Appendix A

2003 Fuels and Fire at the Landscape Scale Module Annual Report Plumas and Lassen Adminstrative Study

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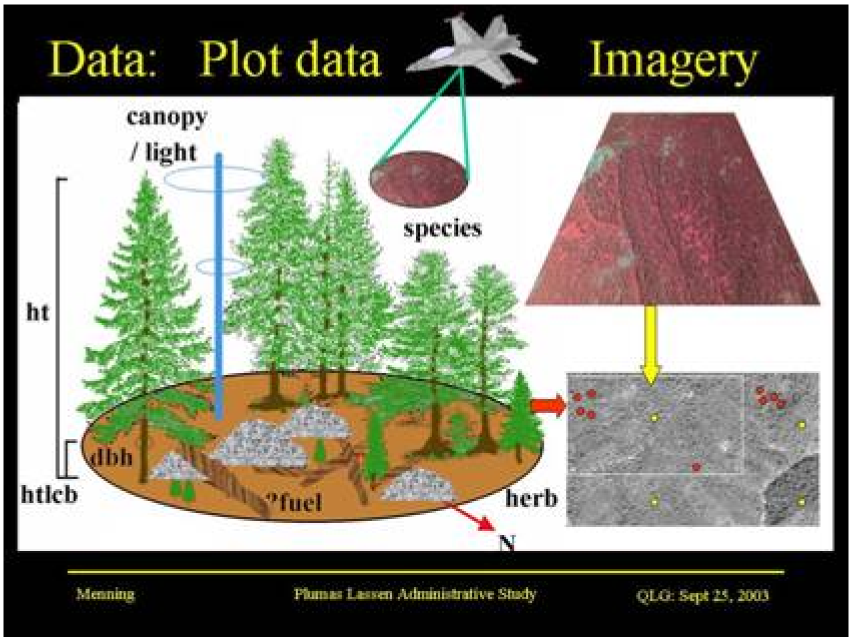
Objectives

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 is being collected at 2 scales, first within the nested vegetation plots (0.05 ha) and second, using remote sensing at the scale of the watersheds (17,800-32,000 ha). In 2003, ground data collection was coordinated with the Vegetation and Songbird modules to maximize efficiency in sampling and analysis. The 2003 field season was our inaugural pilot sampling season. We collected more data than we plan to collect in future summers. In December, 2003, we convened a meeting of the modules to determine which data collection efforts would persist and which would be eliminated. In 2004, we should have a streamlined data collection effort.



Plot Layout and Design

An extensive array of plots was established using a stratified-random approach. Plots were distributed in strata of elevation, aspect and vegetation type using the VESTRA layers previously supplied. This process identified over 500 plot locations in treatment units 3 and 4. The vegetation crew began sampling these locations in 2003.

Please refer to the Vegetation Module's report for the fullest description of plot layout and design. The Vegetation crew set up plots and led the effort to collect data. Basic plots were 12.6m in radius.

Additionally, less intensive forest structure and fuels data were collected along the songbird transects by the Songbird module. Along their transects of 12 plots, two were sampled intensively, following the vegetation crew protocols, and ten were sampled quickly using a less-intensive sampling scheme.

Forest structure and composition

In the Vegetation crew's 12.6m radial plots species and diameters were recorded for all trees along with categorical estimates of their heights and crown profiles. Additional data were collected on the degree of infestation by mistletoe (see Vegetation module for details).

Ground based sampling of ladder, surface, and ground fuels

Surface and ground fuels were 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 were used to sample surface fuels. Along each azimuth we set up a 10 meter fuel transect and sampled 1 and 10 hour fuels were sampled from 10-12 meters, 100 hour from 9-12 meters, and 1000 hour fuels data from 2-12 meters. Duff and litter depth (cm) were measured at 5 and 8 meters along each transect. Maximum litter height was additionally sampled at three locations from 7 to 8m.

