Red Mountain Mastication Study

2006 Annual Report

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Introduction

Land managers seek an answer to the question of whether mastication units can be and ‘walked away from’, or if follow-up treatments such as prescribed burning are needed to meet resource and fire objectives. Adaptive Management Services Enterprise Team (AMSET) is collaborating with the Greenhorn Ranger District of the Sequoia National Forest in order to assess effectiveness of mastication fuel treatments on modifying wildland fire behavior and evaluating tree mortality related to prescribed fire. This annual report presents the current situation for the Red Mountain Mastication Study. Pre-treatment and year-one post-mastication data has been gathered thus far. All data will be analyzed and fully presented once prescribed fire treatments are accomplished and post-fire data are gathered for this project.

Objectives

Objective 1. Determine the effectiveness of using mastication alone or mastication in combination with prescribed burning to meet resources objectives while modify wildfire behavior and improving fire suppression opportunities under 80^{th}, 90^{th}, and 97^{th} percentile weather conditions. Hypotheses associated with this objective fall into two groups:

1. *Fuel Conditions:* How does mastication alone and with prescribed burning affect fuel conditions such as amount, size, and configuration compared to the control?
   Hypotheses
   - a.) Mastication will reduce abundance of the 1000 and 100 hour fuels and increase the 10 and 1 hour fuels.
   - b.) Mastication will decrease canopy bulk density (CBD), increase canopy base height (CBH, due to small tree removal).
   - c.) Mastication will reduce fuel bed depth.
2. *Fire Behavior:* Determine if mastication alone is sufficient to significantly reduce wildfire behavior under 80^{th}, 90^{th}, and 97^{th} percentile weather conditions. This question will be addressed through a series of hypotheses on fire behavior characteristics, including rate of spread, fire type, fire intensity and resistance to control:
   Hypotheses
   - a.) Mastication alone is enough to reduce fire behavior model predictions of rate of spread compared to model predictions for unmasticated sites.
   - b.) According to model prediction, mastication combined with prescribed burning will result in shorter flame lengths and lower fire intensities of shorter duration compared to predictions for unburned, masticated units and unmasticated sites.
   - c.) Mastication with follow-up underburning will provide the greatest decrease in firefighting resistance to control.

Objective 2. *Tree Mortality:* Through this study, AMSET will quantify effects of mastication and mastication with prescribed burn treatments on tree mortality. This issue will be addressed through the following hypotheses:

a.) Fire-related mortality will be higher than targeted resource objectives in masticated units.

b) Pulling masticated slash away from boles will significantly decrease prescribed burn related tree mortality.

Methods

Study Site

This study is located in the Red Mountain plantation, ranging from 5,200 to 6,600 feet in Greenhorn Ranger District of the Sequoia National Forest. Red Mountain is a 24-year-old Ponderosa pine plantation, planted after a 2,500 acre 1970 wildfire. The site is productive; with pines that are approximately 30 feet high and in some areas form a nearly continuous canopy. Oak, white fir, and incense cedar also grow in patches throughout the plantation. The mean annual precipitation in this area averaged 15 to 20 inches, falling primarily as rain, although snow can cover the upper parts for up to 4 months per year.

Treatments

The study includes three treatments plus controls. Treatments will include mastication only, mastication with prescribed fire and mastication with slash pulled 3m away from tree boles along with prescribed fire. Burn units will also be executed under the same prescription.

Code	Treatment
M	Thinning by mastication
MB	Thinning by mastication followed by prescribed burn
MPB	Thinning by mastication, pull slash 3m from tree boles, prescribed burn
NA	No action (controls)

Study Design

A random-block design is being used in which each treatment is repeated once in each of four randomly distributed blocks (n = 4). Blocks are 200 by 405 meters (20 acres), divided into four 5-acre treatment areas, referred to as “plots” hereafter. Four blocks were randomly selected from the plantation using ARC GIS. To ensure that the design could be implemented, we included a road access layer and constrained selections to within ¼ mile of any road, and where slopes did not exceed equipment limitations. The plantation has a number of roads that cross through it, ensuring that the sites constrained by distance to road are representative of conditions throughout the plantation. At each randomly selected cross-point, the orientation of the block was be determined by randomly selecting the bearing of the block’s long axis.

