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POSTHARVEST RESIDUE BURNING UNDER ALTERNATIVE SILVICULTURAL PRACTICES

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ABSTRACT

Prescribed burning of logging slash was done in clearcut, overstory removal, and understory cutting units in a Douglas-fir stand on the Lubrecht Experimental Forest near Missoula, Mont. The burning prescriptions and actual burning conditions are described. Data on preharvest, postharvest, and postburn conditions are reported.

KEYWORDS: prescribed burn, fire, fuels management, logging slash

INTRODUCTION

Timber harvesting activities in western Montana coniferous forests leave varying amounts of wood residue after the merchantable products have been removed. Burning is a common means of treating these residues. In addition to consuming the smaller fuels and thus reducing the fuel hazard, burning is an effective means of site preparation for regeneration. It also stimulates plant nutrient release in the soil. Partial cut silvicultural systems of harvesting could reduce fuel amounts or complicate burning to such an extent that burning logging debris becomes questionable as a logging site treatment. The more fuel that exists after logging, the greater the flexibility in prescribing slash burning. The use of burning as a slash treatment depends on the weight, depth, and size class distribution of fuels, and the constraints imposed by the silvicultural system selected for a given timber stand.

This study was conducted to determine the influence of three silvicultural practices on fuel availability and on the physical feasibility of postharvest slash burning. The study took place on the University of Montana's Lubrecht Experimental Forest and included three logged units, each receiving a different silvicultural treatment. These units are defined briefly as "overstory removal," where all trees over 9 inches d.b.h. were cut with an effort to leave a substantial understory stand; "understory removal," where the overmature trees were cut, the 5-9-inch d.b.h. class was thinned, and all trees less than 5 inches d.b.h. were removed and remaining stems slashed; and "clearcut," where merchantable material is removed and slash is left.

Table 1 shows the preharvest timber stand characteristics and table 2 the silvicultural prescription imposed on each cutting unit.

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Table 1.--*Stand characteristics (preharvest, Lubrecht Experimental Forest)*

Sawtimber: (9 inches d.b.h. +)	85 stems per acre (212 stems per hectare) One-half is over 120 years Three-fourths is Douglas-fir Heights range from 50-100 feet (15-30 meters)
Poles: (5-9 inches d.b.h. +)	115 stems per acre (288 stems per hectare) One-fourth is over 120 years Three-fourths is Douglas-fir Heights range from 30-60 feet (9-18 meters)
Saplings: (0.1-5 inches d.b.h.)	400 stems per acre (1,000 stems per hectare) Over three-fourths is Douglas-fir Heights range from 5-30 feet (1.5-9 meters)
Seedlings: (<0.1 inch d.b.h.)	2,000 stems per acre (5,000 stems per hectare) Almost all are Douglas-fir

Table 2.--*Silvicultural prescriptions (harvesting specifications, prescribed burn, Lubrecht Experimental Forest)*

			Stems per acre (per hectare)			
			Cut[1]		Leave[1]	
Prescription	Cutting specifications[1]		DF	PP and WL	DF	PP and WL
Understory removal	Cut only "older" trees	Sawtimber (9 inches)	50 (125)	> 0 (0)	15 (38)	<20 (50)
	>9 inches d.b.h.	Poles (5-9 inches)	55 (138)	0 (0)	30 (75)	<30 (75)
	Thin 5-9 inches d.b.h.	Saplings (1-5 inches)	300 (750)	100 (250)	--	--
	favoring WL and PP	Seedlings (4 ft)	2,000 (5,000)	--	--	--
	Cut all trees <5 inches d.b.h.					
Overstory removal	Cut all 9 inches d.b.h.	Sawtimber	65 (163)	20 (50)	--	--
	Cut all DF 5-9 inches d.b.h.	Poles	85 (170)	0 (0)	--	<30 (75)
	and thin remaining WL	Saplings	225 (563)	75 (188)	75 (188)	25 (63)
	and PP if needed.	Seedlings	1,850 (4,625)	--	150 (375)	--
	Thin trees 5 inches d.b.h.,					
	favoring DF					
Clearcut	Clearcut all	Sawtimber	65 (163)	20 (50)	--	--
	merchantable material	Poles	85 (170)	30 (75)	--	--
	Slash remaining	Saplings	300 (750)	100 (250)	--	--
	material	Seedlings	2,000 (5,000)	--	--	--

[1]DF = Douglas-fir
PP = Ponderosa pine
WL = Western larch.