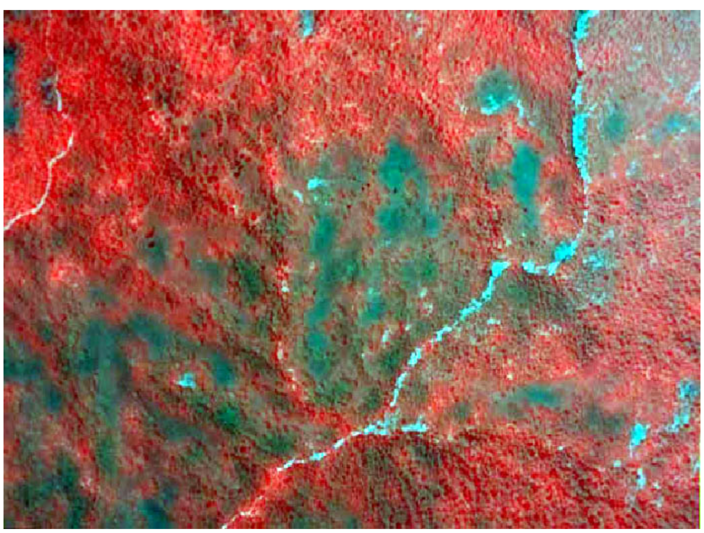
At the songbird sites, fuel loads were rapidly occularly estimated using the fuel photo series (Blonski and Schramel 1993) on ten of the twelve locations along transects. At two plots per transect a full inventory was done, following the Vegetation protocol.

Ladder Fuel Hazard Assessment (LaFHA)

We devised and implemented a mixed quantitative-expert system for assessing ladder fuels. Named the LaFHA approach, this system allows a trained field crew member to rapidly assess low aerial, mid aerial and aerial fuels in four regions of the plot while assessing the continuity of the fuel ladder. Later, slope and vegetation data are used to modify the ratings quantitatively. Please see the attachments for the flowchart that guides this process.

Remote sensing

Two different remote sensing methods are being implemented. First, high-resolution IKONOS imagery of several treatments was collected covering treatment units 3 and 4 to provide information on continuous forest pattern, structure, cover and variability using methods developed by Menning (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 and Root (2003) in Yosemite National Park is being used to provide information on fuel production on an annual cycle. Two thematic mapper (TM) scenes are used to help differentiate the forest types. One TM scene is obtained in June and another over the same area from October. The two scenes are used to differentiate the vegetation types including forests, deciduous hardwoods, montane chaparral, wet meadows, and dry meadows. The spatial resolution of this second class of data is 30m by 30m. Bands 3 and 4 are being used from the TM data to calculate Normalized Difference Vegetation Index (NDVI). The result of this procedure will 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).

Analytical methods

Calculation of Fuel Loads

Ground and surface fuel loads are being calculated by using equations developed for Sierra Nevada forests (Menning 2003, van Wagtendonk et al. 1996; van Wagtendonk et al. 1998). Coefficients required to calculate all surface and ground fuel loads are arithmetically weighted by the basal area fraction (percent of total basal area by species) that are collected in the vegetation portion of this study. This methodology produces 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

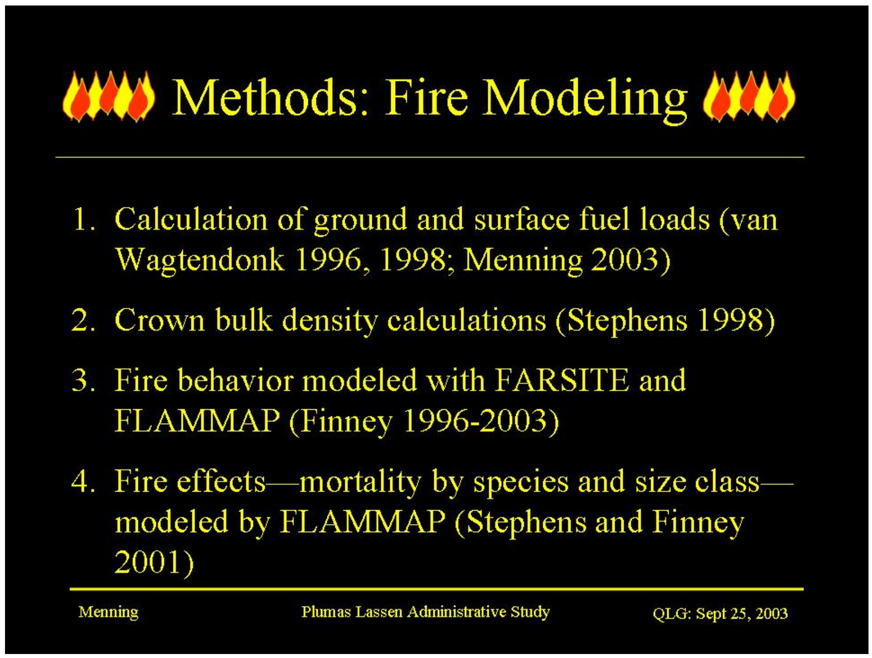
Plot based fuel measurements are being used to create a set of custom fuel models (Burgan and Rothermel 1984) for this area. Fuel model development includes a stochastic element to more closely model actual field conditions that have a large amount of spatial heterogeneity. Stochastic fuel models are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

Potential fire behavior

Potential fire behavior is being estimated using a similar technique developed 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 are being used to quantify the potential fire behavior of the different treatment approaches.