Each block was evenly divided into four 5 acre treatment plots (approximately 200 by 101 meters). Treatments were randomly assigned within each block. Thus, there are 16 study plots (an over all n of four for each of four treatments), within which replication of each response variable measurement is detailed in Appendix B.

Treatment Implementation and Timing of Sampling

It would be preferable for all blocks to be treated within the same short-term timeframe (days) if feasible. The sizes of the treatment areas have been designed to facilitate this. Plots may be treated in the fall or spring, depending on when prescription conditions have been met. It is acknowledged that fire behavior and effects may vary with season (e.g. tree mortality), however, we are not intending to compare fall and spring treatments but mastication with or without burning.

Project Team and Responsibilities

AMSET will partner with the Greenhorn Ranger District of Sequoia National Forest in order to achieve the goals of this project. As detailed in the project proposal, the Ranger District has committed to complete all NEPA requirements and project implementation. The District will also develop the treatment prescriptions. These will be typical for what they would normally develop, ensuring that the study is representative of real management applications. AMSET team members will be responsible for preparing, collecting, and analyzing all data before, during and after treatments.

Accomplishments

Pre-treatment Data Collection

During the summer of 2005, treatment blocks and research plots were installed. Pre-treatment data were gathered on plots during the summer of 2005. Data were entered during the fall of 2005. GPS points were taken at plot corners and plot corners were flagged with blue and white polka-dot flagging.

Mastication Treatments

Between the summer of 2005 and late summer to 2006, most plots were masticated. Some plots that were slated to be masticated, were not masticated due to slope constrictions. This will necessitate a slight change in statistical methods that will be used for analysis. The plots which were designated as part of the mastication treatment, but were not masticated are highlighted in the list below. Also, due to several plots not being masticated on Block 4, the remaining plot that has been masticated is not slated for prescribed fire treatment.

<u>Block 1</u>
Mastication: masticated (lightly)
Mastication/burn: masticated (lightly)
Mastication/pull-back/burn: masticated (lightly)
Control: not masticated

<u>Block 2:</u>
Mastication: masticated
Mastication/burn: masticated
Mastication/pull-back/burn: masticated
Control: not masticated

Block 3:
Mastication: **not masticated**
Mastication/burn: masticated
Mastication/pull-back/burn: masticated
Control: not masticated

Block 4:
Mastication: masticated (now plan to burn this unit, since it is only unit treated in this block)
Mastication/burn: **not masticated**
Mastication/pull-back/burn: **not masticated**
Control: not masticated

Post-mastication Data Collection.

During the summer of 2006, post-mastication data were gathered on plots which received mastication treatment. Control, or non-masticated plots were not reread this season. Control plots will be re-read when final post-burn data are collected. Data have been entered and will be analyzed and presented fully after prescribed fire treatments are accomplished and post-burn data collected.

Blue and white polka-dot flagging was reinforced on plot corners and edges. Additionally, orange and white-striped and polka dot flagging were placed along the plot edges which will require fireline for burn treatments. Crews were shown the location of blocks for future treatment.

Project Duration

The project timeline will have to be extended because the prescribed fire treatment was not implemented in 2006. The original timeline was as follows:

Task	Completion Date
Meet with host District to discuss project	May 2005
Develop mastication and burning prescriptions with host district	May 2005
Gather equipment and personnel for field	May 2005
Hire and train field crew	June 2005
Layout experimental plots	June 2005
Collect pre-treatment data	June-September 2005
Complete NEPA for treatments (District)	September 2005
Implement mastication treatments	October 2005
Collect post-treatment data on masticated plots	Winter/Spring/Summer 2006
Enter data, analyze, prepare annual report	Winter 2006/7
Implement prescribed burns	Spring or Fall 2006/Spring or Fall 2007
Collect field data on post-burn plots	Summer/Fall/Winter 2007
Enter and analyze remaining data	Fall 2007
Submit final report to JFSP, submit publications	Spring 2008

It is estimated that the prescribed fire treatments will be implemented in the fall of 2007. The revised timeline is presented below, and the AMSET budget will be adjusted accordingly.

