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Introduction

Forest managers increasingly apply prescribed, broadcast fire as a management tool in the northern Rocky Mountains. In 1957 about 2,000 acres of recently harvested timber stands were purposely burned by federal, state, and private agencies in western Montana and northern Idaho after late summer and autumn rains reduced the risks of wildfire. By 1967 more than 30,000 acres were treated annually with broadcast fire. Logging debris on an additional 60,000 acres is machine-piled into windrows and subsequently burned each year.

Timber harvest operations are currently progressing from readily accessible, gentle topography to steep, less accessible terrain where heavy machinery cannot windrow the logging residue. The proportion of slash acreage which can be treated by machine piling and subsequent burning will, therefore, be reduced. This trend in logging practice will likely result in applying broadcast fire to about 100,000 acres of cutover commercial forest land per year. Land managers show concern over the increasing demand for manpower and administrative resources to do the burning job each autumn during the relatively short burning season. A possible solution to the problem is to broadcast burn in the spring and possibly summer seasons to accomplish the expanding job.

Regulation of fire intensity to meet the burning purposes described above can best be accomplished by scheduling treatment during different seasons of the year. This was an exploratory study designed to clarify the effects of both spring and autumn burning on duff depth and on area revegetation. Future studies will explore the more complex and hazardous consequences of summer slash burning.

Purposes of Burning Treatments

Modern clear-cutting practices are based upon the regeneration requirements and growth patterns of indigenous coniferous species. Harvested stands must be completely cleared to make room for a vigorous new generation—usually consisting of subclimax tree species. Newly germinating seedlings of most seral species require mineral soil seedbeds and a minimum of overhead shading. Mechanical scarification or burning is needed to transform the accumulated organic mantle which existed under the mature stand into an adequate seedbed. Such treatment is frequently necessary to reduce vegetative competition to planted seedlings.

Wildfire hazards posed by logging slash seriously threaten adjacent, uncut stands for many years after harvest. Again, mechanical bunching of felled material or prescribed broadcast burning will help prevent damage to the site and surrounding values if a wildfire were to follow logging. Moreover, wildfires in slash are difficult and costly to control. Hazard reduction thus becomes an important corollary management objective of site preparation on cutover blocks.

Big-game habitat similarly benefits from clearcutting and subsequent burning. Stable ungulate populations are associated with the consistent availability of browse commonly found on logged and burned tracts. Prescribed fires of regulated intensity can hasten and proliferate sprouting of important browse species.

Season of Burning Treatment

Changes in elevation and exposure create a wide range of environmental conditions. Fuel volume and moisture conditions, therefore, may vary greatly on different clear-cut blocks. Different management objectives dictate a range of burn intensities. Extension of

[1]This study was conducted under the authority of Cooperative Agreement Supplement No. 8 to the Master Memorandum of Understanding between the University of Montana and the Forest Service, United States Department of Agriculture, January 26, 1953.

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the prescribed burning period from autumn into spring and summer can provide the flexibility needed to match the burning requirements of a given clear-cut block with fuel and environmental conditions optimum for treatment.

Conventional autumn slash burning in the northern Rocky Mountains coincides with gradual wetting of fuels by the rain showers which signal the end of a summer wildfire season. Spring also offers a burning season as fuels dry out after wintertime saturation. The dead foliage, upper duff, and twigs become combustible while larger fuels remain moist. We hypothesized that spring fires would leave a deeper mantle of organic matter on the soil surface than autumn fires on comparable blocks.

Mature timber is harvested throughout the year in western Montana. Slash created by these logging operations may be burned the autumn following cutting, or be held over for a full year to cure before burning. To make our results applicable to both conditions, we chose to burn experimental plots in the spring and in the autumn in two successive years. Each burned block was observed for one full growing season after treatment to assess early recovery of the lesser vegetation.

Description of the Area

Physiography and Soils

The 40-acre tract chosen for this study is at an elevation of 5,000 feet with a uniform easterly exposure and a 30 percent average slope. It is located on the University of Montana Lubrecht Experimental Forest in the NW¼NE¼ of Section 29, T.13N., R.14W., Missoula County, Montana.

The soil parent material is quartz monzonite in contact with a gray and white, relatively pure, calcareous marble. The soil varies from calcareous and orange to sandy, granitic and green colored. The soil at the surface is a deep, sandy loam. The area is classified as site Class III for ponderosa pine.

Climate and Weather

The climate on the study area is typical of the lesser mountain ranges in western Montana. Snow covers the area from November through April to an average maximum depth of 28 inches. Annual precipitation at a nearby weather station is 19.7 inches. Spring weather is unsettled with showers occurring every several days until late June. However, forest fuels do dry enough after snowmelt to provide a short spring slash-burning period.

The weather in autumn is generally drier than in spring. As a rule, a short period of rain in the latter part of August or the early part of September is followed by an Indian summer, with clear days and cold nights. Forest fuels have thoroughly dried during the summer and have been only temporarily wetted by the first fall rains. They are usually dry enough for a month-long burning period. Increasing frequency of rainstorms or early snows finally saturate fuels by early November. The weather during the two-year duration of this experiment was fairly typical as indicated by our weather records.

Methods

Stand Treatment

Prior to its harvest in 1962, the average acre contained 50 mature Douglas-fir trees averaging 16 inches in diameter and with a volume of 13 M f.b.m. The understory consisted of 100 pole-size trees and 110 saplings per acre. The ground was covered with pine grass, small shrubs and herbs, and numerous Douglas-fir seedlings.

A few large Douglas-fir and western larch trees had been removed from the lower part of the 40-acre tract during the 1930's. No visible slash remained from this cutting.

The area was clearcut in the summer of 1962. Most of the logs were jammer-skidded uphill to spur roads constructed on the contour at intervals of approximately 300 feet. This type of skidding permitted the uniform distribution of limbs and tops.

