Plumas-Lassen Administrative Study: Fuels and Fire at the Landscape Scale

Annual Report for 2008

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Project Background:

Past management activities including fire suppression, timber harvesting, and livestock grazing have changed the structure and composition of many coniferous forests in the Sierra Nevada, particularly those that once experienced frequent, low-moderate intensity fires (Parsons and Debenedetti 1979; SNEP 1996; van Wagtendonk 1996, Stephens 1998, Stephens and Moghaddas 2005a:b, Stephens et al. 2009). These changes in vegetation have altered habitat for a variety of species. Correspondingly, changes in vegetation and fuel loads have increased the probability of high severity fire (Miller et al. 2009).

The USDA Forest Service is currently actively managing vegetation with the goal of reducing the probability of large, intense, or severe fires while minimizing negative effects on wildlife habitat and ecosystem stability. Proposed treatments in portions of the Plumas and Lassen National Forests include group selections and defensible fuel profile zones (DFPZs). Group selection treatments involve the harvest of all trees smaller than 30" diameter at breast height (DBH) over a one to two acre area (Stine et al. 2002). DFPZs are areas with extensive forest thinning and activity fuel treatment intended to reduce surface and canopy fuel loads. They are also known as shaded fuel breaks and are designed to allow access for active fire suppression and burn-out operations. DFPZs are spatially-extensive, covering hundreds to thousands of acres (Stine et al. 2002).

Currently, there is limited information on the effects of landscape fuels treatments on reducing severe fire behavior and effects, especially at the landscape scale (Agee et al. 2000; Fites-Kaufman et al. 2001, Finney et al. 2007). Elsewhere in the Sierra Nevada, group selections have been shown to have little effect on the landscape-level behavior of fire (Stephens 1998); the proposed group selections in the Plumas, however, retain more large trees per acre than typical group selections. To date, the modeled effects of group selections with large tree retention have not been published for this forest type.

Assessing the effects of these vegetation management strategies—group selections and DFPZs—across the forested ecosystems of the Plumas and Lassen National Forests is the goal of the Plumas-Lassen Administrative Study (Stine et al. 2002). The study is composed of five research teams with distinct focuses: California spotted owls, small mammals, songbirds, fuels and fire, and vegetation. Due to practical considerations of a study as spatially extensive as this, we have to mix research with monitoring. The overall study does not comprise a formal scientific experiment in that the scientists involved had no control over actual treatments. The study amounts to far more than monitoring, however, in that we are independently assessing a large landscape and modeling changes to that landscape given a set of prescriptive treatments.

For the Fuels and Fire Module we investigated the landscape-scale effects of the proposed forest treatments by answering a suite of questions: First, what are current conditions, in terms of fuel loads and vegetation, measured directly in the field? Second, what is the current potential fire behavior and effects given these measured fuel and vegetation conditions? Third, how would landscape fuels treatments affect vegetation condition and fire behavior and effects?

The current work is focused on the mixed conifer forests in the Spanish Creek (Meadow Valley and surrounding areas) watershed in the Plumas National Forest. This area has received actual DFPZ's and group selection openings whereas other areas in the Plumas and Lassen National Forests are still in the planning phase of project implementation. The Meadow Valley area has real DFPZ's installed, other areas are still in the planning phase and DFPZ's are normally outlined on maps as continuous lines versus separate units that were actually treated.

Study Area:

Our study area is a subset of the Plumas National Forest in Northern California, USA. The original research plan was to focus on the forests in the study area's treatment units (TU) 2, 3 and 4 (Stine et al. 2002), which present widely varying topographical conditions and contain a variety of owl habitat quality. The total area of these three TUs is about 60,000 ha (150,000 ac) (Keane 2004). Vegetation varies widely through this region, presenting a good opportunity to examine fire behavior and end effects across a spectrum of conditions. As written previously, we have now focused our work on the only region to actually receive the prescribed treatments which is largely the area covered by TU 4. The town of Quincy lies directly eastward of Meadow Valley Research Area (core area encompasses approximately 46,000 acres, buffer around this area of 18,600 acres).

