When Logged Units Burn in a Wildfire, Does Slash Treatment Mitigate Effects?[1]

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ABSTRACT: Major wildfires have affected millions of acres of forest lands in the continental United States during recent years. Often, these wildfires burn through intensively managed, timber producing areas. This study presents a comparison of fuel consumption, soil fire severity, and smoke pollutant production from logged units treated with prescribed fire, and logged units that were left untreated, then burned during the Shady Beach wildfire in western Oregon. There was an average of 55 percent less fuel consumed when the Shady Beach wildfire burned across a treated unit as compared to an untreated unit. The treated units had a lower index rating for soil fire severity and produced 59 percent less smoke than the untreated units.
Keywords: wildfire effects; emission production; fuel consumption; soil fire severity

INTRODUCTION

In the last few decades, millions of acres of forest lands in the continental United States have been affected by wildfire. Several of these wildfires, such as the Shady Beach Fire in Oregon, burned through both untreated logging slash areas and areas treated by broadcast burning. Visual evidence suggests that the immediate site effects were more severe in the untreated areas. To quantify the spatial variability in fire severity and relate fire severity to prefire fuel treatment and postfire effects (such as soil damage, nutrient loss, vegetation response, biological diversity subsequent to the fire, or visibility and health effects from smoke production), it is necessary to understand fuel consumption on treated and untreated logging sites burned by wildfire.

The objectives of this study were to (1) reconstruct post-logging fuelbed conditions, determine biomass consumption during treatment and wildfire, and estimate smoke emissions produced on untreated and treated logging slash areas of the Shady Beach wildfire; and (2) demonstrate the differences in soil fire severity and smoke production from a wildfire passing through untreated areas and sites treated with prescribed fire.

Nineteen clearcut units affected by the Shady Beach wildfire were selected for the study. The units are located on the Rigdon Ranger District, Willamette National

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Forest, Oregon, and on private land owned by the Pope and Talbot Company. Nine of these units were prescription burned before the wildfire; the other ten were not.

METHODS

Reconstruction of post-logging biomass profiles for this study were done by using surface and aerial photographs, biomass profiles developed for western Oregon by owner class (Sandberg et. al 1988), smoke management reports, and available ground inventories.

Thirty permanent plots were established in a systematic grid within each unit selected to measure post wildfire fuel loading. Large woody fuel loading for each unit was estimated by using the planar intersect inventory (Brown 1974). Woody fuel loading was measured by two permanent transect lines (100 feet each) randomly directed from each plot, for a total of 6,000 feet of inventory line. Duff-depth measurements were taken at two points along each transect line--a total of 120 measurements per unit--to estimate the amount of duff remaining after the wildfire.

Postfire aerial and ground photographs, ground-fuel inventories, weather documentation, and fire behavior documentation were used to reconstruct the amount of biomass consumed and to evaluate the fire's effect on the site. Fire behavior documentation and the best available emission factors were used to estimate emissions production (Ward and others 1989).

Soil fire severity was estimated by using a qualitative scale presented in the environmental impact statement prepared by the Shady Beach Fire Recovery Project (USDA Forest Service 1989). Severity and mineral soil exposure were estimated by 2 microplots, 2 feet in diameter, located 10 feet and 100 feet along each transect line.

Data from the weather statuib at Oakridge Airport were used as a primary source to represent the fire area. Where necessary, supplementary weather data from the weather stations at the Willamette Fish Hatchery and the Mckenzie Bridge were used to reconstruct a weather record for the years in which prescribed burning was done on the treated units. The weather records, plus preburn loading of woody fuels and duff, were then used in CONSUME (Ottmar et. al 1993) to predict woody fuel and duff consumption during the pre-wildfire treatments. Remaining fuels were compared to fuels measured after the wildfire to determine fuel consumption on treated units during the wildfire. Fuel consumption on untreated units was determined by using estimates of post-logging fuels and measurements of post-wildfire fuels. The determined fuel consumption was then used in the Emission Production Model (EPM) to estimate emissions from both treated and untreated units during the wildfire, and to estimate emissions from treated units during slash burns (Peterson and Ottmar 1991).