In the autumn of 1962 all remaining standing trees were felled by hand. An effort was made during the slashing of the nonmerchantable trees to prepare as uniform a fuel bed as possible. Openings in the logging debris were filled with felled trees. All slashing of nonmerchantable material was complete before snowfall. The snow compressed these fuels before the first burn in the spring of 1963.

Contour jammer roads divided the area into uniform-sized blocks. By cutting a fire trail downslope perpendicular to the contour roads, the area was divided into eight rectangular blocks ranging in size from three to five acres. These eight blocks were randomly assigned burning treatments; two for each spring, and two for each autumn in 1963 and 1964. Figure 1 is a map of the experimental area indicating the location and time of each burn. Figure 2 is an aerial photograph of the clearcut during July 1963.

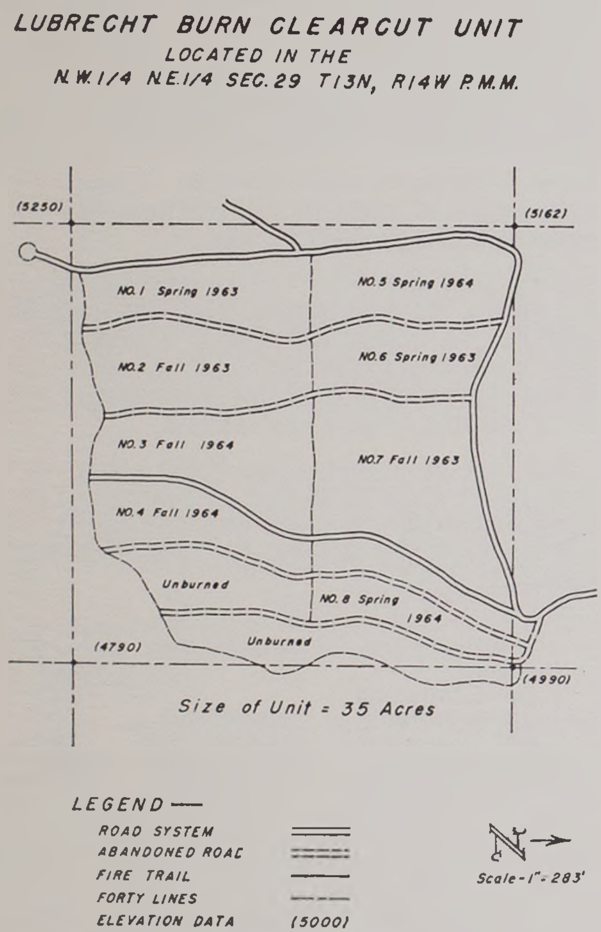

Figure 1.—Map of Lubrecht burn area Number 1.

Fuel Inventory Procedures

Interblock differences in fuel volume, fuel moisture, and size class distribution could, if large, obscure the effects of burning season. Similarly, differences in the time of occurrence of precipitation, drying periods, and other weather conditions could mask the effect of slash age on burn accomplishment. Therefore, fuels on each block were inventoried shortly before treatment, and records were kept of both weather and fuel moisture during the snow-fire seasons preceding each fire.

One month prior to each burning period, five sampling points were selected at random within each block. At each of these points all fuels were removed from two-square-meters (21-square-feet) of area. Logs, foliage, branches, and duff down to the mineral soil surface were separated and weighed by the following diameter classes: 0-½, ½-1, 1-3, 3-10, and 10+ cm. (0-¼, ¼-½, ½-1¼, 1¼-4, and 4+ inches). Most of the forest floor fell into the smallest size class. All fuels were transported to the laboratory for ovendrying and weighing.

The depth of the organic mantle was measured at 48 pre-selected points within the slash and 55 points under adjacent timber. These data served to provide a base level for duff depth before cutting and burning treatments.

Fuel Moisture Records

Standard one-half-inch dowel fuel moisture sticks were installed at five random locations within each block about one month prior to treatment. Three sets of sticks were stacked at each location: (1) on the litter surface beneath the slash, (2) at the upper surface of the slash, usually about one meter above the litter, and (3) midway between these two elevations. The upper set was subject to full sunlight while the lower two sets were partially or completely shaded by slash.

Semiweekly weighing of these standardized stick sets, at 1600 hours, up to and at the time of burning provided a reasonable analog of actual slash moisture content. Foliage, small twig, and duff surface moisture trends were incorporated as part of routine fire-weather measurements.

Despite the utility of fuel stick measurements in the slash for making burning date decisions, the time required for these observations precluded their continued use during the second year of treatment. Stick sets at the fire-weather station were relied upon for data on slash moisture during 1964.

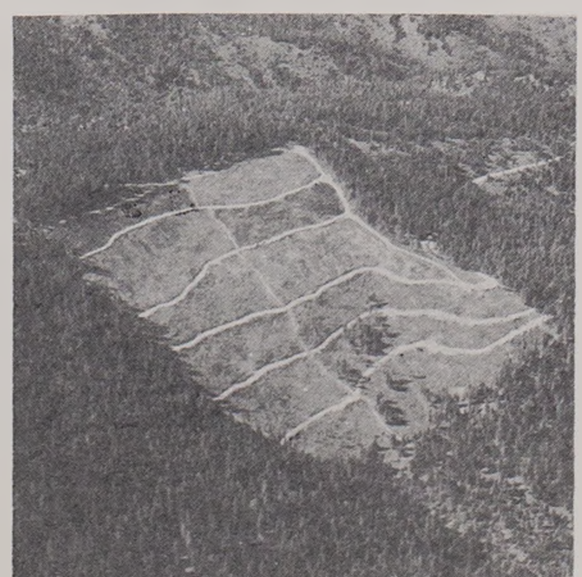

Figure 2.—Aerial view of Lubrecht burn area number 1. Two of the blocks have already been burned.