Vegetative cover in this area is primarily mixed conifer forest. The mixed conifer forest community comprises a mix of three to six conifers and several hardwoods (Barbour and Major 1995; Holland and Keil 1995; Sawyer and Keeler-Wolf 1995). Common conifers include ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi*), sugar pine (*P. lambertiana*), incense-cedar (*Calocedrus decurrens*), Douglas-fir (*Pseudotsuga menziesii)* and white fir (*Abies concolor*). Red fir (*Abies magnifica*) is common at higher elevations where it mixes with white fir (Holland and Keil 1995; Sawyer and Keeler-Wolf 1995). At mid to lower elevations, common hardwoods include California black oak (*Quercus kelloggii*) and canyon live oak (*Q. chrysolepis*) (Rundel et al. 1995).

In addition, a number of species are found occasionally in or on the edge of the mixed conifer forest: western white pine (*P. monticola*) at higher elevations, lodgepole pine (*P. contorta*) in cold air pockets and riparian zones, western juniper (*Juniperus occidentalis*) on dry sites, California hazelnut (*Corylus cornuta*), dogwood (*Cornus spp.*) and willow (*Salix spp.*) in moister sites, California bay (*Umbellularia californica*) and California nutmeg (*Torreya californica*) in lower, drier areas (Griffen and Critchfield 1976; Holland and Keil 1995; Rundel et al. 1995).

A variety of vegetation types currently comprise the matrix of covers in which the mixed conifer forest is arrayed. Vegetation in the matrix ranges from chaparral on exposed, shallow soils on south and west facing slopes to oak woodlands and riparian meadows. At higher elevations, particularly toward the Bucks Lake Wilderness, red fir may be found in pure stands.

Methods:

Plot Layout and Design

Data on forest cover and fuels has been collected in 0.05ha (0.125 ac) plots 12.6m (41.3 ft) in radius. Plot locations were established using a stratified-random approach. Strata of elevation, aspect and vegetation type were defined using the layers previously supplied by the contractor VESTRA (Stine et al. 2002). This process identified over 700 plot locations in TU's 2, 3 and 4. In addition to the randomly-stratified plot locations described above, similar data was collected at locations identified by the other modules: plots are located at each owl nesting site and mammal study grid in the three treatment units. There is a total of 615 inventory plots in TU's 2, 3, and 4 and 255 of these plots are in the Meadow Valley Research Area.

We collect data on tree species, diameter at breast height (DBH), categorical estimate of height, and height to lower crown. Site data collected include location (using high-precision GPS), slope, and aspect. Canopy cover is assessed at 24 points (every 1 meter) along two linear fuels transects using a site tube.

Surface and ground fuels were sampled in each plot using the line intercept method (Brown 1974; Brown et al. 1982). Ground and surface fuels were sampled along two transects radiating from plot center. The first transect is located along a random azimuth and the second falls 90 degrees clockwise from it. We sampled 1 and 10 hour fuels from 10-12 meters along each transect, 100 hour fuels from 9-12 meters, and 1000 hour fuels data from 1-12 meters. Duff and litter depth (cm) were measured at 5 and 8 meters along each transect. Maximum litter height is additionally sampled at three locations from 7 to 8m (Brown 1974; Brown et al. 1982). Total fuel loads were estimated using equations derived for Sierra Nevada tree species (van Wagtendonk et al. 1996, 1998). Ladder fuels in all plots were assessed using a standard approach (Menning and Stephens 2007).