The area was logged in summer 1977 using crawler tractors for skidding. The stand remaining after harvest is summarized in table 3. Prescribed burning was done in late summer 1978, after one season of slash curing. Each silvicultural treatment poses a different set of burning constraints and each will be discussed separately.

Table 3.--*Lubrecht harvesting study postharvest stand table*

	Number of trees per acre							
	Overstory removal				Understory removal			
D.b.h.	DF	WL	PP	Total	DF	WL	PP	Total
2	272.3	2.3	2.3	276.9				
4	109.2	1.5	2.3	113.0				
6	42.3	2.3	--	44.6	10.7	--	1.4	12.1
8	20.8	6.9	--	27.7	11.3	--	--	11.3
10	.8	.8	--	1.6	12.0	--	--	12.0
12					4.7	1.3	--	6.0
14					6.7	.7	--	7.4
16					2.0	.7	--	2.7
18					4.0	1.3	--	5.3
21+					.7	--	.7	1.4
Totals	445.4 (1,113.5/ha)	13.8 (34.5/ha)	4.6 (11.5/ha)	463.8 (1,159.5/ha)	52.1 (130.3/ha)	4.0 (10.0/ha)	2.1 (5.3/ha)	58.2 (140.6/ha)

Clearcut

Slash from the harvesting consisted of some concentrations. Some cleared areas had no slash because of skid trails. The fuel bed contained 29 tons of dead fuel per acre (65 metric tons per hectare).

Burning slash in clearcut areas is designed to consume as much fuel as possible as a fire hazard reduction, add as many soil nutrients as possible from the ash, and provide as many regeneration sites as possible for starting new forest stands. The idea is to get a fire as hot as possible within the constraints of safety and confinement to the clearcut area. In this study, the following prescription seemed feasible to accomplish this:

Fine fuel moisture	10 - 18 percent
Temperature	60° - 80°F (15° - 27°C)
Relative humidity	20 - 60 percent
Windspeed	less than 12 mi/h (19 km/h)

Ignition pattern: Ignite the fire such that a concentration of heat will develop down the center of the area first, then ignite the edges so the fire will "pull in" toward the center.

Actual burning of this unit occurred under the following conditions:

Fine fuel moisture	18 percent
Temperature	84°F (29°C)
Relative humidity	18 percent
Wind velocity	2 mi/h (3.2 km/h)

The fire was ignited so that heat would develop rapidly in the center of the area. As the edges were later ignited, the flames pulled toward the center producing a tall straight convection column. The igniting took about 15 minutes. The fire burned intensely, rapidly consuming the fuel load; 64 percent of the dead fuel was consumed (table 4). The fire blackened the entire area except where skidding had removed all fuel down to the mineral soil. A variety of microsites were created for regeneration.

Table 4.--*Lubrecht harvesting study fuel data*

Fuel size class	Tons per acre					
	Preburn			Postburn		
	Clear-cut	Overstory Removal	Understory removal	Clear-cut	Overstory removal	Understory removal
0-1/4 inch	0.71	0.63	0.46	0.06	0.18	0.20
Percent consumed	--	--	--	92	71	57
1/4-1 inch	3.95	2.43	2.43	.53	1.11	1.36
Percent consumed	--	--	--	87	54	44
1-3 inches	4.84	7.26	4.84	2.03	3.41	3.38
Percent consumed	--	--	--	58	53	30
3 inches + sound	15.26	5.94	8.27	7.36	3.82	6.52
Percent consumed	--	--	--	52	36	21
3 inches + rotten	4.66	5.82	2.13	.74	.32	.52
Percent consumed	--	--	--	84	95	76
Total	29.42 (66.9 t/ha)	22.08 (49.6 t/ha)	18.13 (40.8 t/ha)	10.72 (24.1 t/ha)	8.84 (19.9 t/ha)	11.98 (26.85 t/ha)
Percent consumed	--	--	--	64	60	34

Overstory Removal

The stand remaining after harvesting consisted of 464 trees per acre (1 160 per hectare), which contained 314 cubic feet per acre (23.6 cubic meters per hectare); 100 (250/ha) were selected as "leave" trees. These remaining trees were the smaller ones of the stand. Many of them between 5 and 11 inches d.b.h. had been suppressed by the overstory, but were considered the best available for developing the future stand.