Weather Measurements

A standard fire-weather station was installed near the center of the clear-cut area as early as snow depth permitted access in the spring of both treatment years. This station, which included an anemometer, hygrothermograph, maximum-minimum thermometers, psychrometer, and standard and weighing rain gauges, was serviced weekly until burning was completed in late autumn. Weather data were applied in the calculation of National Fire-Danger Rating Indices including Fine Fuel Moisture Content, Spread Index, and Buildup Index. Wind, relative humidity, and spread indices were recorded during each fire treatment.

Burning Procedures and Measurements

We burned during the afternoon and early evening. Firing sequence was designed to develop a central convection column. Each block was first ignited along a line about 20 meters (65 feet) below its uphill edge. The outer border was ignited as the fire front approached the upper fireline. Block sides were ignited next. Finally, the lower edge was ignited to produce a heading, uphill fire over most of the area. Although spot fires did occur, they were easily contained.

After about one cm. (½ inch) or more of rain had fallen on each block—sometimes as late as several weeks after treatment—the depth of residual organic matter, or duff, was measured to the nearest ½ centimeter (¼ inch) at 50 evenly-distributed points. Unburned patches were tallied separately.

Vegetative Cover Measurements

At one month intervals during the growing season following each treatment, we collected plant abundance-cover data from five randomly located four-square-meter (42-square-feet) plots within each block. Braun-Blanquet phytosociological procedures were employed.[4] Plot size was determined through preliminary sampling of nested quadrats and construction of a species-area curve.

At the beginning of the 1963 growing season, six control plots were installed on unburned portions of the clear-cut area, and three plots were established in adjacent uncut stands of similar composition and exposure to the treated blocks.

Each plot was observed for one full growing season after treatment since our concern centered on immediate effects of fire rather than long-term vegetation changes. Data collected represent late spring, midsummer, and early autumn vegetative aspects.

Six sets of observations were made on a total of 49 plots in spring, summer, and autumn of the growing season immediately following each treatment per the following schedule:

Block No.	Burning Date	Observation Period
Unlogged		1963
1 and 6 unburned		1963
1 and 6 burned	Spring 1963	1963
2 and 7 burned	Autumn 1963	1964
5 and 8 burned	Spring 1964	1964
3 and 4 burned	Autumn 1964	1965

Results

Fuel Inventory

Collection, sorting, and drying of 10-square-meters (105.6 square-feet) of fuel required about 100 man-days—an indication of the need for more efficient sampling procedures in the future.

Fuel volumes were similar on all blocks. Total organic matter on the tract after log-

[4]Braun-Blanquet, J. Plant sociology. Transl. by G. D. Fuller and H. S. Conrad. 439 pp. New York: McGraw-Hill Co. 1932.

TABLE 1.—AVERAGE WEIGHT PER UNIT AREA OF FUELS COLLECTED FROM EIGHT BLOCKS BY YEAR AND SEASON OF FIRE TREATMENT

Year	Treatment Season	Block No.	Size class (cm.) 0-½	½-1	1-3	3-10	10+	Total	Total ½-10
			(kg./M²)						
1963	Spring	1	1.6	0.5	1.6	3.4	1.8	8.9	5.5
1963	Spring	6	2.5	0.6	2.1	3.3	2.8	11.3	6.0
1963	Autumn	2	5.6	0.8	2.2	2.8	11.0	22.4	5.8
1963	Autumn	7	3.8	0.7	2.8	2.2	4.1	13.6	5.7
1964	Spring	5	2.6	0.5	2.2	2.6	3.8	11.7	5.3
1964	Spring	8	3.4	0.5	2.4	3.4	2.0	11.7	6.3
1964	Autumn	3	6.0	0.5	1.9	3.2	7.9	19.5	5.6
1964	Autumn	4	3.9	0.5	2.1	4.1	5.0	15.6	6.7
Mean (all blocks)			3.7	0.6	2.1	3.1	4.8	14.3	5.9
Standard deviation (n=40)			2.1	0.3	1.1	2.0	5.1	7.6	2.7

ging and slashing averaged 14.3 kilograms per square meter (64 tons per acre) with a standard deviation of 7.6 kg./M^2. A complete record of the fuel inventory is included in appendix A. Fuel distribution by season, size class, and year of treatment is summarized in Table 1.

We recognized in planning the inventory that poor precision would result in sampling material larger than 10 cm. in diameter by the two-square-meter plots. However, the contribution of these large fuels to the energy released by prescribed fires is relatively small, thus a wide variation in this size class is accepted. Most of this material remained after the fires.

A greater weight of material in the 0 to ½ cm. size class was collected during autumn sampling than in the spring. Most of the organic mantle of the forest floor is included in the 0 to ½ cm. size class. High moisture content precluded clear differentiation of F and H layers from incorporated mineral soil in the springtime.

For these reasons, an accurate comparison of fuel volume on the eight blocks is best made by using the three most consistent, intermediate size classes, namely from ½ cm. to 10 cm. in diameter. The last column in Table 1 reveals the relatively uniform means in fuel weight when both the logs and the duff are excluded from the calculations.

Fuel Moisture and Weather

Sets of half-inch dowel fuel moisture sticks installed at three elevations in the slash during 1963 reflected a vertical gradient in moisture content more pronounced in autumn than in spring. Mean percentages calculated from semiweekly readings of sticks on the litter surface, at midslash depth, and at the upper surface of the slash were as follows:

	Top	Midslash	On litter
Spring	10.2 percent	10.1 percent	11.1 percent
Autumn	10.0 percent	11.4 percent	17.0 percent

Stick sets exposed at the fire-weather station adjacent to treatment blocks had the same moisture content as those at the top of the slash during both seasons.

Analysis of variance on fuel moisture stick weights showed differences due to season and stick position to be significant at the 99 percent confidence level ($N = 60$, $F = 16.9$ and 18.1, with 2 and 35 degrees of freedom). No significant differences appeared between stick set moisture contents at the same depth within each block. Further study would be required to assess the importance of these results.

