A. 1997. "Historic landscape pattern and process: fire, vegetation and environment interactions in the northern Sierra Nevada." Ph.D. dissertation. Univ. Washington, Seattle, WA.

Graham, R.T., Harvey A.E., Jain, T.B., and Tonn, J.R. 1999. The effects of thinning and similar stands treatments on fire behavior in western forests. USDA Forest Service Pacific Northwest Research Station General Technical Report PNW-GTR-463: Portland, OR.

Graham, R.T.; McCaffrey, Sarah; Jain, Theresa B. (tech. eds.) 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Hornbeck, J.W., M.B. Adams, E.S. Corbett, E.S. Verry, and J.A. Lynch. 1993. Long-term impacts of forest treatments on water yield: a summary for northeastern USA. Journal of Hydrology150:323–344.

Omi, Philip N. and Erik J. Martinson. 2002. Effects of Fuel Treatment on Wildfire Severity, Final Report; Joint Fire Science Program, Western Forest Fire Research Center, Colorado State University, Ft. Collins, CO.

Pollet and Omi 2000. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. International Journal of Wildland Fire, 2002, 11,1-10

Rothermel, Richard C. 1983. How to predict the spread and intensity of forest and range fires. Gen. Tech. Rep. INT-143. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 161 p.

Rothermel, Richard C Predicting behavior and size of crown fires in the northern Rocky Mountains. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station; 1991; Res. Pap. INT-438. 46.

Scott, Joe H.; Reinhardt, Elizabeth D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Research Paper RMRS-RP-29. Fort Collins, CO: U.S.

Scott, Joe H. and Robert E. Burgan. 2005. Standard fire behavior fuel models: A comprehensive set for use with Rothermel's surface fire spread model. USDA Rocky Mountain Research Station RMRS-GTR-153. Available at: http://www.fs.fed.us/rm/publications/online/rmrs_gtr.html

Skinner, C.N. and C.R Chang. 1996. *Fire Regimes, Past and Present. Sierra Nevada Ecosystem Project*: Final report to Congress, vol. II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources.

Stratton, Richard D. 2004. Assessing the Effectiveness of Landscape Fuel Treatments on Fire Growth and Behavior. Journal of Forestry. October/November 2004

Stratton, Richard D. 2006. Guidance on spatial wildland fire analysis: models, tools, and techniques. Gen.Tech. Rep. RMRS-GTR-183. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

USDA Forest Service. 2004. Sierra Nevada Forest Plan Amendment Final Supplemental Environmental Impact Statement, Record of Decision. USDA Forest Service, Pacific Southwest Region. Vallejo, California.

USDI and USDA. 2000. Managing the Impacts of Wildland Fires on Communities and the Environment - A Report to the President (National Fire Plan)

USDI and USDA 2001. A Collaborative Approach for Reducing Wildland Fire Risk to Communities and the Environment 10 Year Comprehensive Strategy.

USDI and USDA 2002. A Collaborative Approach for Reducing Wildland Fire Risk to Communities and the Environment: 10-Year Comprehensive Strategy: Implementation Plan Available at:

USDI et al. (USDI/ USDA/ DOE/ DOF/DOC/EPA/FEMA/NAOSF). 1995. Federal Wildland Fire Policy. and for 2001 updates.

USDI and USDA. 2008. Interagency Fire Regime Condition Class Guidebook. Version 1.3.0

Van Wagner 1977. Conditions for the start and spread of crown fire. Can. J. For. Res. 7: 23-34.