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# Slash and duff reduction by burning on clear-cut jack pine sites in central Saskatchewan



Z. Chrosciewicz

**SLASH AND DUFF REDUCTION BY BURNING  
ON CLEAR-CUT JACK PINE SITES IN CENTRAL SASKATCHEWAN**

**BY**

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### ABSTRACT

Twenty-six burns were experimentally tested on fresh, moderately moist, and moist clear-cut jack pine (*Pinus banksiana* Lamb.) sites in central Saskatchewan. The burns were conducted over a range of Duff Moisture Codes that were then statistically correlated with the postburn duff depth and the postburn duff cover. Slash burned well under all conditions tested, but the duff reductions varied with the Duff Moisture Codes. The resulting straight-line regressions showed that the duff-depth reductions were considerably more predictable than the duff-cover reductions, and that the correlations were generally much better on the fresh and moderately moist sites than on the moist site. The application of these results in future burning operations is discussed.

### RESUME

Vingt-six brûlages ont été expérimentés sur des stations de Pin gris (*Pinus banksiana* Lamb.) coupées à blanc, fraîches et modérément humides, dans le centre de la Saskatchewan. Les brûlages furent menés en couvrant un éventail d'Indices de l'humus qui furent ensuite statistiquement mis en corrélation avec l'épaisseur de l'humus brut après brûlage et avec la couverture (ou le couvert) d'humus brut après brûlage. Les rémanents brûlèrent bien dans toutes les conditions expérimentées, mais les réductions de l'humus brut varièrent avec les Indices de l'humus. Les régressions en ligne droite résultant de cette expérience indiquèrent que des réductions de l'épaisseur de l'humus brut étaient considérablement plus faciles à prévoir que les réductions de la couverture d'humus brut, et que les corrélations étaient généralement beaucoup meilleures dans les stations fraîches et modérément humides que dans les stations humides. L'auteur discute l'application de ces résultats à des brûlages ultérieurs.

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## INTRODUCTION

Jack pine (*Pinus banksiana* Lamb.)<sup>1</sup> is one of the most important commercial tree species in central Saskatchewan, and industrial demands for its products are steadily increasing. Since 1967, large annual pulpwood volumes have been harvested, and there was a general apprehension that the resulting clear-cut areas would not be adequately restocked back to pine unless supplementary treatments were carried out. Field studies in Ontario (Chrosiewicz 1959, 1967, 1968, 1970, 1974) and Minnesota (Ahlgren 1970) have shown that the pine can be efficiently regenerated by the postcut use of burning and seeding treatments. It was then assumed that both these treatments could be effectively adapted to the local conditions through additional experimentation. Several burning and seeding combinations were tested between 1970 and 1972 on fresh to moist sites at latitudes 53°49' - 53°51'N and longitudes 105°02' - 105°05'W, some 21 km by road northeast of Candle Lake, Saskatchewan.

The results of burning are presented in this report. Regeneration studies are continuing, and further information pertaining to the postburn seeding and jack pine re-establishment will be presented in a future report.

## THE SITES

### Physiography

The tests were conducted on five flat, or almost flat, clear-cut sites. The mineral soil materials were deep, podzolized loamy tills containing by volume 5-30% stones. In texture, the loamy tills varied from sandy loam to sandy clay loam, with the leached uppermost horizon consisting of silty sand. The depths to groundwater averaged more than 2.4 m on two sites, 1.8 m on two sites, and 1.2 m on one site, and the soil moisture regimes (Hills 1955) were 2, 3, and 4, respectively. Consequently, the sites were classified "fresh", "moderately moist", and "moist".

### Slash and Duff

The original stands were 81 years old, with basal areas of about 24-28 m<sup>2</sup>/ha on the fresh sites, 21-31 m<sup>2</sup>/ha on the moderately moist sites, and 26 m<sup>2</sup>/ha on the moist site. These were essentially jack pine stands, but containing varying admixtures of black spruce (*Picea mariana* (Mill.) BSP.). In terms of basal area, the spruce content was 1-9% on the fresh sites, 9-33% on the moderately moist sites, and 46% on the moist site. A very few widely scattered tamarack (*Larix laricina* (Du Roi) K. Koch) grew along with the spruce, and aspen (*Populus tremuloides* Michx.) was always present next to the conifer stands. The timber was clear-cut in 1968-69, and only stumps and slash remained by the start of burning in 1970. The slash averaged 0.3-0.4 m in depth. It was randomly distributed and provided an intermittent ground cover totalling 76-83%.

The duff consisted of moss and litter materials in varying states of decomposition from the mostly unaltered state right at the surface down to, and including, the semi-fermented state with traces of true, well-decomposed humus just above the mineral soil. One fresh site and one moderately moist site had "thin duff" ranging in depth from 1 to 11 cm. The three other sites, one fresh, one moderately moist, and one moist, had "moderately thick duff" ranging in depth from 1 to 16 cm. Some mineral soil was exposed during logging operations but about 95-100% of the original duff cover remained undisturbed.