TABLE 2.—FUEL AND WEATHER DATA FOR LUBRECHT BURN TREATMENT DAYS

	1963 Spring	1963 Autumn	1964 Spring	1964 Autumn
Date of burn	5/24	9/6	5/27	9/11
Temperature (°F.)				
Maximum	62	82	62	68
During burn	56	82	61	68
Minimum	48	58	38	48
Relative Humidity (percent)				
Maximum	95[1]	40	45	50
During burn	90	18	30	30
Minimum	38	16	28	28
Windspeed (m.p.h.)	5	6	13	7
Fuel Moisture (percent) (half-inch dowel)	9	10	8	10
National Fire-Danger Rating Values				
Fine Fuel Moisture	20	3	16	7
Buildup Index	63	62	55	18
Spread Index	6	34	21	21

[1]Burning immediately preceded a rainstorm.

Fire-weather and fuel moisture data for each burning day are included in Table 2. Appendix B contains a complete record of the N.F.D.R.S. values for 1963 and 1964, and fuel moisture stick data for both years.

The fuel moisture and weather at the hour of treatment determine to a large extent the quality of burn achieved. Although fuel moisture stick weights were similar on all treatment days, windspeed was above average in the spring in 1964, Fine Fuel Moisture was low in autumn in 1963, while Buildup Index was low in autumn in 1964. However, within seasons, higher Buildup Index was associated with lower residual duff depth. A given Buildup Index apparently reflects different burning conditions in spring than in autumn. Further confounding of this relationship results when slash loses its needles before fire treatment, as occurred in the second year of our study.

Duff Residual

When regeneration of cutover stands is a burning objective, the residual depth of the duff provides a measure of burn accomplishment. Average duff depths observed prior to cutting and burning are listed below:

	Under standing timber	Under unburned slash
Number of measurements	55	48
Mean duff depth (cm.)	4.92	4.56
Standard deviation	.98	.95

Table 3 summarizes duff depth data collected from 50 points uniformly distributed on each of the eight blocks after rain had compacted the ash following burning. From 66 to 100 per cent of each block was burned over.

TABLE 3.—AVERAGE DEPTH OF ORGANIC SOIL MANTLE (DUFF) AFTER FIRE TREATMENT BY YEAR AND SEASON (n = 50 PER BLOCK)

Treatment Year	Treatment Season	Block no.	Percentage of area burned	Residual organic matter on burned area Mean (cm.)	Residual organic matter on burned area S.D. (cm.)
1963	Spring	1	82	2.1	1.2
1963	Spring	6	76	2.8	1.2
1963	Autumn	2	100	0.6	1.1
1963	Autumn	7	76	0.7	1.4
1964	Spring	5	96	3.0	0.8
1964	Spring	8	96	1.4	0.7
1964	Autumn	4	67	1.8	0.7
1964	Autumn	3	66	1.5	0.7

Measurements of residual duff taken within the burned areas averaged 1.2 cm. (3/5 inch) after autumn treatments and 2.3 cm. (1 1/10 inch) after spring treatments, in spite of fallen needles and a low Buildup Index during the second autumn of burning. Insufficient replications are available for rigorous statistical treatment of the data in Table 3. However, standard deviations for each block are included in the table.

We do not have confidence in the adequacy of these duff depth data to differentiate between one- and two-year-old slash burns in comparable seasons. However, the data suggest a more complete burn the first year of treatment than the second—probably due to needles on the slash which enhance fuel continuity. Further support may be observed in the relatively low percentage of the area burned during autumn 1964, as shown in Table 3.

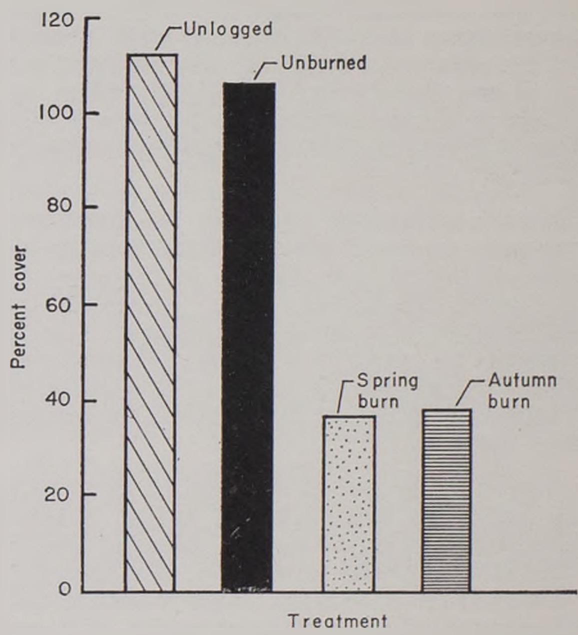

Figure 3.—Percent vegetative cover in midsummer of the following year.

Vegetative Cover Changes

A total of 50 plant species were recorded on all plots. Table 4 summarizes the average number of plant species per Braun-Blanquet abundance-cover class tallied during the growing season of observation. Increasing abundance-cover can be detected on plots located in spring-burned blocks during the same growing season. Autumn-burned blocks, however, reflect nearly full vegetative coverage the following spring and the remainder of the subsequent growing season.