The dead fuel accumulation on the forest floor plus slash from the cut trees amounted to 22 tons per acre (55 metric tons per hectare). This fuel lay in a fairly continuous mat, interlaced by skid trails on which no fuel existed.

To assure that the smaller isolated leave trees and clumps of seedling-sized trees a foot or so high would survive a slash disposal fire, limited rearrangement of this fuel was necessary. Some hand piling helped reduce fuel concentration adjacent to leave trees and clumps of seedlings The resulting fuel bed consisted of piles with scattered limbs and tops put in areas where no leave trees existed. This treatment took 5 man-days of effort for the unit, or 1.1 man-days per acre.

The job required of this prescribed fire was: (a) to eliminate the fire hazard in dead fuels less than 1 inch in diameter; (b) to provide some added soil nutrients from the ash; and (c) to limit its intensity and location should a wildfire occur so as to preserve the understory trees. This understory consisted of trees 5 inches d.b.h. and less as well as clumps of seedling-sized trees purposefully left after harvesting. In this situation, fire has a difficult role to play because the small trees and clumps of seedlings are not capable of tolerating much heat. Some degree of heat management can be accomplished by careful igniting procedures, and by burning under conditions close to the following prescription:

Fine fuel moisture	17 - 22 percent
Temperature	60° - 70°F (15° - 21°C)
Relative humidity	30 - 60 percent
Windspeed	4 - 8 mi/h (6.4 - 12.8 km/h)

Ignition pattern: Ignite in strips concentrating on piles of fuel and then wait for the heat to "pulse out" before igniting further fuel. Move the firing into the wind.

Actual burning of this unit occurred under the following conditions:

Fine fuel moisture	20 percent
Temperature	75°F (24°C)
Relative humidity	30 percent
Wind velocity	4 mi/h (6.4 km/h)

The fire was ignited on the uphill side first, then progressively down slope toward the road. The unit was considered as two separate parts because of the difference in terrain: the west was a slope, the east half flat. Igniting was complete on the west half before it was started on the east. Piles and concentrations of slash were ignited and allowed to "pulse out" in heat output before any further ones were ignited. This scheme functioned well and allowed us to manipulate the fire well enough to preserve most of the leave trees and some of the clumps of seedling-size Douglas-fir trees. Many of the clumps of seedling-size trees survived because there was almost no dead fuel present. Where concentrations of fuel existed, the fire burned all fuel and created some microsites for possible seedling establishment.

The conditions under which this fire was ignited allowed enough flexibility for fire manipulation so that close to desired results were possible. About half of the marked leave trees were killed from crown scorching and excess cambium heating, and some clumps of seedlings were lost. Many leave trees, however, were of low vigor and had sustained dead crown material from spruce budworm defoliation.[2] This probably increased their susceptibility to fire. The fire consumed 60 percent of the available fuel, including 95 percent of the rotten wood fuel (table 4).

Understory Removal

The stand remaining after harvesting consisted of 58 trees per acre (145 per hectare), containing 1,122 cubic feet per acre (84 cubic meters per hectare). These trees were reasonably well spaced and constituted a forest stand suitable for many years of continued growth.

The dead fuel accumulation on the forest floor plus that from the cut trees amounted to 18 tons per acre (40 metric tons per hectare) (table 4). This fuel, in an uneven array, had some concentrations piled around the standing leave trees.