A historic fire risk map is being produced to estimate the probability of ignitions in the treated areas when FARSITE is used. The risk map is being 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 is being used and this data is being 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 is used to compare the effectiveness of the different landscape level restoration treatments.

Fire effects



Fire effects are being 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 is being estimated for each 30m by 30m 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.

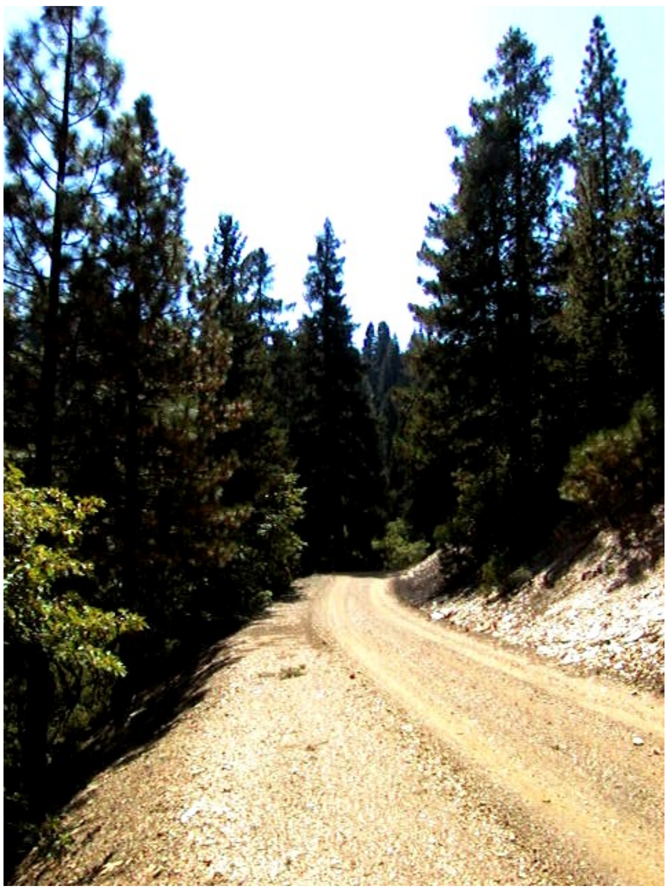
Response variables

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 is being 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) is being 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 is being 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 is being 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 is being 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 is being estimated before and after treatments to determine if treatments reduce fire spread from spotting. The response variable is the percentage change in spot fire initiation before and after landscape level fuel treatments.

Field Season Progress 2003



Initial data collection began in summer 2003, with the Vegetation sampling crew. After being trained by Menning, the Vegetation crew visited 68 plots during the months of July and August to sample forest and fuels conditions. Basal area in these plots averaged 46.3m^2/ha. Fuller analysis of plot data is underway. Menning spent a total of 3 and a half weeks training the field crews and assisting data collection.

Remote sensing image acquisition will also began in the summer of 2003. High resolution IKONOS satellite imagery was collected over treatment units 3 and 4. Raw data were supplied to minimized acquisition cost and to allow the highest quality orthocorrection possible given the complex topography. This work is being performed in the Center for Assessment and Monitoring of Forest and Environmental Resources (CAMFER) by Menning.

