Response Variable Modules; Progress in 2002

Fuels and Fire Module

2002 Annual Report: Landscape Fuel Treatment Effectiveness in the Plumas and Lassen National Forests

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Objectives

The goal of this component in the project is to determine how landscape level fuels and silvicultural treatments affect potential fire behavior and effects. Past management activities including fire suppression, harvesting, and livestock grazing have changed the structure of many coniferous forest in the western United States, particularly those that once experienced frequent, low-moderate intensity fires (Biswell 1961, Hartesveldt and Harvey 1967, Parsons and DeBendeetti 1979). Changes in climate over the 20th century could have also influenced present ecosystem structure. Restoration of these ecosystems is the goal of the project but there currently is limited information on the effects of such treatments, especially at the landscape scale.

Data collection methods

Information will be collected at 2 scales, first within the nested vegetation plots (0.1 to 1 ha) and second, using remote sensing at the scale of the watersheds (17,800-32,000 ha). Ground data collection is being coordinated entirely with the vegetation module sampling crew to maximize efficiency in sampling and analysis.

Ground based sampling of ladder, surface, and ground fuels

Surface and ground fuels will be sampled in each of the vegetation field plots using the line intercept method (Brown 1974) augmented with information collected from Sierra

Nevada conifers (van Wagtendonk et. al 1996; 1998). At each plot center, two randomly placed azimuths will be used to sample surface fuels. Each azimuth will have a 10 meter fuel transects installed and 1 and 10 hour fuels will be sampled from 0-2 meters, 100 hour from 0-3 meters, and 1000 hour fuels data from 0-10 meters. Duff and litter depth (cm) will be measured at 3 and 10 meters along each transect.

Ladder fuel height will be estimated ocularly to the nearest 0.25 meters at each plot. Average fuel height will also be estimated ocularly at each plot to the nearest 0.25m. In addition, an expert-based set of criteria will be used to assign an overall ladder-fuel hazard rating to each site.

Data will be collected to quantify course woody debris (CWD) as a supplement to fuel load data. Fuel load data will give excellent estimates of loads (metric tons/ha) but will not give good information on the size distribution and condition of such materials. At each fuel sampling point, a strip-plot (4 meters by 20 meters) will be established with one of the respective woody fuel transect lines serving as the strip-plot centerline.

Within each strip-plot only logs or parts of logs that are at least 1m in length and have a large end diameter 15cm or greater will be measured and counted. The species (if possible) and decay class of each log will be recorded. The following decay classes will be used to rate the CWD (Thomas 1979):

Decay Class 1 Bark is intact; twigs are present; wood texture is sound; log is still round; original wood color.
Decay Class 2 Bark is intact; twigs are absent; wood texture is sound or becoming soft; log is still round; original wood color.
Decay Class 3 Bark is falling off; twigs are absent; wood texture is hard; log is still round; original color of wood is faded.
Decay Class 4 Bark is absent; twigs are absent; texture of wood is soft, blocky pieces; shape of log is oval; wood has faded to light yellow or gray.
Decay Class 5 Bark is absent; twigs are absent; wood texture is soft and powdery; shape of log is oval; wood has faded to light yellow or gray.

Remote sensing

Two different remote sensing methods are possible. First, high-resolution IKONOS imagery of several treatments will be collected to provide information on continuous forest pattern, structure, cover and variability using methods developed by Menning (dissertation, 2003) including spectral entropy canopy diversity analysis (SpECDA). These data and analyses have the benefit of being linked to analyses of vegetation and wildlife habitat conducted by other researchers in the project.

Second, an approach similar to that developed by van Wagtendonk (2001) in Yosemite National Park is being considered to provide information on fuel development. Two thematic mapper (TM) scenes could be used to help differentiate the forest types. One

TM scene could be obtained in June and another over the same area in October. The two scenes would be used to differentiate the vegetation types including forests, deciduous hardwoods, montane chaparral, wet meadows, and dry meadows. The spatial resolution of all data would be 30 m X 30 m. Bands 3 and 4 will be used from the TM data and Normalized Difference Vegetation Index (NDVI) would be computed. The result of this procedure would be a high quality forest ecosystem map that will include rock, meadows (dry and wet), bare ground, montane chaparral, riparian areas over 30 m in width, and the 3 most common forest types (ponderosa pine, mixed conifer, white fir).

If pursued, this second technique would be performed before and after restoration treatments for all treatment units. The vegetation map under development for the project will be used in the fuels classification. It will not have the spatial resolution (approximately 5 ha) required to develop a GIS fuels layer but will have excellent information on the dominant vegetation in each polygon.

Analytical methods

Calculation of Fuel Loads

Ground and surface fuel loads will be calculated by using equations developed for Sierra Nevada forests (Menning dissertation 2003, van Wagtendonk et al. 1996; van Wagtendonk et al. 1998). Coefficients required to calculate all surface and ground fuel loads will be arithmetically weighted by the basal area fraction (percent of total basal area by species) that will be collected in the vegetation portion of this study. This methodology will produce accurate estimates of fuel loads (Stephens 2001). Many fuel inventories done in the Sierra Nevada have assumed that the fuel particles being inventoried had similar properties to those found in the northern Rocky Mountains (Brown 1974). Van Wagtendonk's comprehensive work in quantifying Sierra Nevada fuel properties, both surface and ground, allow custom fuel load equation to be developed for this project.