Task	Date	Achievement
Meet with host District to discuss project	May 2005	Completed
Develop mastication and burning prescriptions with host district	May 2005	Completed
Gather equipment and personnel for field	May 2005	Completed
Hire and train field crew	June 2005	Completed
Layout experimental plots	June 2005	Completed
Collect pre-treatment data	June-September 2005	Completed
Complete NEPA for treatments (District)	September 2005	Pending
Implement mastication treatments	Fall 2006	Completed
Collect post-treatment data on masticated plots	October 2006	Post-mastication data gathered
Enter data, analyze, prepare annual report	Winter 2006/07	Report prepared
Implement prescribed burns	Fall 2007	
Collect field data on post-burn plots	Fall/Winter 2007	
Enter and analyze remaining data	Winter 2007	
Submit final report to JFSP, submit publications	Spring 2008	

Appendix A.

Pre and Post Mastication Photos

Block 1
Pre Mastication

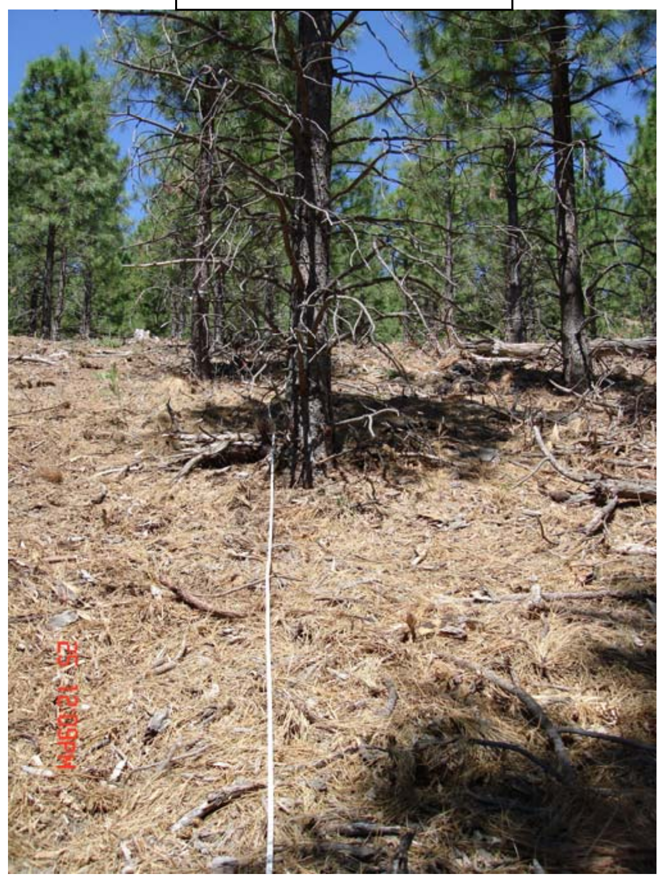
Block 1
Post Mastication

Block 2
Pre Mastication
Pre Burn

Block 2
Post Mastication
Pre Burn

Block 3
Pre Mastication
Pre Pull-back/Burn

Block 3
Post Mastication
Pre Pull-back/Burn



Block 4
Pre Mastication
Pre Burn

Block 4
Post Mastication
Pre Burn

Appendix B.

Data Collection and Analysis Methods

<u>Fuels and Tree Mortality</u>

Measurements characterizing fuel conditions will be used to address our hypotheses and will also be used in order to develop custom fuel models for mastication. These custom models will be used to compare predicted fire behavior under a range of weather conditions and will be provided to managers in the mastication guide.

Subplot size and location: Four subplots will be randomly located in each 5 acre treatment using ARC GIS. Subplots will not be placed near the edges of the treatment units, allowing for a 3 m set-back from the edge to reduce effects of treatment initiation. Based on an extensive fuels treatment monitoring data set across three National Forests in the northern Sierra Nevada, this is the calculated number of plots per stand needed to obtain mean estimates of surface fuel loadings within 20% and a confidence level of 80%. Based on this sampling analysis, we concluded that six plots per stand are optimal for treated stands that are variable natural stands. Our sites are more uniform, in a plantation and therefore, we expect that four sub-plots will more than adequately capture variability within each plot, especially since they will encompass a sample of 20% of the treated areas. Subplots will be 1,000 m^2, as defined by a radius extending 17.85 m from the subplot center. Fuels data will be collected three times: once before any treatments, once following all mechanical treatments, and once following controlled burns.