Remote Sensing

High resolution IKONOS imagery covering part of the study area was acquired from Space Imaging in 2003 and another, overlapping section, in 2004. This high spatial resolution imagery was used to provide information on continuous forest pattern, structure, cover and variability using methods developed by Menning (2003). Both acquisitions had identical prescriptions: 1 m panchromatic and 4 m multispectral imagery collected with an upgraded and narrowed field of view (72-90 degrees from azimuth). Delivered products were not radiometrically or geometrically corrected but were sent in a GeoOrtho kit. We completed radiometric corrections in our lab to minimize backscatter and distortion due to atmospheric moisture and haze. We used PCI Geomatica 9.1's EASI modeler module to apply sun angle corrections. Dark target haze removal corrections were completed using lakes in the scenes as targets. These radiometrically-corrected images were spatially corrected—orthorectified—using Geomatica 9.1's Orthoengine module. To support this effort, ground control points (GCPs) had been collected in the field using a Trimble GeoXT Global Positioning System (GPS) with hurricane antenna with sub meter accuracy using wide-angle area support (WAAS). After the orthorectification was completed we evaluated the results using twelve independent ground reference points. The analysis indicated the five scenes of the imagery were accurate within 2.0, 2.6, 2.8, 3.4 and 3.6 m with an overall average of 2.9 m. Each of these measures is within a single 4 m pixel of the multispectral imagery and so the resulting orthorectification was deemed precise and consistent enough to use.

Fuel characteristics were mapped from the IKONOS mosaic using supervised classification cross referenced with pre-treatment data from our PLAS vegetation data plots and HFQLG pre-treatment monitoring data. Five layers were created as inputs to

FLAMMAP and FARSITE: vegetation and fuel type, canopy cover, crown base height, crown height, and crown bulk density (Finney 1998; 1999). We mapped vegetation and fuel types applying fuel types described by Burgan and Scott (2005). The national Landfire project uses these fuel types and we were able to apply a reduced set drawing on extensive inventory plots and field time in the area.

Supervised classification of vegetation and fuel models was completed in Erdas Imagine 9.0. Training sites for were chosen using the high resolution panchromatic imagery as well as the multispectral IKONOS mosaic. Between five and ten training sites were chosen for each class with emphasis on minimal intermixing of other vegetation types in the training sample. Four additional data layers were created for input into FLAMMAP and FARSITE (Finney 2006). Canopy cover was linked to the vegetation and fuel type (Table 1). To create a more realistic setof continuous values for the canopy cover, we smoothed the canopy cover values (7x7 pixel FAV filter, PCI Geomatica). The resulting canopy cover across the landscape ranges from zero, where no trees are classified, to 90% for pure, almost completely overlapping stands that occasionally occurred on northern aspects. As a result of the smoothing, however, patches of forest usually average a more realistic and variable 30-80% canopy cover, depending on tree density. Predictably, the densest stands grow on northern aspects and this is where the canopy cover is highest. Canopy height and crown base height were assigned as set values for each vegetation and fuel class (Table 1).

As we were unable to differentiate different species of conifers, we assigned a standard bulk density for each class and made it respond to the canopy cover. Thus, where canopy cover is high, bulk density is assumed to be high (up to 0.25 kg/m^3) and where canopy cover is low, so is bulk density. To create the post-treatment landscape files we altered a copy of the original vegetation by changing the vegetation and fuel in areas where DFPZs and group selection units were created.

Post treatment DFPZ treatments and locations are based on refined maps provided by the Plumas National Forest (in 2009). These maps reflect changes to the proposed DFPZ treatments in Meadow Valley. Specifically, these maps show which treatments were implemented after areas were "dropped" for access issues. As post treatment vegetation data was not collected within DFPZ units under the PLAS project, post treatment conditions were defined using HFQLG post treatment monitoring data. This data was used to define a range of scenarios that reflect post treatment stand conditions in the DFPZ treatment areas. This range of scenarios was randomly applied to DFPZ treatments across the landscape. Within group selection units, previously published young plantation vegetation characteristics (Stephens and Moghaddas 2005b) were used to populate the post treatment FLAMMAP layers.

To verify accuracy of the pre and post treatment FLAMMAP layers, fires were modeled and compared to actual fire data from the 2008 Rich Complex (Figure 1). Crown fire potential generally cross referenced well with actual fire severity maps provided by Jay Miller (unpublished, 2009). If the vegetation and fuel value was originally grassland or woodland, we left the value the same. Thus, we did not “create” a coniferous forest where none was previously; these areas retained their non-forest characteristics.

Weather data were drawn from the remote access weather station (RAWS) in Quincy and Cashman, CA., from a recent ten year period and processed in Fire Family

Plus (Main et al.1990). We chose this ten-year period rather than a longer duration as we wanted to simulate conditions given the likely continuing warming and drying this region has experienced in the last decade. Data were collected for 2 weather scenarios—severe and extreme.