### Vegetation

Many identical plant species occurred on all five sites. Dominant within the lower stratum were Schreber's moss (*Pleurozium schreberi* (Brid.) Mitt.), twinflower (*Linnaea borealis* L. var. *americana* (Forbes) Rehd.), and bunchberry (*Cornus canadensis* L.). Immediately above were sour-top blueberry (*Vaccinium myrtilloides* Michx.), Labrador tea (*Ledum groenlandicum* Oeder), fireweed

<sup>1</sup> Species' nomenclature follows Scoggan (1957) for vascular plants, Crum *et al.* (1973) for mosses, and Hale *et al.* (1970) for lichens.

(*Epilobium angustifolium* L.), grass (*Calamagrostis canadensis* (Michx.) Nutt. and *Elymus innovatus* Beal), and sedge (*Carex adusta* Boott, *C. aenea* Fern. and *C. houghtonii* Torr.). The taller shrubs included rose (*Rosa acicularis* Lindl.), raspberry (*Rubus idaeus* L. var. *strigosus* (Michx.) Maxim.), willow (*Salix bebbiana* Sarg.), some green alder (*Alnus crispa* (Ait.) Pursh), and aspen. Reindeer moss (*Cladina alpestris* (L.) Harm. and *C. rangiferina* (L.) Harm.), rock cranberry (*Vaccinium vitis-idaea* L. var. *minus* Lodd.), and common bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.) were present on the fresh and moderately moist sites with the thin duff; a few black spruce were widely scattered on the fresh to moist sites with the moderately thick duff.

Much of the vegetation averaged in height 0.5 m on the fresh sites, and 0.6 m on the moderately moist and moist sites, with some of the shrub heights ranging up to 2.0 m. The total moss cover was 40% on the fresh sites and 90% on the moderately moist and moist sites. The herbs, grasses, sedges and shrubs provided a combined cover of about 90% on all five sites.

## METHODS

### Experimental Layout

Twenty-six 0.16-ha plots were used in the burning tests, twelve on the fresh sites, seven on the moderately moist sites, and seven on the moist site. The plots were 40 by 40 m, most situated in gridlike formations, and all individually enclosed by 6-m-wide bulldozed fire guards.

Ten uniformly spaced transects were established on each of the plots. The individual transects consisted of 20 sample quadrats, each 4 m<sup>2</sup> in area. The resulting 200 quadrats per plot provided for a 50% areal sampling.

### Fuel Assessments

The assessments on each plot were done mostly by means of the 10 transects. They included determinations of slash depth

and slash cover before and after burning on 200 quadrats, mapping to scale duff cover before and after burning on 200 quadrats, and measurements of duff depths before and after burning at 200 randomly spaced steel observation pins. A dot-grid method was subsequently used in converting the mapped duff-cover information to numerical values. Changes in vegetation cover resulting from the burns were, in each case, estimated for the entire plot area.

The slash and duff materials were sampled on each plot just before burning to determine their moisture contents. The per-plot slash sample consisted of 30 sheared branch segments, all 2.5 cm long from exposed locations at 0.6 m above the ground, and replicating by groups of 10 the thicker-end diameters of 0.5, 1.3, and 2.0 cm. Pine needles attached to the slash 0.6 m above the ground were also sampled. The per-plot duff sample consisted of 20 vertical cores, all taken with a 3.8-cm-across tubular auger, 10 from exposed locations outside slash and 10 from shaded locations under slash. The total duff depth was sampled, 5 cm on the fresh and moderately moist sites with the thin duff, 7 cm on the fresh and moderately moist sites with the moderately thick duff, and 8 cm on the moist site with the moderately thick duff. The sampled materials were subsequently transported in airtight containers to a field laboratory where they were weighed, dried at 100°C, and then weighed again when completely dry. The resulting differences were expressed as moisture contents in percentage of net oven-dry weights.

### Weather Measurements

A master weather station was established in a large forest clearing near some of the plots, with the most distant ones less than 3 km away. Using standard methods of instrumentation, the factors measured at the station included rainfall, cloud cover, air temperature, relative humidity, and two concurrent wind speeds, one at the 1.2-m level and one at the 10.0-m level. In addition, rainfall was measured at a number of substations adjacent to the plots on all five sites.

The weather measurements were taken daily at 13:00 Central Standard Time (CST), starting in spring of each year on the third day after the snow had melted and ending with the last burn for that year. Using these data, various fuel moisture codes and fire behavior indices were determined directly from appropriate tables (Anonymous 1976).

The weather was also measured right on location before, during, and after each burn. Portable instruments were used for this specific purpose.