Crown Fuels: All living and dead trees will be tagged with sequentially numbered brass tags nailed in at dbh prior to any treatments. For all live trees $\geq$15cm dbh, the following information will be collected:

1. tag number, species, dbh (cm)
2. alive (y/n)
3. height to live crown
4. total tree height (m).

Tree damage will also be noted. For snags, information collected will be:

1. tag number
2. species
3. dbh
4. total tree height
5. decay class (1 thru 5)

Following mastication and controlled burns the following will be collected:

1. height to live crown
2. char height (on the bole)
3. proportion of circumference of bole charred
4. crown scorch height(foliage brown but not consumed)
5. torch height (foliage consumed)
6. tree status (dead or alive)

For smaller trees (2.5 to <15 cm dbh and $\geq$ 1.37 m in height) and seedlings, a smaller circle will be sampled that is centered at a random point along the perimeter of the subplot. A circle with a 8.92 m radius will then be defined from this point. All pole size trees will be tagged with numbered brass tags and the same set of information will be collected on these trees as from the trees that are $\geq$15 cm dbh. Information on seedling and canopy cover will be collected from a 3.99 m radius circle centered at the pole-tree plot center. In this area, the following information will be recorded: seedling species, alive (y/n), height class ($\leq$15cm = 15, $\leq$30cm = 30, $\leq$60cm = 60, $\leq$100cm = 100, $\leq$200cm = 200, $\leq$300cm = 300, etc.).

Surface Fuels: Brown's planer intercept method will be used to measure surface fuels (Brown 1974). From the subplot center, one 50 foot transect will be placed along a randomly selected bearing. Beginning and ending of transects will be marked with rebar to ensure exact placement pre- and post-treatment. Transects will be photographed, and the slope and bearing recorded.

Litter Samples: To ensure that 1-hour fuels information is adequately captured, Brown's 1982 recommendations to supplement planar intercepts with dry weight samples of litter will be used. Randomly located 30x30cm quadrats within each fuel subplot will be collected. Litter will include pine needles, bark and pine cones. Litter will be placed in bags, air dried, then oven-dried at 70^{o}C for 48 hours and weighed.

Live Understory Fuels: Biomass of live understory fuels, including shrubs, forbs and graminoids, will be estimated using Behave Fuel Subsystem NEWMDL program v 2.0 (Burgan and Rothermel 1984). Life form, density class, depth and cover are required inputs. A belt transect will be established along the Brown's planar intercept that is 50 feet long (same as intercept) and 1 meter wide. Within that belt transect we will classify and record shrub, herb, and grass cover using cover classes (1=0-5%, 2=6-25%, 3 =26-50%, 4= 51-75%, 5 = 76-95%, 6 = 96-100%), percent dead, and average height (cm), and dominant species. The Burgan and Rothermel (1984) lifeform and density class will be assigned to each understory component and fuel loading calculated according to their algorithms.

Tree Mortality: One-year post-burn mortality will be assessed by tracking tree survival in the subplots. We will compare mortality between masticated plots burned with and without the mitigation treatment of pulling material away from the boles and root zone. In addition, we will gather fire behavior data soil surface temperature maximums and duration near trees, as described below.

<u>Fire Behavior</u>

Key characteristics of fire behavior will be measured and paired with information on fuel characteristics in order to develop and calibrate a custom fuel model for each treatment. Direct fire behavior measurements will be summarized for use by managers in predicting fire behavior during prescribed burns of masticated units. The data will also be analyzed in relation to tree mortality.

Four key fire behavior characteristics will be measured at each plot burned including, rate of spread, flame length, soil surface temperature, and fire type. In addition, weather data will be collected (temperature, humidity, and windspeed) before and during the prescribed burns at least every 30 minutes and during the time the fire is passing through individual subplots. A portable RAWS weather station will be established in a representative area in addition to of weather monitoring practices used during prescribed burn operations. We will place sensors and make observations at least at each of the four subplots within each treatment plot.