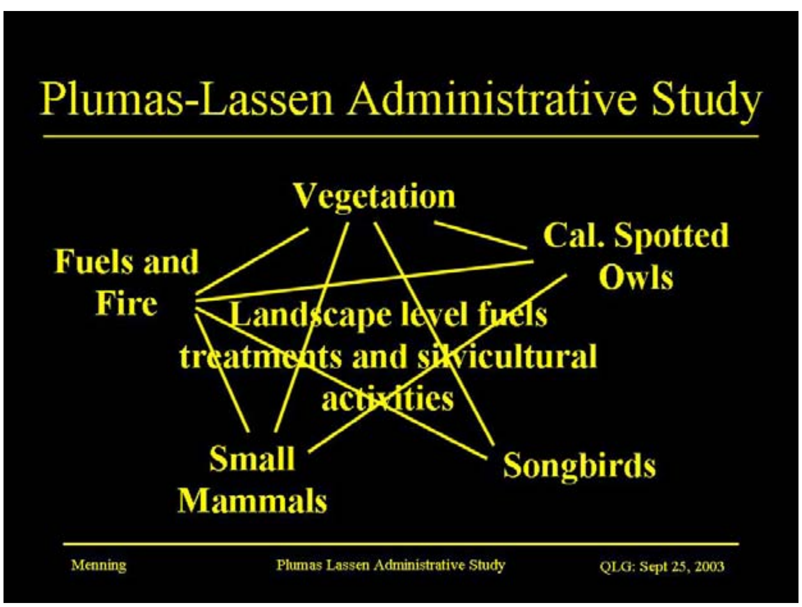
Field Season 2004

In 2004, the Fuels and Fire Module will send out its own field crew. This is intended to maximize the efficiency of both the Vegetation crew, which has other objectives, and to allow our module to focus on the data necessary for completion of our project. It is important that we acquire an extensive array of data for the characterization of landscape vegetation and fuels conditions. In addition, these extensive data are necessary to provide high quality ground reference for the remote sensing data. The field season is planned for 3 months of the summer.

We will continue to work with the Songbird module to have them collect extensive fuels and forest structural data along their transects.

Collaboration, Integration of Five Modules

All data collection beginning in 2003 was coordinated entirely with the vegetation and songbird modules. Menning trained approximately thirty members of these two crews, plus the owl crew, to collect vegetation and fuels data. Due to time constraints, the owl crew was not able to collect fuels data, however. We will continue to work with and train representatives of the Songbird Module to collect data from their plots.



Landscape-level analyses conducted using the remote imagery will provide data on continuous landscape characteristics such as fuel production, canopy cover, and forest structural diversity. We are coordinating with researchers from the Songbird and Owl 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.

Literature Cited

Biswell, H. H., 1961. The big trees and fire. National Parks and Conservation Magazine 35:11-14.

Blonski, K.S. and J. L. Schramel, 1993, Photo series for quanitifying natural forest residues: Southern Cascades, Northern Sierra Nevada. Boise, Idaho, National Interagency Fire Center.

Brown, J.K. 1974. Handbook for inventorying downed wood material. USDA Forest Service, General Technical Report INT-16.

Burgan, R.E., and Rothermel, R.C., 1984. BEHAVE: fire behavior prediction and fuel modeling system - Fuel modeling subsystem. USDA Forest Service General Technical Report INT-167. Intermountain Research Station, Ogden, Utah. 126 pp.

Finney, M.A., 1996. FARSITE fire area simulator. Users guide and technical documentation. Systems for environmental management, Missoula, MT. 116pp.

Hartesveldt, R.J., and Harvey, H.T., 1967. The fire ecology of sequoia regeneration. Proceedings of the 6th Tall Timbers Fire Ecology Conference, Tallahassee, FL. 65-77.

Menning, K. M. (2003). Forest heterogeneity: methods and measurements from extensive field plots, fire modeling, and remote sensing of the mixed conifer forest of the southern Sierra Nevada, USA. Environmental Science, Policy and Management, University of California, Berkeley

Parsons, D.J., and S.H. DeBendeetti. 1979. Impact of fire suppression on a mixed-conifer forest. For. Ecol. Manage. 2(1):21-33.

Stephens, S.L., and M.A. Finney, 2001. Prescribed fire mortality of Sierra Nevada mixed conifer tree species: effects of crown damage and forest floor combustion. Forest Ecology and Management (in press).

Stephens, S.L. 2001, Fire history of adjacent Jeffrey pine and upper montane forests in the Eastern Sierra Nevada. Inter. J. of Wildland Fire 10: 161-176.

Stephens, S.L. 1998. Effects of fuels and silvicultural treatments on potential fire behavior in mixed conifer forests of the Sierra Nevada, CA. Forest Ecology and Management vol 105, no. 1-3, pp.21-34.

Thomas, J.W., Tech. Ed. 1979. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. Agric. Handbook. 553. Washington, D.C., USDA Forest Service, 512pp.

