QUANTIFYING CANOPY FUELS

STUDY PLAN

Introduction

Crown fire is now a chief concern among many forest managers in the western US and Canada because they have increased in frequency, intensity and size in many areas (Mutch et al. 1993, Arno and Brown 1988). Compared to surface fires, crown fires are responsible for many more burned acres, more smoke per acre, greater and longer lasting ecological damage (i.e. higher severity), greater threats to firefighter and public safety and increased risk of property and structure loss. Research over the last two decades has identified four canopy characteristics that significantly affect the incidence of crowning. The crown base height (height of the bottom of the live crown from the ground surface), crown bulk density (mass per unit volume of combustible crown biomass, including foliage, twigs and branches), stand height (average height of the dominant tree strata in a stand) and canopy closure (percent vertically projected canopy cover in the stand). A number of fire models and computer-based fire modeling systems require estimates of these canopy fuel characteristics to accurately simulate crown fires.
The goal of this research is a comprehensive description of crown fuel characteristics for fire management. This study is a two-pronged effort to measure the crown fuel characteristics germane to fire modeling using the (1) simple and easy measurements of standard forest inventory measurement techniques and (2) leaf area measurement equipment.

Methods

We measured canopy fuels exhaustively on a single fixed-radius plot at each of five study sites in the Interior West, each in a different conifer forest type. Each branch on each tree was measured and weighed, and a subset of branches were sorted by size class and ovendried. We conducted the sampling in stages, beginning with the smallest diameter trees in each plot and working toward the larger diameter trees. Before sampling and after 25, 50 and 75 percent of the basal area was removed we photographed the stand (using both stereo and hemispherical photography), and used several optical sensors to estimate gap fraction and leaf area index. This method provided estimates of canopy fuel characteristics as if the stand had received thinning from below treatments of increasing intensity.

A stereo-photoguide (Scott and Reinhardt,2005) allows managers to estimate canopy fuels visually. Methods have also been published (Keane and others, 2005, Reinhardt and others, 2006) to estimate canopy fuels from optical data and from stand data.

Results and Application: This study has developed methods used to map canopy fuels, model crown fire occurrence and behavior, and evaluate effectiveness of fuel treatments designed to reduce crown fire hazard. The methods have been used in LANDFIRE (a national interagency fuel mapping project), FFE-FVS (the Fire and Fuels Extension to the Forest Vegetation Simulator), and site-specific as well as regional analyses of crown fuel hazard and fuel treatment strategies.

Sampling in Stages

To expand the range of canopy conditions for this study, we removed a fixed amount of basal area from the stand in three separate cuts to provide estimates of four different stand structures or closures. We will remove approximately 25 percent of the basal area in three harvest entries to vary crown density and distribution conditions. The first cut will bring the stand to 75 percent basal area, then the second to 50 percent, then 25 percent. The last 25 percent basal area will be left on the stump. This cutting technique will provide us with four crown fuel conditions (100%, 75%, 50%, 25%).

Percent of Original Basal Area

Coconino National Forest 7 mi NW of Flagstaff, AZ


100%

75%

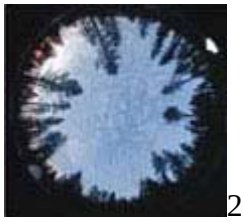
50%

25%

Digital hemispherical photographs Lolo National Forest 40 mi W of Missoula, MT


100%

75%

50%

25%

Inventory

A stand inventory (size, location, species), age structure, and mapping of the sample plot will be performed and the surface fuels will be measured.

 Jim Reardon

Sorting

A subsample of all sawn branches harvested from the lowered or climbed trees will receive additional detailed measurements. These detailed measurements will quantify the biomass of each crown fuel component on the subsample branch. The wet and dry weight of live foliage, live branchwood (divided by diameter class), cone weight, dead branchwood (divided by diameter class), and lichen and moss will be recorded.

Diameter Classes

- 0-3 mm
- 3-6 mm
- 6-10 mm
- 10-25 mm
- 25-50 mm
- 50-75 mm

 Matt Duveneck and Kylie Kramer sorting live and dead branches on a small tree.

 Kylie Kramer and Bill Ballinger sorting branches into diameter classes.

 Canopy Crew

Branch before sorting.

Branch after sorting.

Destructive Sampling

Canopy fuel characteristics will be measured in a range of forest types and stand densities using standard plant biomass sampling techniques. These accurate measurements will then be compared with estimates made using indirect techniques (optical sensors and inventory-based methods).

Each tree in the plot will be marked to be cut for a given basal area harvest level. They will be harvested either by rigging and lowering or climbing, depending on size. On the larger trees, the climber will progressively move up the tree bole, sampling and cutting branches along the way. The tree is "topped" when the climber reaches a bole diameter of approximately 5 inches. Once the top is on the ground, field crews then perform measurements of remaining branches. The vertical branch angle, branch height, branch azimuth, branch basal diameter, live branch ratio, branch length, branch width, and branch weight will be measured.

Lowering rigged tree.

Matt Duveneck removing branches from the bole.

Kylie Kramer rapelling after removing branches and topping the tree.

Kylie Kramer weighing branch.

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STATUS

- Workshop January 2000
- All five sites completed 300 main canopy trees sorted
- 300 under and middle story trees sorted
- 12,000 branches processed (13,000 kg)
- 900 branches sorted into class size