Whiskeytown National Recreation Area

National Park Service
U.S. Department of the Interior

FIRE SEVERITY AND INTENSITY IN NATURAL AND MANIPULATED FUELS DURING SPRING BURNING IN MIXED SHRUB WOODLANDS

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INTRODUCTION

Whiskeytown National Recreation Area is characterized by an assortment of oak woodlands, chaparral, mixed conifer, and knobcone pine vegetation types. Historically, fire has been the primary tool used for ecosystem restoration and risk reduction in these fire-prone landscapes. However, the development of homes along the park's boundary exacerbates the level of risk associated with the application of prescribed fire. Within recent years, the park has applied a variety of alternative fire risk reduction methods, including vegetation chipping and mastication and understory thinning.
Although these techniques expand the list of options for fire managers, the ecological impacts and long-term effects are uncertain.

To address these uncertainties, Whiskeytown has initiated a study with support from the Joint Fire Science Program. The first phase of this project aims to examine fire severity and behavior in spring burned masticated and unmanipulated fuels. This project will provide critical information on the impacts of fuel reduction treatments and enable the Fire Management Program to refine fuel reduction projects to effectively manage for fire safe communities while balancing the ecological impacts.

STUDY OBJECTIVES

For masticated and unmanipulated treatments, this project proposes to identify and evaluate the following:

1. **The key components to fire severity and fire behavior prediction**
2. **The achievement of the following fire and resource management objectives:**

TABLE 1

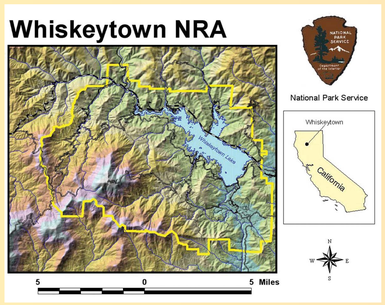
Objectives	Masticated	Unmanipulated
Reduce surface fuel accumulations (litter, duff, 1, 10, 100, 1000 hr TLFM)	15-35%	25-70%
Reduce live density of small (< 8"dbh) knobcone pine trees	0-25%	10-75%
Reduce live density of all other small (<8"dbh) trees	0-25%	0-40%
Limit mortality of overstory trees (> 8"dbh)	0-15%	0-15%
Reduce cover of live shrubs	0-25%	15-75%

STUDY DESIGN

The 70 acre study area is located between 1,250 and 1,500 ft. elevation and is characterized by an overstory dominated by black oak (*Quercus kelloggii*) and knobcone pine (*Pinus attenuata*). The dense shrub understory is dominated by whiteleaf manzanita (*Arctostaphylos viscida*), which accounts for 65-90% of total shrub cover. Sites were stratified by vegetation characteristics, slope and aspect, resulting in the selection of 10 different treatment blocks. Each treatment block was divided into 14 approximately equal-sized plots ranging from 0.05 to 0.15 ha, with two plots from each block representing one of the following seven different experimental treatments :

1. **Masticated brush burned in the fall**
2. **Masticated brush burned in the spring**
3. **Unmanipulated brush burned in the fall**
4. **Unmanipulated brush burned in the spring**
5. **Masticated brush left on the ground as mulch**
6. **Brush cut by hand and removed from the site to mimic biomass removal**
7. **Control (no mastication, burning, or thinning)**

Collection of fire behavior data.



MASTICATION

- **All mastication treatments occurred in the fall of 2002.**
- **Vehicle with rubber tires/tracks and no greater than 3-1/2 PSI ground pressure.**
- **Reduce understory bulk density 60-95% by thinning small trees and shrubs less than 3-4 meters in height.**
- **Retention of a limited shrub cover where overstory trees were absent.**

Treatment of a masticated plot.

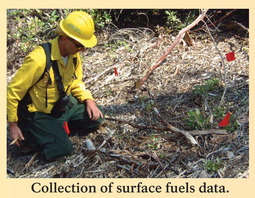
North Tree Fire ASV Posi-Track.

SPRING BURNING

Spring burning was initiated on April 8, 2003, following leaf-out of the dominant vegetative species. All fires were backing with respect to slope and/or wind, utilizing drip torches and applying a combination of strip and spot ignition patterns. Roughly 50% of the plots were completed by April 10, at which point burning was halted due to unfavorable (rainy) weather. The remaining plots were all burned on May 15, 2003.

- **Soil and duff moistures were very high (0.3-0.4 kPa tension) as recorded with a Delmhorst KS-D1 soil moisture tester at reference locations.**
- **Temperature extremes recorded on-site ranged from a low of 59°F at 1:30 pm on April 10, to a high of 71°F at 2:00 pm on April 9.**
- **Relative humidity ranged from a high of 73% recorded at 1:30 pm on April 10, to a low of 34% recorded at 2:00 pm on April 9.**
- **Winds averaged 2 mph with a maximum wind speed of 6 mph on April 10.**

Fire whirl in masticated fuels.



Collection of surface fuels data.