Topographic variables—slope, elevation and aspect—are mapped across the study area using pre-existing Digital Elevation Models (DEM) on a 10x10m grid. Fire modeling was conducted in two major phases: first, we evaluated fire behavior and potential using current condition and post-treatment conditions.

Simulations: Potential fire behavior

Potential fire behavior is being estimated using a similar technique developed by Stephens (1998) but at much broader spatial scales. The effectiveness of the different treatments was assessed with computer model FlamMap (Finney 2006) and FARSITE (1998). Weather scenarios use data from 90th (severe) and 97th (extreme) percentile conditions collected from local weather stations. Outputs from the fire simulation include GIS files of fire line intensity (kW/m), heat per unit area (kW/square meter), rate of spread (m/s)**,** area burned (ha), and if spotting and crowning occurred. This information will be used to compare the effects of the different landscape level restoration treatments on altering fire behavior (including no treatment).

A critical response variable focuses on escapements of fire across the landscape during a longer time period. We will report the flame characteristics near DFPZ's as a proxy for fire suppression effectiveness. This will be defined at 90th and 97.5th percentile fire conditions. This will be an important measure of the effectiveness of the DFPZs at reducing the chance of fire spreading across the landscape.

Surface and canopy fires are dramatically different in behavior, severity, intensity and likelihood to spread across a forested landscape. Surface fires are often beneficial, reducing fuel from the ground and surface, and reducing competition for small trees. Another response variable, therefore, is a ratio of the area of canopy fire to total fire extent.

FARSITE will be used to model fire spread and behavior under 90th and 97.5th percentile weather conditions. Problem winds based on the analysis of historic wind records are from the southwest. The effectiveness of the DFPZ network and group selection units will be assessed using fire size, flame lengths, and the number of spot fires. Conditional burn probability maps will also be created using FLAMMAP for the pre and post treatment Meadow Valley landscape.

The general approach is to determine pre and post treatment crown fire potential and average flame lengths across the study area (Figures 2 and 3). These values will be analyzed across the different land allocations within the study area to determine fire risk by land use allocation. Specifically, modeled flame length and crown fire potential values will compared between Protected Activity Centers ("PAC'S"), Riparian Habitat Conservation areas ("RHCA'S), Off base and Deferred areas (OBD), Defensible Fuel Profile Zones ("DFPZ's"), and Group Selection ("GS") land allocations.

Complete project outputs will be done by the in early April and a journal publication will be produced and submitted after the public meeting. During the presentation in early April a summary of the fire behavior effects of the DFPZ and group selections will be provided.

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Table 1: Values used in development of fuel and canopy layers needed to model fire in FARSITE and FLAMMAP.

#	*Burgan & Scott Fuel Model*	*Description*	*Occurrence in study area*	*Initial Canopy Cover (%)*	*Canopy Bulk Density (kg/m3)*	*Canopy Height (m)*	*Canopy Base Height (m)*
98	NB8	Water	• Major water bodies	0	0	0	0
99	NB9	Bare ground	• Bare ground, talus, roads, urban areas	0	0	0	0
102	GR2	Grass – Low load dry grass	• Extensive grasslands in American & Indian Valleys	0	0	0	0
144	SH4	Low load shrub	• South facing slopes • Recovering timber harvest areas	0	0	0	0
147	SH7	Shrub – chaparral	• Chaparral type, dense, south and west aspects	0	0	0	0
145	SH5	Shrub with low forest cover	• South aspects only • Forest present but canopy cover low	0.25	tracks canopy coverage from 00.25	24	0.6
188	TL8	Moderate load needle litter	• Red fir, and higher white fir areas	0.9	tracks canopy cover 0-0.25	28	1.8
189	TL9	Hardwood with fuel understory	• Aspen stands Oak • stands in riparian areas	0.75	tracks canopy cover 0-0.25	14	2.2
163	TU3	Moderate fuel load timber-shrub	• Extensive	0.9	tracks canopy cover 0-0.25	21	1.2
165	TU5	High fuel load timber-shrub	• Northern aspects only	0.9	tracks canopy cover 0-0.25	31	1.2