In order to protect the leave trees from excessive heat, we rearranged some of it. Concentrations of slash fuel next to the leave trees were scattered, but no hand piling was done. This treatment resulted in a more even fuel bed but did not anywhere near make a completely uniform fuel bed. This treatment took 6 man-days for the unit, or 1.1 man-days per acre (2.75 man-days per hectare).

The job required of the fire here was: (a) to reduce the fire hazard by eliminating the fine fuels (up to 1 inch in diameter); (b) to add some nutrients to the soil from the resulting ash; and (c) to limit the intensity such that the leave trees would not be killed by cambium heating or by excessive scorch to the live crowns. This type of fire is possible if fuel and weather conditions are right and if care is taken during igniting. The following prescription was deemed suitable in this case:

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[2]Benson, Robert E. Damage from logging and prescribed burning in partial cut Douglas-fir stands. USDA For. Serv., Intermt. For. and Range Exp. Stn., Res. Note. [In press.]

Fine fuel moisture	18 - 25 percent
Temperature	60° - 70°F (15° - 21°C)
Relative humidity	30 - 60 percent
Windspeed	5 - 8 mi/h (8 - 12.8 km/h)

Ignition pattern: Ignite in strips that head at right angles to the prevailing wind and that move progressively into the wind.

Table 4 shows postburn fuel amounts and the percent of fuel consumed by size classes. The unusually low consumption of fuel in the understory removal unit resulted from the large proportion of tree boles and small amount of fine fuels plus high fuel moisture during the burn.

Actual burning of this unit occurred during the following conditions:

Fine fuel moisture	24 percent
Temperature	70°F (21°C)
Relative humidity	28 percent
Windspeed	0 mi/h

The fire was ignited in strips along the east side, then moved progressively west. It was necessary during this burn to buck up and pile some of the material to get a satisfactory burn. The fuel consisted largely of trees 3 to 5 inches in diameter that were suppressed much of their life and had little crown. This condition produced a small amount of fine fuels, resulting in many unburned pieces. Less than 5 percent of the marked leave trees were killed. About 25 percent had light crown or bole scorch.

Prescribed burning is feasible under standing timber where the slash is created by removing the understory trees. The fuel, however, is predominantly tree boles with a minimum of fine fuels. This condition makes it difficult to produce the lesser amount of heat desired for standing tree protection. Some fuel rearrangement is also needed because of the tendency for accumulations of limbs and tops to occur adjacent to the standing trees. If the fire manager is willing to do limited fuel arrangement work ahead of burning and can wait for a day with the prescription conditions, such a practice is possible. The results of this experimental burn showed that only 34 percent of the total fuel was consumed (table 4). This rather low fuel consumption occurred because the burn was conducted at the "wet end" of the prescription limits and because of the limited amounts of fine fuel in proportion to the amount of larger fuel (3 inches +).

DISCUSSION

The use of fire for hazard removal and site preparation was evaluated in this study. While fire use necessitates having sufficient fuel to burn, it is also necessary to manipulate the fire for desired levels of heat output. In the three treatments--clearcut, overstory removal, and understory removal--where no fuel was added or removed after the harvesting, ample fuel existed for such burning.

The problem here was not with fuel amount, but with other constraints such as air quality restrictions and the close prescription limits for burning under standing trees. The study showed that when fuel composition lacks sufficient fine fuels, as it did in the understory removal unit, the fuel moisture needs to be lower for the adequate fuel consumption a suitable prescription would need. This condition makes it difficult to manage the fire so that scorching and cambium heating can be kept at a suitable minimum. In the overstory removal unit there was a suitable mixture of fine and larger fuels so that adequate fuel consumption was possible at the prescribed limits of fuel moisture. The problem here was that small leave trees and clumps of seedlings were killed easily by the fire.

The standard local constraints on prescribed burning for smoke management limit the days suitable for burning under standing timber more than they do for clearcut burning because of the need for higher fuel moisture. This limitation can be tolerated, however, and more experience will probably show it can be done under a wider variety of conditions than previously thought feasible.

We also need to recognize that, although using fire to prepare sites for continued timber production or for starting a new stand may be cheaper than other methods, it does require spending money for fuel bed preparation. This cost probably can be reasonable if fuel arrangement is limited to protecting the standing trees from obvious concentrations of fuels around their bases.