DATA COLLECTION

Using a stratified random approach, four monitoring plots were established within each burn plot for the following data:

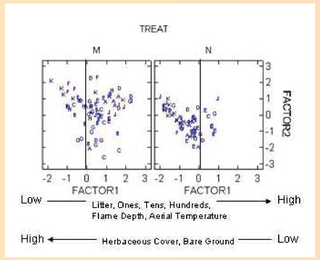
- **Pre and post fire measurements for fuels (1 hr, 10 hr, 100 hr, and 1000 hr cover, and litter and duff depth).**
- **On-site fire behavior estimates for flame length, flame zone depth, and rate of spread.**
- **Maximum temperature (175, 225, 325, 500, 750, and 1000°F) measured by temperature sensitive OMEGALAQ paints applied to brass tags located 0.5 meters above the surface, on top of the litter, and at the interface between duff and soil layers.**

On a macroplot basis, data was collected on the following:

- **Scorch of dominant trees and shrubs (within one month of burning).**
- **Shrub, overstory and pole-sized tree mortality (seven months post burn).**

RESULTS

A Principal Components Analysis (PCA) was used to characterize patterns in fire behavior, severity, and surface fuels (Graph 1). A two-tailed t-test on the PCA scores demonstrated a difference in the amount of surface fuels, fire behavior, and fire severity variables with mean Factor 1 scores for masticated plots (0.480) significantly ($P<0.001$) greater than in the unmanipulated plots (-0.583). The high Factor 1 scores for masticated plots indicated a high amount of surface fuels (litter, 1 hr, 10 hr, and 100 hr fuels), wide flame zone depth, and high aerial temperatures. Unmanipulated plots had a high percent cover of herbaceous species, bare ground, and low surface fuels, fire behavior and severity values.



Graph 1

- **A two-sample independent t-test for both flame length and flame zone depth indicated greater values in masticated plots when compared to unmanipulated plots. Mean flame length (28 inches) and flame zone depth (19 inches) were significantly greater ($P<0.001$) in masticated plots than the mean flame length (10 inches) and flame zone depth (6 inches) in the unmanipulated plots.**

- **A two-sample independent t-test for temperature tags placed in the litter and 0.5 meters off the ground indicated similar results. Mean temperatures for litter (65°F) and aerial (277°F) tags in the masticated plots were significantly greater ($P<0.001$) than temperatures recorded for litter (219°F) and aerial (59°F) tags in unmanipulated plots (Chart 1).**

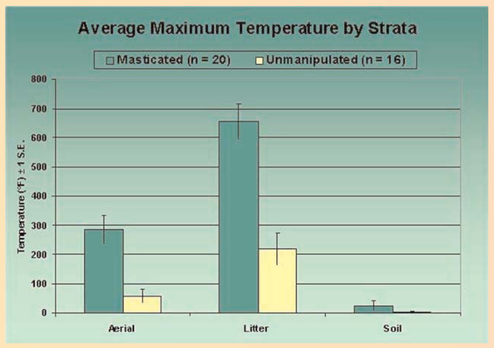


Chart 1

The mastication treatment significantly altered the fuel profile, converting live and dead standing materials into downed woody debris and resulting in an approximate 200% average cover increase in woody fuel loading for 1 and 1000 hr TLFM size classes, and greater than 300% average cover increase in 10 and 100 hr TLFM size classes.

In addition to a fuel quantity increase, the removal of overstory shading directly contributed to an increase in air circulation (drying of fuels) and an increase in direct solar radiation (increased surface fuel temperatures). With the combined effects of these factors, fuel consumption patterns differed significantly among treatments (Chart 2). As a consequence, fire behavior indices also differed significantly, leading to strikingly different severity effects to live vegetation (Table 2).

Table 2: Average Mortality of Trees and Shrubs

	Overstory (>8" dbh)		Pole (<8" dbh)	
Species	**Unmanipulated**	**Masticated**	**Unmanipulated**	**Masticated**
Knobcone Pine *(Pinus attenuata)*	0%	16%	15%	66%
Black Oak *(Quercus kelloggii)*	0%	23%	17%	47%
Canyon Live Oak *(Quercus chrysolepis)*	0%	49%	21%	98%
Shrubs	Unmanipulated 30%		Masticated 96%	

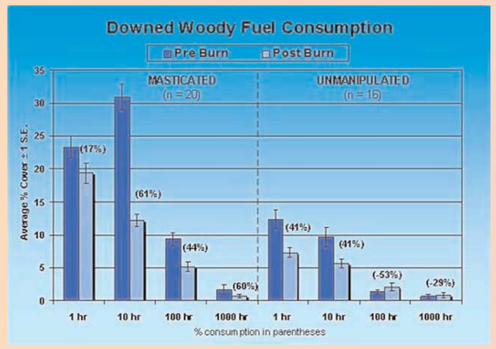


Chart 2

RECOMMENDATIONS

Results from this study showed significant differences between masticated and unmanipulated treatments. In particular, these results highlight the complexity of burning in masticated fuels when the objective is to retain overstory trees and some vegetation. Where spring burning of masticated fuels is a consideration, the following treatment recommendations have been developed for retention of residual vegetation:

1. Decrease in the level of mastication thinning
A decrease in the level of mastication would have contributed to lower fire behavior indices and severity results by reducing surface fuel loading, decreasing wind circulation, and increasing shading of fuels.

2. Apply fire under a more mild prescription
Without the experience of applying fire in masticated fuels, park staff developed a prescription based on unmanipulated fuels. Future prescribed fire treatments in masticated fuels should consider the differences in expected behavior and subsequent severity.

3. Avoid burning within the early growing season
The post green-up application of fire in our study coincided with a vulnerable phenological period in plant development, when leaf, bud, and cambium tissues are particularly susceptible to thermal effects. Prescription windows that are scheduled during the dormant season would likely minimize severity to retained vegetation.

Spring burning in unmanipulated fuels.

Spring burning in masticated fuels.

FUTURE WORK

- Fall 2003: Additional masticated and unmanipulated plots will be burned in the study area.
- Winter 2004: Samples will be collected to examine the effects of mastication and burning on soils.
- Spring 2004: Vegetation data will be collected in burn plots one year post burn and in control plots two years post treatment.

Vegetation monitoring.

ACKNOWLEDGEMENTS

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Toxicodendron diversilobum.