Fuel models

Plot based fuel measurements will be used to create a set of custom fuel models (Burgan and Rothermel 1984) for this area. Fuel model development will also include a stochastic element to more closely model actual field conditions that include a large amount of spatial heterogeneity. Stochastic fuel models will be produced for each strata (forest type, aspect, seral stage, etc.). The vegetation component of this study will measure crown cover and average tree height at each plot. Crown bulk density estimates will come from previous work by Stephens (1998). Topography information will be generated from a digital elevation map (DEM) for all areas. All information will be produced at the 30m X 30m scale.

Potential fire behavior

Potential fire behavior will be estimated using a similar technique done by Stephens (1998) but at much larger spatial scales. The effectiveness of the different restoration treatments will be assessed with computer models such as FARSITE (Finney 1996) and FLAMMAP. FARSITE is a deterministic, spatial, and temporal fire behavior model that uses fuels, slope, aspect, elevation, canopy cover, tree height, height-to-live crown base, crown density, and weather as inputs. FLAMMAP is similar to FARSITE but does not use a user-determined ignition but burns the entire landscape using one set of weather data. These models will be used to quantify the potential fire behavior of the different treatment approaches.

A historic fire risk map will be produced to estimate the probability of ignitions in the treated areas when FARSITE is used. The risk map will be used to generate an actual ignition point in each FARSITE simulation. The duration of each simulation would be 4 days approximating the duration of many large-scale wildfires in the Sierra Nevada. Weather information at the 90th percentile condition will be used and this data will be collected from local weather stations. Fire simulations would be constrained and unconstrained by suppression activities. Constrained simulations will use typical fire suppression tactics and resources. 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), emissions (tons) and if spotting and crowning occurred. Scorch height (m) would be calculated from fireline intensity, air temperature, and wind speed. This information was used to compare the effectiveness of the different landscape level restoration treatments.

Fire effects

Fire effects will be modeled using the GIS outputs from the FARSITE and FLAMMAP simulations coupled to quantitative models that estimate tree mortality (Stephens and Finney 2001). The percent tree cover removed and amount of bare mineral soil exposed by the simulated fires will be estimated for each 30 X 30 meter pixel. This will require generating GIS based fire effects models from published studies. This will enable the estimation of fire effects at the landscape scale.
Response variables

Large wildfires in the Sierra Nevada are commonly high severity events that kill the majority of the small and medium sized trees within their perimeters. This tree mortality will significantly reduce canopy cover. Many wildlife species such as California spotted owls prefer diverse forest structure for foraging and breading. Research indicates that owls prefer to nest in areas with canopy cover in excess of 65 percent. Reduction of canopy cover below 55 percent may reduce the nesting habitat quality for the owl. Consequently, one response variable will be the percentage of the landscape where canopy cover was reduced from over 65 percent to below 55 percent after simulated wildfires. A spatial constraint (minimum of 50 ha) will be used in this analysis since small patches of habitat are probably not be used by this species. Spotted owl foraging habitat has a more diverse desired structure. Telemetry studies have indicated that owls prefer foraging habitat with patches of forest with at least 50 percent canopy cover. Some areas of lower cover can also be included in the foraging habitat but this should probably only comprise a maximum of 20 percent of the area. Foraging habitats are much larger than nesting habitats with a minimum size of approximately 500 ha. A second response variable will be the percent of the landscape after simulated fires that surrounded a nesting habitat where percent cover was reduced from over 50 percent to below 45 percent in 75 percent of an area (minimum of 500 ha). The GIS based fire mortality models will allow for such spatially explicit estimates.

The change in suppression efficiency from the different treatments will also be a response variable. All treatments employ defensible fuel profile zones and 2 treatments use the group selection silvicultural system. Addition of these landscape elements may affect the ability of a wildfire suppression crew to successfully extinguish a fire during initial attack. FARSITE will be used with realistic suppression elements (15 person hand crews, aircraft, bulldozers, etc.) to determine if these landscape level fuel treatments will increase suppression efficiency when compared to the untreated condition. The response variable will be the percentage of wildfires contained below 5 ha in size in one burning period (24 hours) before and after landscape fuel treatments.

It is common for wildfires to be propagated by spotting and this can exponentially increases the size of the fire during the early periods (1-24 hours). The ability of a treatment to reduce the number of spot fires is an important fire behavior characteristic. The number of spot fires will be estimated before and after treatments to determine if treatments reduce fire spread from spotting. The response variable will be the percentage change in spot fire initiation before and after landscape level fuel treatments.

Field Season Progress 2002

No data were collected in 2002. Data collection will begin in summer, 2003, with the vegetation sampling crew. Remote sensing image acquisition will also begin in the summer of 2003.

Collaboration, Integration of Five Modules

All data collection beginning in 2003 and beyond will be coordinated entirely with the vegetation module. This will increase efficiency in sampling and improve our ability to statistically link fuel attributes to the surrounding vegetation as measured by the vegetation crew. In addition, because the vegetation plots overlap many of the sampling sites of other modules, this collaborative approach allows us to provide fuel load and fire risk information to researcher from other modules who need to understand how these factors vary at their sites. In Autumn 2002, we conducted a field trip with representatives of the vegetation crew to work on joint sampling methodologies.

We are using remote sensing to collect data covering several of the treatment units. Landscape-level analyses conducted using this imagery will provide data on continuous landscape characteristics such as fuel production, canopy cover, and forest structural diversity. We have initiated discussions with researchers from the other modules about correlating our findings with their assessments of population and habitat suitability. We anticipate these collaborations may enhance all modules’ abilities to extend analyses to the landscape scale.

Coordination with Interested Parties

We plan to work closely with Mark Finney, a fire-modeling expert in Missoula, Montana on fire behavior assessments. In addition, we anticipate close coordination with fire management offices at the Forest Service districts.

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