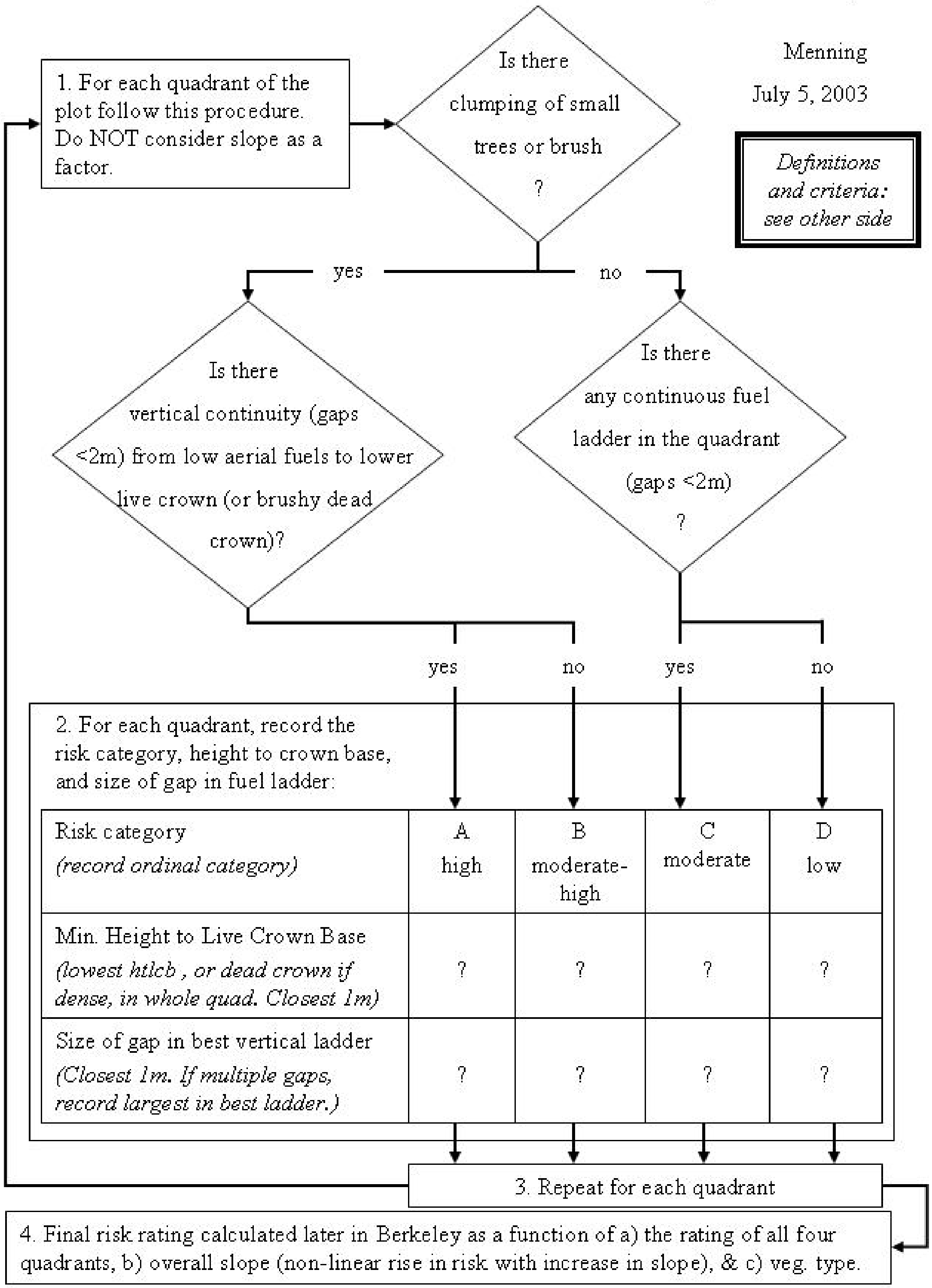
van Wagtendonk, J. W. and R. R. Root (2003). "The use of multi-temporal Landsat Normalized Difference Vegetation Index (NDVI) data for mapping fuel models in Yosemite National Park, USA." International Journal of Remote Sensing **12 (in press)**: 1-29

van Wagtendonk, J.W., J. M. Benedict, and W. S. Sydoriak. 1998. Fuel bed characteristics of Sierra Nevada conifers. Western Journal of Applied Forestry 13(3): 73-84.

van Wagtendonk J.W., J.M. Benddict, and W.M. Sydoriak. 1996. Physical properties of woody fuel particles of Sierra Nevada conifers. International Journal of Wildland Fire 6(3): 117-123.