This study showed that clearcutting, overstory removal, and understory removal harvesting resulted in sufficient fuel for adequate prescribed fire. The fuel reduction was greatest in the clearcut and least in the understory removal, but was adequate to sufficiently reduce the fire hazard to acceptable levels (fig. 1). The cost of fuel manipulation and subsequent thinning was not excessive, at least on the relatively level ground where this study took place.

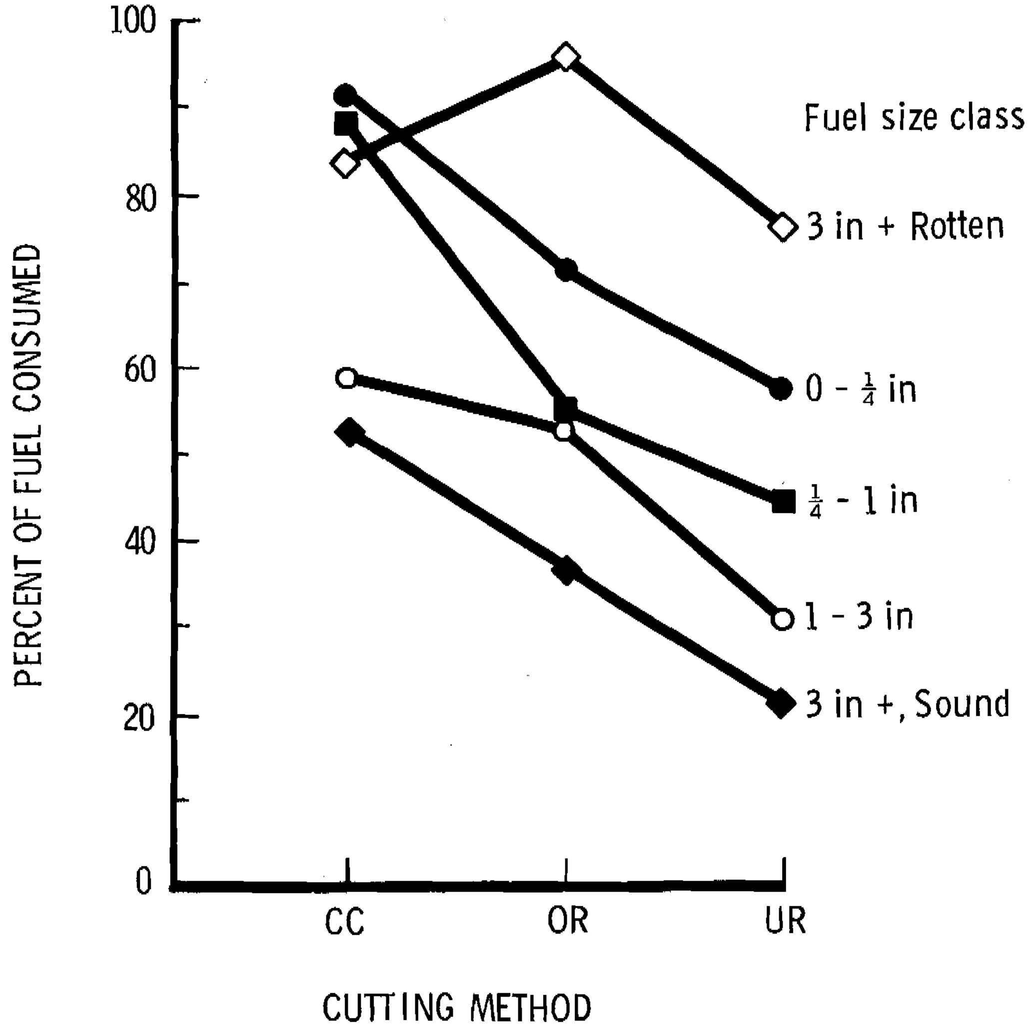

Figure 1.--Percent of fuels consumed in prescribed burning of clearcut, overstory removal, and understory removal cutting units.

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