STATISTICAL ANALYSIS

T-tests were completed to compare treated and untreated units for woody fuel loading and duff depth, measured fuel consumption, emissions, and mineral soil exposure on areas previously logged. A Median test was done to compare soil severity ratings on treated and untreated units. A one-way ANOVA and the Student-Newman-Keuls (SNK) test was conducted to analyze the relation between post-fire soil severity ratings and fuel consumption that resulted from the wildfire. Significance of all tests is reported at alpha=0.05, unless otherwise noted. All tests were done by using SAS, version 6.03 (SAS 1990).

RESULTS

Woody fuel loadings after logging ranged from 20 to 107 tons per acre; duff depths ranged from 0.9 to 2.2 inches (table 1). T-tests showed no significant differences in pretreatment or wildfire woody fuels and duff between treated and untreated units. After the wildfire, woody fuel loadings ranged from 11 to 36 tons per acre on treated units, and 8 to 42 tons per acre on untreated units. Duff depths ranged from 0 to 0.3 inches on treated units, and 0 to 0.5 inches on untreated units.

Wildfire consumption of woody fuels ranged from 1 to 60 tons per acre on treated units, and 12 to 81 tons per acre on untreated units (table 1). Duff consumption ranged from 0 to 30 tons per acre on treated units, and 17 to 41 tons per acre on untreated units. T-tests showed consumption of woody fuels and duff, as well as total fuels (woody plus duff), to be significantly lower on treated units.

Mineral soil exposures ranged from 94 to 98 percent on treated units, to 86 to 100 percent on untreated units. A T-test showed no significant difference in mineral soil exposure between treated and untreated units.

Soil fire-severity estimates yielded overall ratings of moderately low to high on treated units, and moderate to high on untreated units. Five untreated units were rated high severity, compared to only one treated unit. When comparing all treated versus all untreated units, the untreated units show significantly higher ratings. When pairs of treated and untreated units are compared (one treated unit was added to make 10 pairs), seven pairs show higher severity ratings on untreated units and three pairs show no significant difference.

TABLE 1: FUEL LOADING AND FUEL CONSUMPTION

UNIT	POST LOGGING WOODY T/A	POST LOGGING DUFF DEPTH IN	POST WILDFIRE WOODY T/A	POST WILDFIRE DUFF DEPTH IN	MEASURED CONSUMPTION WOODY T/A	DUFF T/A	TOTAL T/A
TREATED							
T1	97	2.2	15	0.0	39	2	41
T2	107	2.2	36	0.1	19	0	19
T3	104	2.2	17	0.1	41	0	41
T4	97	2.2	14	0.0	60	30	90
T5	50	0.9	22	0.0	8	13	21
T6	48	2.0	34	0.5	0	0	0
T7	58	1.8	16	0.0	19	15	34
T8	71	0.9	11	0.1	38	0	38
T9	63	2.2	29	0.3	1	0	1
UNTREATED							
U1	97	2.2	26	0.1	71	39	110
U2	97	1.5	26	0.0	71	28	99
U3	58	2.2	13	0.1	45	39	84
U4	97	2.2	16	0.0	81	41	122
U5	61	0.9	35	0.0	26	17	43
U6	20	1.8	8	0.0	12	34	46
U7	42	1.8	9	0.0	33	34	67
U8	63	2.2	42	0.2	21	38	59
U9	63	2.2	37	0.5	26	32	58
U10	74	2.2	21	0.0	53	41	94

An ANOVA of fuel consumption and soil fire severity was significant at 0.001. The SNK test showed that mean total consumption was significantly greater when severity ratings were high (97.6 tons per acre) than when severity was moderate (56.4 tons per acre) or moderately low (27.0 tons per acre), at alpha=0.05. No significant difference was found for mean consumption between severity ratings at moderate and moderately low.

Emissions during the wildfire, expressed as total suspended particulates (TSP) in pounds per acre, ranged from 789 to 2,271 on treated units, and 1,792 to 3,447 on untreated units (table 2). Emissions from the prescribed burns on treated units ranged from 713 to 3,132 pounds per acre TSP. A T-test showed emissions during the wildfire to be significantly lower on treated units. Total emissions for prescribed-burn treatment plus wildfire on treated units were compared to wildfire emissions on untreated units. No significant difference was found.