Attachments

Ladder Fuel Hazard Assessment (LaFHA)



Definitions

- **Division of plots**: Use a compass to quickly divide plots into four quadrants: northeast, southeast, southwest and northwest. Use trees for reference.
- **Clumping:** Brush or small trees covering an area of at least 4 square meters (2m x 2m) with gaps of less than 50cm. If it is particularly dense, or tall and brushy, a clump may cover a small area. A particularly dense clump may cover as little as $2m^2$ on the forest floor, for example. Branchy dead fuel or stems may be included in the assessment. Remember not to worry too much about definitions but to return to the question, "is this a dense clump of potential fuel?"
- **Risk categories** are given letters (A, B, C, D) instead of numbers to prevent confusion: categories are not of interval or ratio quality quality ("Is category 4 twice as risky as category 2?" Probably not). Also, final ratings depend on additional information (see Step #4 at bottom of flowchart page).
- **HTLCB**: Height to live crown base: The live crown base is the lowest extent of the live canopy. Note: if the crowns of small trees are completely separate from the overhead canopy do not consider them. If they connect, or are close, do consider them.
- **Dead Crown** and when to consider it: Include dead branches in a tree's crown if they are particularly branchy or brushy. This will almost never happen in pines, but is common in white fir and Douglas-fir. If the branches radiate laterally and are well spaced (common with incense-cedar) do not consider them to be part of the ladder fuel matrix (live crown and brushy dead crown). In order to be considered part of a ladder, the branches should be dense and mostly vertical. Lichens, moss and needles increase the fuel hazard. Consider this in your assessment.
- **Ground and surface fuels**: do not adjust your assessment of the risk category by the presence or absence of ground or surface fuels (litter and duff with branches and cones mixed in). Consider only clumping and the presence of ladder fuels.
- **Canopy or No Canopy?**: Consider only conifer and oak tree species as part of the canopy. Do not consider chaparral to have a canopy for this analysis. If there is no higher canopy, then record the gap as –99. This is important to distinguish from empty fields which may mean a datum was or was not recorded. A –99 value indicates that data were recorded and that the gap was infinite because there was no crown.

Datasheet for 2003, page 1

Plumas Veg Module — Data sheet

3/4/2004

Data for the whole plot

Plot	Date	UTM-E		UTM-N			50m radial plot		Logs	
		Aspect		Slope			Habitat typ		Snags <10	
		Recorders		Photo #			Water Y/N		Snags 10-30	
							% Road		Snags >30	

Variable Radius (50m) Plot Species Tallies (panama angle gauge)

Species (live)											
Number stems											

50m Plot Layers + --> Species and their percent cover

	Herb (+seed) (<50cm)	Real Shrub (0.5-5m)	Small tree (Tree shrub)	All veg 0.5-5 (Tot. shrub)	Big tree (Tree)
%cover					
Low Bnd					
Low Bnd Sp					
Up Bnd					
Up Bnd Sp					
DBH min					
DBH min sp					
DBH max					
DBH max sp					

Real shrub (0.5-5m)		Small Trees (tree shrub, 0-5m)		
Species	% Cover	Size class	Species	% Cover
		Small Tree (Tree Shr) (<5m)		
			total	100%
		Big Tree (Tree, >5m)		
total	100%		total	100%

12.6 m Radial Plot Fuels & Fire Risk Assessments

Fuel Photo Series		LaFHA			
Fuel size	Count	Quadrants	Haz. Rating	Min Cr Ht	Max Lad Gap
0-3"		N (1)			
3-9"		E (2)			
9-20"		S (3)			
>20"		W (4)			

Brown's Transects 12.6m

Tallies		1 hr (0-0.6cm)	10 hr (0.6-2.5)	100 (2.5-7.6)	Litter @ 5	Duff @ 5	Litter @ 12	Duff @ 12	max depth 1	max depth 2	max depth 3	Sight tube
A												
B=A+90												
A: 1000hr	Diam											
	Sound/Rot											
Shrubs	Species											
	Length											
	Ht class											
B: 1000hr	Diam											
	Sound/Rot											
Shrubs	Species											
	Length											
	Ht class											

Plot | **Sheet 2**

Trees in 12.6m radius plot								Snags in 12.6m radius plot			
Species	DBH	Height	Ht. Low Cr.	Cr. Width	Shape	Mistletoe 0-6		DBH	Ht. Class	Decay class	Cav>10cm