Figure 1. Canopy cover change resulting from the 2008 Rich fire, derived from an initial assessment of burn severity using Landsat TM imagery (severity estimates here may be 10-20% higher than actual; a one-year post fire image will be collected and processed later to more accurately estimate wildfire severity). The Rich fire occurred just north of the Meadow Valley study area and was largely within the greater PLAS study area. As a result, we were able to simulate the Rich fire to test fuel and canopy layers we develop in order to run FARSITE and FLAMMAP. We adjusted fuel and canopy layers such that our simulations yielded fire types reasonably consistent with the observed canopy cover change.

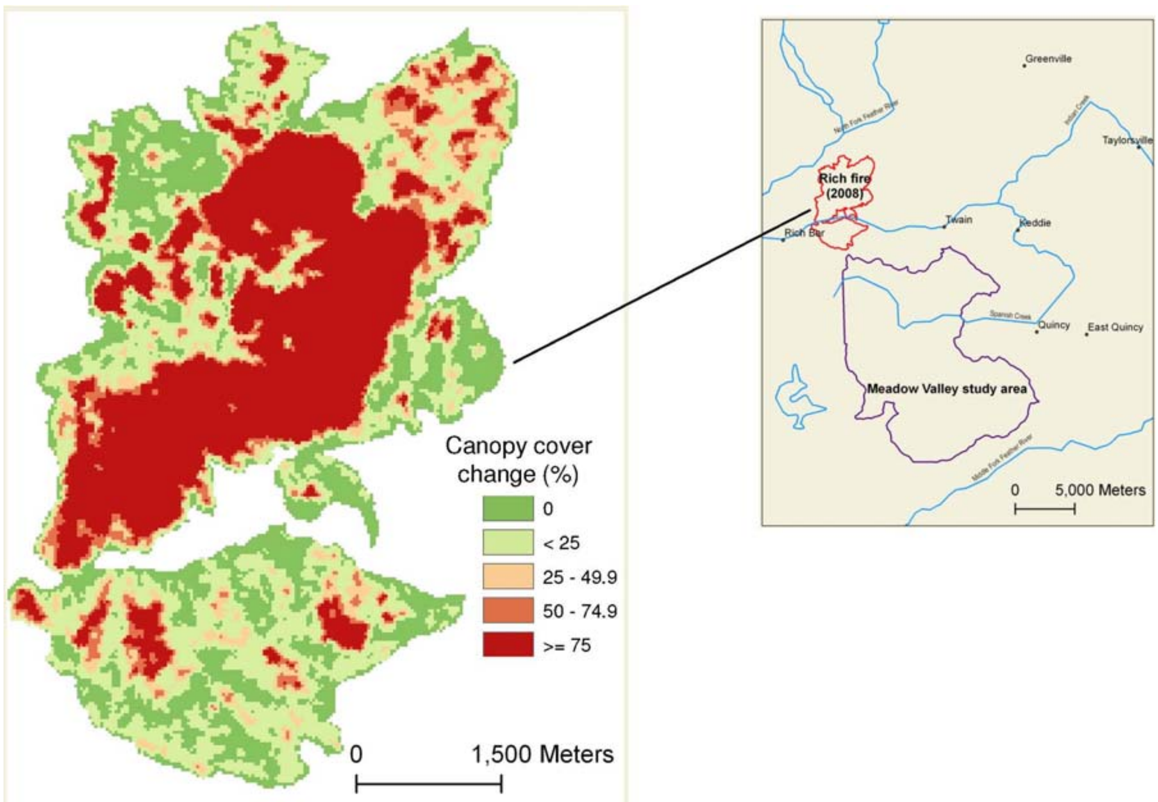

Figure 2. Modeled flame lengths output from FlamMap under 97th percentile fire weather conditions (fuel moisture and wind speed) for Meadow Valley study area (outlined in orange/light line in black and white). The left image represents the Meadow Valley landscape prior to implementation of DFPZ and group selection treatments. The right image represents the post-treatment landscape, using only those treatments actually implemented (as of 2008).