When percentage of shrub, grass, and forb cover is considered alone, and both years of treatment are averaged, the contrast between unlogged, logged but unburned, and burned treatments is striking. Figure 3 depicts average percent cover in midsummer of the season

TABLE 4.—AVERAGE NUMBER OF PLANT SPECIES BY TREATMENT, ABUNDANCE-COVER CLASS, AND OBSERVATION TIME

Abundance-cover class		+			1			2			3			4			All classes		
Observation time[1]/		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Treatment	n[2]/	(number of species)																	
Unlogged	3	7.0	5.3	3.0	2.0	3.7	4.7	2.0	1.3	0.7	1.3	0.7	1.0	0.0	0.3	0.3	12.3	11.3	9.7
Unburned	6	6.2	5.7	5.5	2.8	3.5	3.8	0.8	0.3	1.2	0.7	0.7	0.0	0.3	0.5	0.7	10.8	10.7	11.2
1 and 6	10	2.7	2.9	3.1	1.5	2.5	3.1	0.1	0.3	0.8	0.0	0.5	0.1	0.0	0.0	0.0	4.3	6.2	7.1
2 and 7	10	4.3	2.7	3.1	2.0	3.2	2.8	1.0	0.5	0.5	0.0	0.1	0.0	0.0	0.0	0.0	7.3	6.5	6.4
5 and 8	10	2.0	2.2	2.9	0.0	2.8	2.4	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	5.3	5.6
3 and 4	10	5.8	4.9	4.2	2.5	3.5	2.6	0.4	0.2	0.5	0.2	0.2	0.1	0.0	0.0	0.0	9.7	10.1	8.1

[1]/ Observation time: 1 = Spring (late June)
2 = Summer (middle of July)
3 = Autumn (late August)
[2]/ n = number of plots per treatment

following treatment. The unlogged and unburned plots were more than 100 percent covered when all layers were combined. On the other hand, burned plots were only 35 to 40 percent covered by the middle of the succeeding summer. No important differences due to season of treatment are apparent.

Much of the cover percentage difference between burned and unburned plots results from the fire's consumption of *Vaccinium membranaceum* stems. Although the *Vaccinium* sprouts readily after burning, several years are required for full development of this species.

Six plant species exhibited a constancy of 40 percent or greater on all blocks. They are: *Arnica coidifolia, Mahonia repens, Astragalus miser, Lupinus laxiflorus, Thalictrum occidentale,* and *Calamagrostis rubescens.* Recovery and development of these species during the first year after treatment is recorded in appendix C.

Summary and Conclusions

Eight experimental blocks of Douglas-fir logging slash mixed with felled noncommercial stems and tops were broadcast burned over a period of two years after timber harvest. Our purpose was to quantify any differences in site preparation and lesser vegetation recovery which might exist between spring and autumn burning treatments. We had to characterize both fuel volume and moisture content to support objective comparisons between season and year of treatment.

Despite the controls applied, internal variation in fuel volume and second-order interactions between weather and fuel moisture content prevented complete differentiation of seasonal fire effects. However, information was accumulated of importance to fire managers who wish to extend effective burning periods, and to researchers planning more sophisticated inquiries into the relationships between burning season and fire effects.

Logging slash, noncommercial residue, and the organic soil mantle together averaged 14.3 kg./M^2 (64 tons per acre). Duff depth before burning averaged 4.7 cm. Twenty-six percent of this potential fuel occurred as duff, needles, and twigs less than one-half cm. in diameter. Forty-one percent of the weight represented branches from ½ cm. to 10 cm. in diameter (¼ inch to 4 inches). The remaining 33 percent was composed of stems larger than 10 cm. We found the ½ to 10 cm. group of size classes to be representative of fuel volume. Sampling methods were inadequate to measure precisely the large stems and the forest floor.

Sets of standard fuel moisture sticks exposed at the surface, within and below the slash, reflected consistent differences in fuel moisture due to position, especially in autumn.

The organic soil mantle (duff) remaining after treatment was used as an index of burn accomplishment. Nearly twice as much duff remained after spring fires as after autumn burning treatments. We were unable to detect differences due to year of treatment.

Abundance-cover observations of lesser vegetation for one year after treatment revealed 35 to 40 percent recovery of both spring- and autumn-burned blocks by midsummer of the following year. We observed no important differences due to season of treatment except that autumn-treated areas were poorly vegetated during the succeeding spring.

Further study will be required to assess the effect of duff moisture content on burn quality and to fill in gaps in fuel inventory procedures, duff depth sampling, and fire characterization. Studies in progress will compare the effectiveness of summer burning with spring and autumn treatments and their respective site preparation accomplishments.