Rate of spread: Rate of spread will be quantified in two ways. First, we will observe and video fire spread. Second, at least four autonomous sensors, RASP-150 (Sigma Delta Technologies will be placed in each plot. These autonomous sensors contain a date and time clock that stops once temperatures exceed 150^{o}C. Locations and the time measurements of the three sensors will provide for calculation of rate of spread. Location of each sensor will be individually mapped with differentially corrected GPS. Triangulation will be used to determine the direction and forward rate of spread, regardless of the direction of fire spread and variability of rate of spread (Simard et al. 1984).

Flame Length and Fireline Intensity: A minimum of three color video cameras (3ccd), housed in fire-resistant cases (Kautz 1997) that will be used to record images from which flame height, flamelength, and fire duration can be measured. These will be placed in locations that include a view of one to several subplots and autonomous sensors. In addition, passive flame height sensors described in Finney and Martin (1992) will be established on site. These sensors are composed of strings dipped in flame retardant and are then nailed up on metal stakes that are set up in the burn area. Six passive flame height sensors will be placed in each 5 acre burn plot, two associated with each of the randomly placed fuel subplots.

Soil Surface Temperature and Duration: Surface and soil temperatures within the dripline of trees will be measured in order to determine the role of heat (maximum and duration) plays in tree mortality compared to crown scorch. Four thermologgers will be deployed in each of the burn plots. Each thermologger is composed of Type K thermocouples to measure temperature connected to dataloggers. On each thermologger, four thermocouples will be attached and two will be placed at surface litter and two within the top 6 cm of the soil surface.

<u>Data Analysis and Modeling</u>

Custom surface fuel models will be developed for each plot or subplot as needed based upon the fuel data and fire behavior measurements during prescribed burning. Existing fire behavior prediction models will be used to compare modeled rate of spread, fireline intensity, flamelength, fire type (surface, passive crown, active crown) torching index and crowning index for the different treatments. Three weather scenarios will be compared including high (80^{th} percentile), very high (90^{th} percentile), and extreme (97^{th} percentile) based on weather from a nearby applicable RAWS (remote automated weather station) station.

Analysis of Variance (ANOVA) will be used to test for significant differences among treatments for each response variable. Response variables are the measured fuel fire behavior, and tree mortality variables. The data will be analyzed as a complete randomized block design with subsamples within each treatment. Blocks will consist of 4, 20-acre areas randomly located in the study area. Within each block, the locations of each treatment will be randomly assigned. Within each treatment, 4 subplots will be randomly located. Therefore, there are 4 observations per treatment within each block. In addition, fire lines will be constructed around each treatment in each block. Even though the study area is relatively homogenous, blocking is necessary for controlling variability in soils, landscape position, topography, and for making the construction of firelines as efficient as possible. Further, blocking will serve to control variability in prescribed burn application, especially if they are not practical to burn on the same day as planned. ANOVA is based on the assumption that all groups of data are normally distributed and have equal variances. Therefore, the groups will be tested for normality by use of the probability plot correlation coefficient (PPCC) test and for equal variances by use of Hartley's test. If there is a significant difference in the overall means using the ANOVA F-test, then tests for individual differences between treatment means will be made using Tukey’s Honestly Significant Difference (HSD) multiple comparisons test.

Appendix C.

Directions to Red Mountain Plots

Blocks 1-3:
Take the 26S15 road South past Evans Flat campground.
Take a right on the 26S05 road.
2.2 miles down the 26S05 you will pass the 26S12 road.
At 3.3 miles there is a lookout rock and lone Ponderosa pine on the right side of the road, Block 3 is on the downhill side just before this.
At 3.5 miles Block 1 is on the uphill side about 100m, park by draw on right.
At 4.6 miles turn left on 26S37 at Baskett Pass.
At 5.5 miles turn left on a road that goes through a campsite.
Take the dim road going SW from campsite 0.1 mi to open area, flagging marks W corner of MPB unit. (the dim road goes through the N/A, control unit).

Block 4:
Take the 26S15 road South past Evans Flat campground.
Take a left on the 26S04 road.
0.6 mi stay on low road, don’t go left.
1.5 miles, pass 26S04C.
2.6 miles turn left on uphill road by stump
2.8 miles talk left uphill fork
3.2 miles = in middle of block 4.