TABLE 2: EMISSIONS BY UNIT

	TREATMENT LBS/ACRE	WILDFIRE LBS/ACRE		TREATMENT + WILDFIRE LBS/ACRE	
	TOTAL TSP*	WOODY TSP	DUFF TSP	TOTAL TSP	TOTAL TSP
TREATED UNITS					
T1	2793	965	48	1013	3805
T2	3132	894	0	894	4026
T3	2952	932	0	932	3884
T4	1074	1251	1020	2271	3345
T5	713	773	391	1164	1887
T6	1973	356	283	639	2612
T7	1152	573	483	1056	2208
T8	1242	642	0	642	1884
T9	2350	642	147	789	3139
UNTREATED UNITS					
U1		1977	1327	3304	
U2		2121	861	2982	
U3		1375	1342	2717	
U4		2120	1327	3447	
U5		1446	470	1916	
U6		698	1094	1792	
U7		1196	1059	2255	
U8		960	1376	2336	
U9		960	1376	2336	
U10		1697	1335	3032	

* TSP = TOTAL SUSPENDED PARTICULATES IN POUNDS PER ACRE

DISCUSSION

Woody fuel loadings and duff depths on previously logged sites were similar for both treated and untreated units. The reduction in fuels accomplished by the prescription burns on treated units is reflected in pre-wildfire mean loadings: woody fuels measured 48 tons per acre on treated units versus 72 tons per acre on untreated units; duff measured 7.5 tons per acre on treated units versus 35.5 tons per acre on untreated units. Subsequent total fuel consumption (woody and duff)

resulting from the wildfire on treated units was less than half the consumption on untreated units.

The fact that average mineral soil exposure was nearly 100 percent on both treated and untreated units after the wildfire indicates that the duff which remained after prescribed fire was consumed in the wildfire. From estimates of consumption during treatment, fuel loadings of 1-hour and 10-hour fuels at the time of the wildfire was less than 1 ton per acre, and 100-hour loadings were 1 to 2 tons per acre. The absence of small fuels on treated units, which would carry the fire and impact duff consumption, means that the duff would have had to burn independently to consume. Sandberg (1980) found that duff less than 4.1 inches deep would burn independently of surface fire when 1000-hour fuel moisture was less than 18 percent [using the National Fire Danger Rating (NFDR) system]. Duff on treated units was shallow (0.1 to 1.6 inches) and NFDR-1000 was 15 percent at the time the wildfire started. Therefore, while duff consumption was reduced on treated units, no appreciable retention of the organic layer was accomplished by the treatment when units burned again in the wildfire.

Although treatment with prescribed fire did not succeed in preserving the organic layer, a difference was seen in the impact of wildfire on treated versus untreated sites. Lower soil fire-severity ratings on treated units are an indication of less severe impacts from wildfire. Fuel consumption associated with high severity ratings was shown to be significantly higher than either moderate or moderately low ratings. The fact that high severity ratings occurred on five untreated sites and on only one treated site indicates a more severe impact occurred on the soil in the untreated units. The treated site that had a high soil fire-severity rating also had--at the time of the wildfire--the highest woody fuel loading and at least twice the duff of any treated unit.

Significant reductions in emissions accompanied reduction in fuel consumption on treated units in the wildfire. Estimated total emissions from treated units during the wildfire was less than half the emissions from untreated units. Emissions that occurred during the prescribed burn treatment and during the wildfire on treated units were combined and compared to emissions from the wildfire on untreated units; no significant difference was seen. Although treatment produced no cumulative savings in smoke production, over half the smoke was produced during treatment when conditions for favorable smoke dispersal can be prescribed.

CONCLUSIONS

The Shady Beach wildfire provided an opportunity to compare fuel consumption and emissions from treated and untreated logging slash areas during a wildfire. The results of the study support the following conclusions:

1. Fuel consumption on treated units was significantly lower than consumption on untreated units. The consumption on treated units was less than half that of untreated units. This supports the assumption that treating logging slash areas with prescribed fire reduces available fuels for wildfires.

2. Another objective of applying a prescribed fire is to retain part of the forest floor organic layer. A combination of weather variables allowed the duff to burn independently during the wildfire, resulting in almost 100-percent mineral soil exposure on both treated and untreated units. No retention of forest floor was accomplished by fuel reduction through prescribed burning when units burned again in this wildfire.

3. Lower soil fire severity ratings were seen on treated units. When the ratings were in the high severity range, as they were on five untreated units, significantly higher fuel consumption occurred.

4. Significantly lower emissions were coincident with significantly lower fuel consumption on treated units. The treated units produced 59 percent less emissions per acre than untreated units.

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