

## 1A.6 FUEL LOADING AND POTENTIAL FIRE BEHAVIOR AFTER SELECTIVE HARVEST IN COAST REDWOOD STANDS

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### 1. Introduction

While logging is used at times to reduce fuel continuity and subsequent fire behavior, there is an inherent increase in down woody fuels from logging slash immediately after harvest, which then potentially serves to create intense, fast spreading wildfires.

Stands of coast redwood (*Sequoia sempervirens* (D. Don) Endl.) on the Valencia forest near Santa Cruz, California were selectively harvested in late fall of 2002 according to prescriptions written by faculty within the Natural Resources Management Department at Cal Poly State University, San Luis Obispo. Various units were either tractor-skidded or cable logged to designated landings depending on terrain and access. The harvest was consistent with the overall mission of implementing an uneven-aged management strategy at Valencia (Piiro et al. 1997).

Because fuel depth and loading play a significant role in fire intensity and rate of spread in redwood forests (Nives 1989), these redwood stands could be at an elevated risk of wildfire following the 2002 harvest. Therefore, this study examined fuel loading and potential fire behavior immediately before and after the selective harvest to evaluate the potential fire hazard in the residual stand. Further, it sought to better understand the effect of yarding technique on fire hazard to determine if additional fuel mitigation is warranted on some areas after harvest.

### 2. Methods

The Valencia forest is in a maritime, Mediterranean climate with cool, rainy winters and dry summers that are moderated by a coastal fog belt. The site is dominated by 100-year old second growth that resulted from clearcuts across

the property, which provided building materials for reconstruction after the 1906 San Francisco earthquake.

Fuels measurements were taken in 23 permanent Continuing Forest Inventory (CFI) plots within the 2002 harvest boundary. 13 plots were located within cable logging boundaries, while the residual 10 plots were located in areas that were tractor skidded.

Surface fuels were sampled and resulting fuel loads were calculated using a point-transect method (Brown et al. 1982) immediately before the selective harvest in September 2002 and again in April 2002 after the selective harvest was completed. At each plot during each sampling period, two transects in random directions were installed. One and 10-hour fuels were sampled from 0-1 meters, 100-hour fuels from 0-1.5 meters, and 1000-hour and larger fuels from 0-13 meters on each transect. Surface fuel, litter, and duff depths were measured at 1 and 1.5 meters on each transect. Because the site was dominated with second growth coast redwood, duff fuel loading was calculated using a bulk density of  $7.15 \text{ Mg ha}^{-1} \text{ cm}^{-1}$  (Finney and Martin 1993). Fixed effects of sampling period and skidding treatment on individual parameters were analyzed using a general linear model procedure (Statistical Analysis System Version 8.02, SAS Institute Inc., Cary, NC, USA).

Potential fire behavior was modeled using the BehavePlus fire modeling software (Version 2.0.0). Pre- and Post-harvest fuel models were created with values initialized from Fuel Model 8, which best characterized the stand before and after the harvest. Initial values for 1-hour, 10-hour, 100-hour fuel loads, and fuel depths were replaced with mean values calculated from the field sampling. For simulation purposes, winds were input as blowing upslope from  $0\text{-}32 \text{ km hr}^{-1}$ .

Slope was input as 35°, which was the mean slope on the sampled plots.

### 3. Results and Discussion

Fuel loading of the 1-hour, 10-hour, and 100-hour timelag fuel classes, as well as litter loading and fuel depth were all significantly higher after the selective harvest (Table 1). These results were expected given the inherent deposition of residual slash during harvest. However, loading in the larger 1000-hour size classes (>7.6 cm) did not increase significantly after harvest, which was somewhat unexpected.

Because tractor skidding intrinsically crushes some slash into the ground during transport to the logging deck, it was originally hypothesized that this method would have a significantly lower fuel loading and fuel depth than cable logging. However, while the mean loading of all parameters were lower in the tractor skidded plots than in cable yarded plots, none differed significantly (Table 1), perhaps due in part to the limited number of plots presented here. It may also result from the mandatory lop-and-scatter fuels treatments after harvests that are mandated by the state of California to mitigate against wildfire hazard. Thus, it does not appear at present that additional fuel mitigation is warranted in areas of cable logging on the site.

As expected, higher fuel loadings and fuel depths after harvest led to a greater fire behavior in the post-harvest stand. Figure 1 illustrates the effect of increasing winds on rate of spread and flame length before and after harvest as compared to Fuel Model 8, a timber type characterized by a closed canopy and litter understory. Before the harvest, potential fire behavior would be fairly benign. However, after harvest, both the potential rate of spread and fire intensity increase dramatically, leading to a significantly greater fire hazard.