Appendix A

OVENDRY WEIGHT (GRAMS) OF FUELS COLLECTED FROM TWO-SQUARE-METER PLOTS

Block no.	Plot no.	Diameter class (centimeters) 0-½	½-1	1-3	3-10	10 plus	Total	Total ½-10
				1963 Spring				
1	1	3,742	1,134	2,949	2,410	7,229	17,464	6,493
	2	4,848	907	2,835	6,039	9,865	24,494	9,781
	3	1,418	511	3,034	2,949	1,247	9,159	6,494
	4	3,515	1,474	4,536	7,455	0	16,980	13,465
	5	3,006	1,077	2,523	15,081	0	21,687	18,681
6	1	3,742	794	1,814	2,410	8,845	17,605	5,018
	2	4,876	1,134	5,216	9,525	0	20,751	15,875
	3	6,350	1,475	3,629	3,742	12,143	27,339	8,846
	4	5,698	1,899	5,102	7,484	3,317	23,500	14,485
	5	4,820	1,020	5,443	9,229	2,814	23,326	15,692
				1963 Autumn				
2	1	8,930	1,276	3,033	5,557	24,353	43,149	9,866
	2	1,956	255	1,219	5,157	23,077	31,664	6,631
	3	10,319	1,389	2,552	5,131	9,979	29,370	9,072
	4	16,160	1,276	3,289	6,946	38,981	66,652	11,511
	5	18,739	3,657	11,283	14,260	17,378	65,317	29,200
7	1	7,144	1,588	3,884	5,131	0	17,747	10,603
	2	11,340	765	4,905	9,044	0	26,054	14,704
	3	5,925	879	3,912	4,621	0	15,337	9,412
	4	6,209	1,786	5,783	4,082	25,005	42,865	11,651
	5	7,286	2,211	8,732	4,338	15,536	38,103	15,281
				1964 Spring				
5	1	3,940	1,020	3,458	1,418	5,784	15,620	5,896
	2	4,254	874	4,506	13,390	0	23,024	18,770
	3	7,404	1,133	4,950	3,346	11,518	28,361	9,439
	4	4,274	936	6,692	2,606	8,564	24,072	10,234
	5	5,218	1,048	2,298	5,302	4,114	17,980	8,648
8	1	7,544	1,244	4,226	8,794	0	21,808	14,264
	2	7,034	1,446	7,774	5,756	8,138	30,148	14,986
	3	9,416	964	5,330	13,588	9,562	38,860	19,882
	4	4,478	280	1,446	1,698	1,160	9,062	3,424
	5	5,358	1,362	5,358	4,568	1,446	18,092	11,288
				1964 Autumn				
3	1	16,512	1,300	4,960	9,304	32,144	64,220	15,564
	2	10,722	1,984	3,346	3,660	13,216	32,928	8,990
	3	5,162	140	1,076	2,578	0	8,956	3,794
	4	9,164	510	4,708	8,536	19,320	42,238	13,754
	5	18,698	1,020	4,422	8,340	14,130	46,610	13,782
4	1	8,368	1,530	5,986	10,666	11,120	37,670	18,182
	2	4,478	168	678	11,574	3,632	20,530	12,420
	3	8,766	1,216	4,114	14,528	30,614	59,238	19,858
	4	9,046	336	1,928	482	0	11,792	2,746
	5	8,710	1,586	8,228	4,114	4,226	26,864	13,928
Totals		295,569	46,604	171,167	264,839	378,457	1,156,636	482,610

Appendix B

NATIONAL FIRE-DANGER RATING SYSTEM DATA—Spring 1963

Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index
	April		29	15	45	12	20	28
15	13	15	30	15	48	13	15	31
16	18	17				14	14	35
17	15	20		**May**		15	15	38
18	18	22	1	18	50	16	17	40
19	19	24	2	19	52	17	18	42
20	16	24	3	17	54	18	16	45
21	20	25	4	19	34	19	15	48
22	19	27	5	16	37	20	16	51
23	19	29	6	13	42	21	15	54
24	19	31	7	16	45	22	14	58
25	15	34	8	16	48	23	14	62
26	14	38	9	16	21	24	20	63
27	19	40	10	16	24	—	—	—
28	17	42	11	15	27	25	16	66

NATIONAL FIRE-DANGER RATING SYSTEM DATA—Autumn 1963

Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index
	August		14	8	105	28	9	154
1	8½	146	15	9	109	29	11	157
2	12	148	16	9	113	30	10	160
3	9	152	17	8½	118	31	13	88
4	8	157	18	9	122			
5	9	161	19	11	125		**September**	
6	9½	165	20	11	128	1	30	43
7	9½	169	21	11	131	2	8	45
8	9	173	22	9½	135	3	6	48
9	9	177	23	11	138	4	4	52
10	11	89	24	11	141	5	3½	57
11	10	92	25	10	144	6	3	62
12	11	95	26	11	147	—	—	—
13	8	100	27	11	150	7	3	67

NATIONAL FIRE-DANGER RATING SYSTEM DATA—Spring 1964

Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index
			10	18	3			
	May					20	14	38
1	20	0	11	16	6	21	19	40
2	23	0	12	14	10	22	20	41
3	27	0	13	18	12	23	16	44
4	23	0	14	15	15	24	16	47
5	18	0	15	16	18	25	15	50
6	19	0	16	13	23	26	19	52
7	20	0	17	17	25	27	16	55
8	19	0	18	14	29	—	—	—
9	17	1	19	13	34	28	19	57

NATIONAL FIRE-DANGER RATING SYSTEM DATA—Autumn 1964

Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index	Day	Fine Fuel Moisture (percent)	Buildup Index
	August		15	8½	72	30	15	57
1	13	70	16	8½	77	31	20	57
2	11	73	17	8½	82		**September**	
3	8½	78	18	10	85	1	13	58
4	9	80	19	17	32	2	10	59
5	10	34	20	13	34	3	7½	44
6	8½	39	21	11	37	4	5½	37
7	9½	43	22	9	41	5	5½	40
8	9½	47	23	11	44	6	5½	43
9	9½	51	24	11	47	7	10	16
10	9	55	25	10	50	8	7	16
11	9	59	26	15	51	9	8	18
12	10	62	27	13	53	10	9	20
13	13	64	28	22	53	11	7	18
14	10	67	29	14	55	—	—	—
						12	6	19

FUEL MOISTURE STICK DATA—Spring 1963

Date	Block no.	Point no.	Percent of fuel moisture: Top of slash	Middle of slash	Litter surface
5/ 7/63	1	1	10.2	11.0	12.6
		2	10.6	10.6	11.7
		3	11.8	11.1	10.4
		4	11.8	15.1	14.0
		5	19.2	19.5	20.7
	6	1	9.6	10.0	14.0
		2	11.0	10.2	10.7
		3	10.3	10.3	11.7
		4	10.4	11.2	13.0
		5	10.3	11.6	10.2
5/14/63	1	1	12.5	12.6	12.6
		2	13.4	13.0	14.0
		3	13.0	12.7	12.2
		4	13.1	12.4	13.1
		5	13.0	12.9	14.8
	6	1	13.0	13.0	13.9
		2	13.8	12.9	11.5
		3	13.5	14.5	18.4
		4	13.1	14.0	16.6
		5	13.4	14.6	11.8
5/17/63	1	1	7.9	8.1	10.5
		2	8.0	7.7	10.0
		3	8.1	7.8	7.5
		4	8.1	7.8	9.0
		5	8.1	8.4	10.9
	6	1	8.4	9.2	10.5
		2	8.4	7.8	10.0
		3	7.7	8.0	11.1
		4	8.1	8.5	10.1
		5	8.9	9.9	6.8
5/20/63	1	1	6.3	6.3	7.5
		2	6.9	6.8	8.1
		3	7.0	6.9	8.0
		4	7.3	7.4	7.6
		5	8.5	9.6	10.1
	6	1	7.1	7.7	8.8
		2	7.7	7.1	8.8
		3	6.8	6.8	9.1
		4	5.4	5.4	7.1
		5	7.2	7.9	6.4
5/24/63	1	1	9.7	9.7	10.0
		2	9.4	9.3	10.1
		3	9.5	9.5	9.9
		4	9.7	9.6	11.1
		5	9.6	9.6	10.6
	6	1	11.3	11.4	12.3
		2	11.5	10.4	11.3
		3	10.7	10.6	12.9
		4	9.8	9.8	10.0
		5	11.1	11.1	9.1