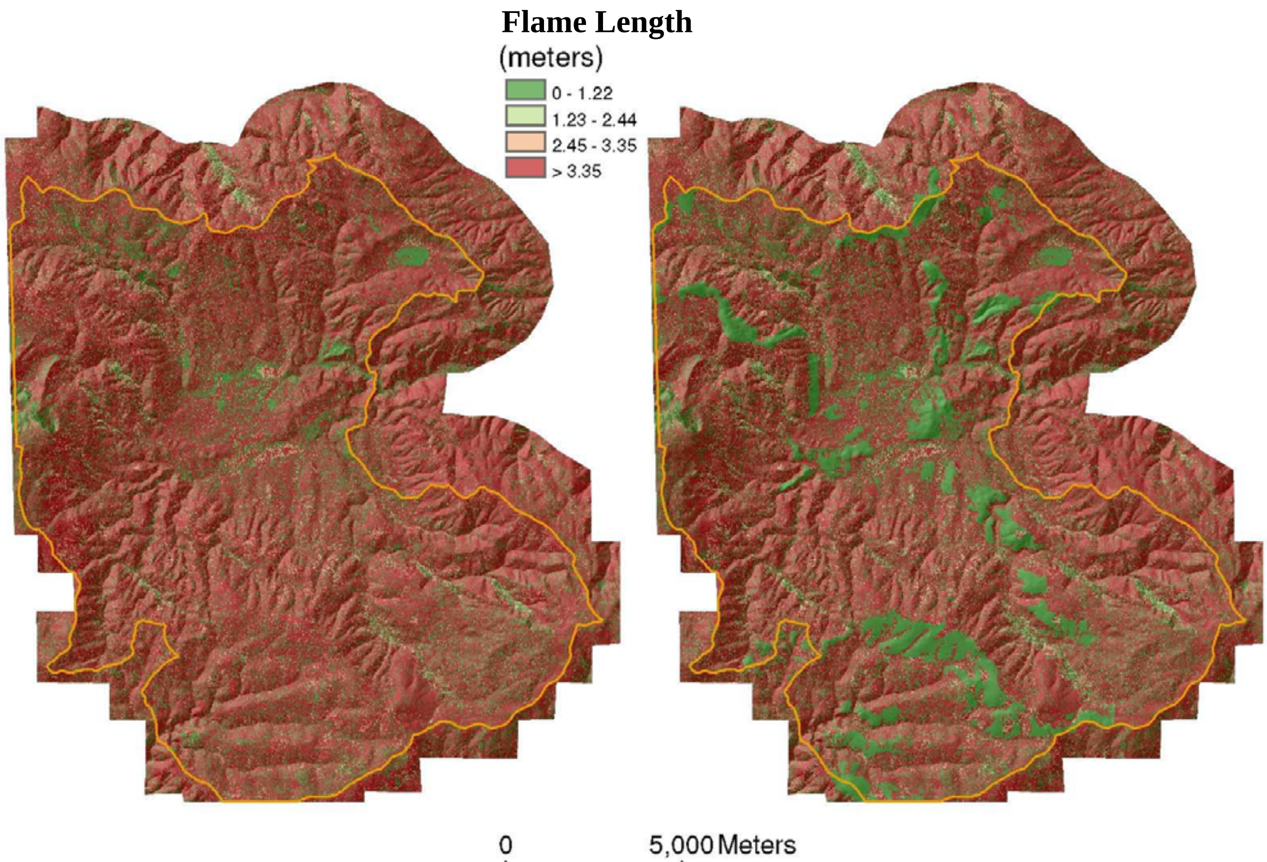

Figure 3. Modeled fire type using FlamMap under 97th percentile fire weather conditions (fuel moisture and wind speed) for Meadow Valley study area (outlined in purple/dark line in black and white). The left image represents the Meadow Valley landscape prior to implementation of DFPZ and group selection treatments. The right image represents the post-treatment landscape, using only those treatments actually implemented (as of 2008).