While not nearly as prolific as in chaparral or in Sierra mixed conifer stands, fire has historically played a substantial ecological role in redwood forests. Typically, fires in the redwood type are low-intensity surface fires as a result of a maritime, Mediterranean climate. Before harvest, fires on the Valencia forest would likely have little residual effect on larger trees due to low fire behavior and redwood's thick, insulating bark. However, the increased fuel load from harvesting coupled with hot, dry foehn winds, which are not

uncommon on the site, could quickly increase fire behavior and subsequent mortality of the residual high-value trees in these stands. Further, home sites adjacent to the study site are presently at an increased risk of wildfire

The length of elevated fire risk in these stands is not known at present. The cool, moist climate that characterizes the site likely facilitates an environment conducive to elevated decay rates. To better understand the dynamics of fuel loading and potential fire behavior in coast redwood stands, fuels on the site will be regularly measured and evaluated.

### 4. References

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Table 1. Mean loading ( $\text{Mg ha}^{-1}$ ) of various timelag fuel classes, fuel depth, and slope on a coast redwood forest near Santa Cruz, California. Data were collected in permanent plots before and after a selective harvest (Pre-harvest and Post-harvest, respectively) in areas that were yarded by either tractor skidder or cable lines (Tractor and Cable, respectively). Numbers in parentheses represent standard errors.

Parameter	Pre-harvest	Post-Harvest		P-values	
	Combined, n=23	Tractor, n=10	Cable, n=13	Pre vs. Post-harvest	Tractor vs. Cable (Postharvest only)
1-hour					
10-hour	0.94 (0.14)	1.27 (0.30)	1.70 (0.25)	0.02	0.27
100-hour	2.07 (0.42)	2.97 (0.83)	5.21 (2.00)	0.09	0.36
1000-hour (Sound)	3.2 (0.82)	5.90 (1.53)	8.34 (2.35)	0.02	0.42
1000-hour (Rotten)	13.46 (4.76)	14.25 (4.30)	17.05 (6.27)	0.70	0.73
Duff	10.10 (3.57)	10.69 (3.29)	12.79 (4.70)	0.70	0.73
Total Load	0.08 (0.01)	0.13 (0.03)	0.10 (0.02)	0.01	0.93
Fuel Depth	29.84 (8.37)	35.20 (8.10)	45.19 (12.29)	0.34	0.53
Slope	0.05 (0.01)	0.12 (0.02)	0.20 (0.07)	0.01	0.57
		28.4 (2.66)	39.57 (7.26)		0.24

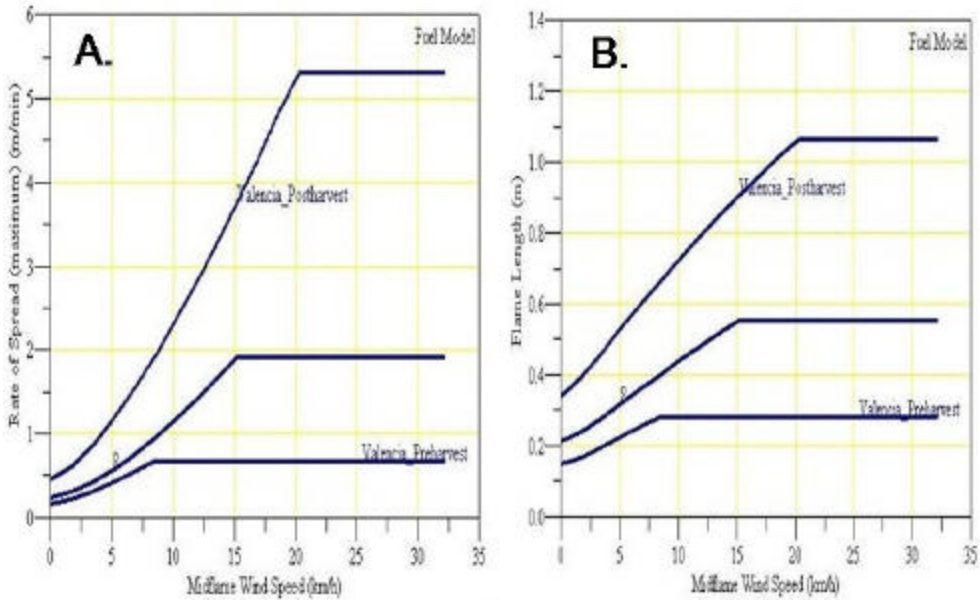


Figure 1. Simulated rate of spread (A.) and flame length (B.) on a coast redwood forest near Santa Cruz, California before and after a selective harvest, relative to standard Fuel Model 8. Model assumes a  $35^\circ$  slope, wind blows uphill, and fuel moistures for 1-hour, 10-hour, and 100-hour fuels of 5%, 6%, and 7%, respectively.