FUEL MOISTURE STICK DATA—Autumn 1963

Date	Block no.	Point no.	Percent of fuel moisture: Top of slash	Middle of slash	Litter surface
8/30/63	2	1	7.5	8.4	9.7
		2	7.5	8.0	8.4
		3	8.1	8.6	8.1
		4	7.5	7.8	9.6
		5	7.6	8.0	9.5
	7	1	7.0	7.0	6.9
		2	7.1	7.2	7.6
		3	7.6	7.6	7.8
		4	7.4	7.3	8.0
		5	6.5	7.0	8.6
9/ 3/63	2	1	14.1	23.3	50+
		2	18.9	18.9	20.4
		3	17.2	17.0	24.8
		4	16.3	29.6	50+
		5	17.6	27.5	50+
	7	1	15.1	15.8	50+
		2	15.8	16.3	24.3
		3	17.6	16.4	35.5
		4	16.0	17.7	22.0
		5	15.0	23.3	50+
9/ 4/63	2	1	9.5	11.9	32.0
		2	10.5	11.5	12.7
		3	12.2	11.7	13.3
		4	14.6	15.7	24.6
		5	11.0	13.8	50+
	7	1	10.8	11.0	16.3
		2	11.4	11.6	11.9
		3	11.3	12.0	14.3
		4	11.6	11.6	11.8
		5	10.6	13.9	28.7
9/ 5/63	2	1	7.1	7.7	23.3
		2	7.5	9.3	8.8
		3	8.7	9.0	10.1
		4	7.0	9.6	12.5
		5	7.8	9.2	19.5
	7	1	7.0	7.8	9.9
		2	8.4	8.5	8.9
		3	7.9	8.4	9.4
		4	8.1	8.1	8.8
		5	7.5	8.4	13.4
9/ 6/63	2	1	6.6	7.9	19.7
		2	7.0	8.1	8.8
		3	7.6	8.3	10.2
		4	6.4	8.9	10.5
		5	7.0	8.4	13.0
	7	1	7.0	7.0	9.7
		2	7.4	8.0	8.6
		3	7.0	7.5	8.9
		4	7.3	7.3	8.4
		5	6.6	7.3	9.8

FUEL MOISTURE STICK DATA

Spring 1964

Date	Fuel moisture percent: Unscreened stick	Screened stick
5/27/63	7.5	8.0
6/23/64	10.5	11.0
6/29/64	6.5	7.0
7/ 7/64	10.0	11.0
7/14/64	21.0	23.0
7/21/64	7.5	8.0
7/28/64	7.0	7.5

Autumn 1964

Date	Fuel moisture percent: Unscreened stick	Screened stick
8/ 4/64	9.0	9.5
8/11/64	7.5	8.0
8/19/64	20.0	30.5
8/26/64	18.0	20.0
9/ 2/64	50+	50+
9/ 9/64	12.0	13.0
9/17/64	6.5	7.5
9/23/64	14.0	15.5

Appendix C

VEGETATION ANALYSIS—LUBRECHT

Abundance-cover observations, June-July-August (three dates) during first growing season after treatment.

Code: r = rare; + = sparse; 1 = Numerous but less than 5 percent area, 2 = 5 to 25 percent area; 3 = 25 to 50 percent area; 4 = 50 to 75 percent area; 5 = greater than 75 percent area.

Block no.	Spp.[1]		1			2			3			4			5			Weighted totals	
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
									1964										
2	Ar	1	1	1	+	+	+	+	1	1	1	1	1	2	1	1	37	21	21
	Mah	1	+	+	—	—	—	—	—	+	—	—	—	+	+	+	6	2	3
	Ast	—	—	—	—	—	—	—	—	—	+	1	+	—	+	—	1	6	1
	Lv	+	+	+	—	+	+	—	—	—	+	1	+	+	1	+	3	12	4
	Th	+	+	+	—	—	—	—	—	—	—	—	—	+	1	1	2	6	6
	Cal	1	1	1	+	1	1	+	+	+	1	1	1	1	1	+	17	21	17
																	66	68	52
									1963										
1	Ar	+	1	1	+	2	2	+	1	1	+	+	+	1	1	1	11	41	41
	Mah	—	—	—	—	—	—	—	+	+	—	—	+	—	—	—	0	1	3
	Ast	—	—	—	—	—	+	—	—	+	+	+	1	—	—	—	1	1	7
	Lv	—	—	—	+	1	2	—	+	+	+	+	+	—	—	—	2	7	27
	Th	—	—	—	+	1	1	—	—	—	+	+	+	—	—	—	2	26	26
	Cal	1	1	1	1	3	1	+	1	1	+	1	+	—	—	—	12	65	16
																	28	141	120
									1965										
3	Ar	1	1	2	1	1	1	1	1	2	+	+	+	2	2	3	41	41	102
	Mah	—	—	+	1	1	+	+	+	+	+	+	1	—	—	—	7	7	8
	Ast	+	+	+	1	1	1	+	+	+	1	1	1	—	—	—	12	12	12
	Lv	—	—	—	+	+	+	—	—	—	+	+	+	—	—	—	2	2	2
	Th	+	1	1	1	1	+	—	+	+	1	1	1	+	+	+	12	17	13
	Cal	1	1	1	3	3	1	1	1	1	3	3	2	1	1	+	115	115	41
																	189	194	178
									1965										
4	Ar	1	1	+	1	1	+	2	2	2	1	1	+	1	1	2	45	45	53
	Mah	1	1	1	+	+	+	+	1	+	+	+	1	—	—	—	8	12	12
	Ast	—	—	—	—	—	+	+	+	1	—	—	—	—	—	—	1	1	6
	Lv	—	—	—	—	—	—	+	+	+	—	—	—	—	—	—	1	1	1
	Th	1	1	+	1	1	1	1	1	+	+	+	+	+	+	+	17	17	9
	Cal	1	1	1	2	2	2	2	2	2	1	1	1	+	1	+	61	70	61
																	133	146	142
									1964										
5	Ar		2	2		1	1		1	1		—	—		—	—		35	35
	Mah		1	+		1	1		1	+		—	—		1	1		20	12
	Ast		+	+		—	—		1	+		+	+		—	—		7	3
	Lv		+	+		—	—		2	1		—	—		1	1		56	11
	Th		+	+		—	—		—	—		—	—		—	—		1	1
	Cal		1	1		1	1		1	1		—	—		1	1		20	20
																	ND	139	82

Table continued on page 12

Block no.	Spp.[1]	1			2			3			4			5			Weighted totals		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
									1963										
6	Ar	1	3	2	1	2	1	+	1	1	—	1	+	+	+	+	12	86	37
	Mah	+	1	1	—	+	+	—	—	—	—	+	+	—	+	1	1	8	12
	Ast	—	+	+	—	+	+	—	—	+	—	—	—	+	1	1	1	7	8
	Lv	+	+	+	1	3	2	—	—	—	+	1	1	+	1	1	8	61	36
	Th	+	1	+	—	—	—	+	+	+	—	—	—	—	—	—	2	26	2
	Cal	2	3	2	1	3	2	1	1	1	1	1	1		1	1	45	115	65
																	69	303	160
									1964										
7	Ar	1	1	1	—	2	2	2	2	1	2	1	+	+	1	+	56	65	37
	Mah	—	—	—	—	+	+	—	—	—	—	—	—	—	—	+	0	1	2
	Ast	—	+	+	—	—	—	+	1	+	+	+	+	—	—	—	2	7	3
	Lv	—	—	—	+	+	+	2	2	1	2	1	+	+	+	+	52	32	8
	Th	—	—	—	—	—	—	+	+	—	—	—	—	+	+	+	2	2	6
	Cal	2	3	2	1	1	1	2	2	2	1	1	1	1	1	2	65	85	85
																	195	192	141
									1964										
8	Ar	—	1	1	+	1	1	+	1	1	+	1	1	—	1	1	3	25	25
	Mah	—	—	—	—	+	+	—	+	+	—	—	—	—	—	+	0	2	3
	Ast	—	+	+	—	1	+	—	1	1	—	2	2	—	—	—	0	36	32
	Lv	—	—	—	—	—	—	+	+	+	+	+	+	+	+	+	3	3	3
	Th	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	0	0	1
	Cal	+	1	1	—	—	—	—	—	—	—	—	+	—	—	+	1	5	7
																	7	71	71
U-1	Ar	3	3	2	2	3	2	1	1	1							80	105	55
	Mah	+	+	+	+	+	1	—	+	+							2	3	7
	Ast	—	—	—	—	—	—	1	1	1							5	5	5
	Lv	3	3	2	+	+	+	+	+	+							52	52	27
	Th	+	+	+	+	+	+	+	1	+							3	7	3
	Cal	3	3	5	1	1	1	1	2	1							60	80	110
																	202	252	207
U-6	Ar	2	1	+	1	+	+	2	1	+							55	11	3
	Mah	+	+	+	+	+	1	+	+	+							3	3	7
	Ast	1	1	1	+	1	2	—	—	—							6	10	30
	Lv	2	2	1	+	+	+	1	1	1							31	31	11
	Th	—	—	+	—	—	—	2	1	1							25	5	6
	Cal	4	4	4	3	4	4	4	4	4							175	225	225
																	295	285	282
	Total, U-1 and U-6																135	116	58
																	5	6	14
																	11	15	35
																	83	83	38
																	28	12	9
																	235	305	335
																	497	537	489
UL	Ar	3	3	2	2	1	—	2	1	—							100	80	25
	Mah	+	+	+	1	1	1	—	—	—							6	6	6
	Ast	1	1	1	—	1	1	2	2	1							30	35	15
	Lv	+	+	+	+	1	1	3	3	+							52	56	7
	Th	+	+	+	—	—	—	+	+	+							2	2	2
	Cal	2	2	3	3	2	3	3	4	5							125	125	200
																	315	304	255

[1]Species with a constancy of 40 percent or greater

Ar = Arnica coidifolia
Mah = Mahonia repens
Ast = Astragalus miser
Lu = Lupinus laxiflorus
Th = Thalictrum occidentale
Cal = Calamagrostis rubescens

Abstract

Experimental blocks of Douglas-fir logging slash were broadcast burned over a period of two years after timber harvest to quantify differences in site preparation and lesser vegetation recovery.

Logging slash, noncommercial residue, and the organic soil mantle together averaged 14.3 kg./M^2 (64 tons/acre). Duff depth before burning averaged 4.7 cm. Nearly twice as much duff remained after spring as after autumn fires.

We were unable to detect differences due to year of treatment. Lesser vegetation recovered 35 to 40 percent by midsummer of the following year.

Support

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