### Burning and Fire Control

Burning was done between 15:00 and 19:00 CST under a variety of weather conditions (Table 1). Spring burning was tested on two plots in 1970, and summer to early fall burning was tested in 1970 and 1971. The burns were conducted over the range of Duff Moisture Codes (DMC's)<sup>2</sup> 18-43 so that, in terms of duff consumption, different degrees of burn were obtained (Table 2). The codes were originally based on duff materials similar to the ones in this experiment, and as such, they were considered suitable for rating the preburn moisture conditions. Moreover, the consistently high Fine Fuel Moisture Codes (FFMC's) of 81-92 on the days of burning ensured that the fine, cured, surface and aerial fuels were sufficiently dry for easy ignition. Other associated ratings included the Buildup Indices (BUI's) of 28-55, the Initial Spread Indices (ISI's) of 4-21, and the Fire Weather Indices (FWI's) of 9-36. There was no difficulty in selecting proper conditions for burning slash because, as demonstrated by other experiments (Chrosiewicz 1959, 1967, 1978; Van Wagner 1966), any fire for duff reduction automatically consumed all, or most, of the finer slash materials.

Each burn began as a U-shaped backfire and was completed by a headfire. At wind speeds of 8 km/h or less, about 10-20% of the plot area was burned over by the backfire before the headfire was started. At wind

speeds exceeding 8 km/h, the ignition of fuels for the headfire was usually delayed until about 30-60% of the plot area was burned over by the backfire. The flames averaged 1.5-3.0 m in height for the backfires and 1.8-6.1 m for the headfires, with occasional ones reaching as high as 9.1 m. The protection crew, however, had no difficulty in confining the burns within the plots.

### Analysis of Data

Slash and vegetation burned well under all conditions tested (Fig. 1), and this aspect of the treatment required no further analysis. Similarly, duff consumption was nearly identical for the backfires and the headfires, so that no corresponding distinctions were maintained when the data were analyzed. However, preliminary summations and plotting of the results in terms of duff-depth and duff-cover reductions by the different DMC's showed definite variation trends and the data were grouped accordingly. The results of spring burning on Plots 10 and 15 did not fit any of the variation patterns, so they were not included. Otherwise, the remaining data were analyzed in three distinctive groups, one containing the results of eight burns on the fresh and moderately moist sites with the thin duff, one containing the results of nine burns on the fresh and moderately moist sites with the moderately thick duff, and one containing the results of seven burns on the moist site with the moderately thick duff. Plots 21 and 24 were situated on rolling topography, and only one-half of the duff measurements on their lower, flat portions could be included with the other data on the moist site.

The mean duff depths before burn (Table 2) varied considerably, owing to random distribution patterns within and between plots. Moreover, the total areas burned (Table 2) showed variations, and some of the observation pins were found within the unburned patches. To overcome this, all duff-depth measurements within the unburned patches

<sup>2</sup> For definitions of the codes and indices as used in this report see Van Wagner (1974) and Anonymous (1976).

TABLE 1. Duff moisture codes and weather on days of burn

		Mean weather during burn				Date of burn —	Time of burn C S T
Duff Moisture Code	Plot No.	Cloud cover <sup>a</sup> %	Air temperature <sup>b</sup> °C	Relative humidity <sup>b</sup> %	Wind speed <sup>b</sup> km/h		
Thin duff over loamy till, soil moisture regime 2							
19	8	100	10	67	16	22 Sep. '70	16:00-17:00
21	5	20	27	27	6	9 Jul. '70	16:00-17:00
31	6	65	22	34	11	19 Jul. '70	16:00-17:00
34	7	75	18	50	13	25 Aug. '70	16:00-17:00
36	4	85	15	39	13	3 Oct. '70	15:00-16:00
Thin duff over loamy till, soil moisture regime 3							
19	1	70	18	56	6	19 Sep. '70	15:00-16:00
20	3	100	9	70	16	22 Sep. '70	15:00-16:00
33	2	10	26	20	6	30 Sep. '70	15:00-16:00
Mod. thick duff over loamy till, soil moisture regime 2							
21	19	5	27	24	3	9 Jul. '70	18:00-19:00
29	11	80	17	38	11	23 Jun. '71	16:00-17:00
31	9	100	20	54	10	31 Aug. '71	16:00-17:00
32	14	100	19	62	10	31 Aug. '71	17:00-18:00
36	12	0	29	48	6	4 Aug. '71	16:00-17:00
42	10	85	23	30	8	1 Jun. '70	15:00-16:00
43	13	50	33	34	8	6 Aug. '71	16:00-17:00
Mod. thick duff over loamy till, soil moisture regime 3							
29	17	95	15	44	10	23 Jun. '71	18:00-19:00
36	16	0	28	51	3	4 Aug. '71	18:00-19:00
42	15	50	24	28	10	1 Jun. '70	17:00-18:00
43	18	35	29	53	6	6 Aug. '71	18:00-19:00
Mod. thick duff over loamy till, soil moisture regime 4							
18	22	75	16	70	8	19 Sep. '70	17:00-18:00
19	25	100	10	70	13	22 Sep. '70	17:00-18:00
29	20	65	22	37	11	19 Jul. '70	18:00-19:00
30	26	30	23	20	8	30 Sep. '70	17:00-18:00
31	21	45	16	60	13	25 Aug. '70	18:00-19:00
33	23	70	15	42	10	3 Oct. '70	17:00-18:00
34	24	100	14	60	10	28 Aug. '70	18:00-19:00

<sup>a</sup> Ocularly estimated.<sup>b</sup> Measured at 1.2 m above ground.



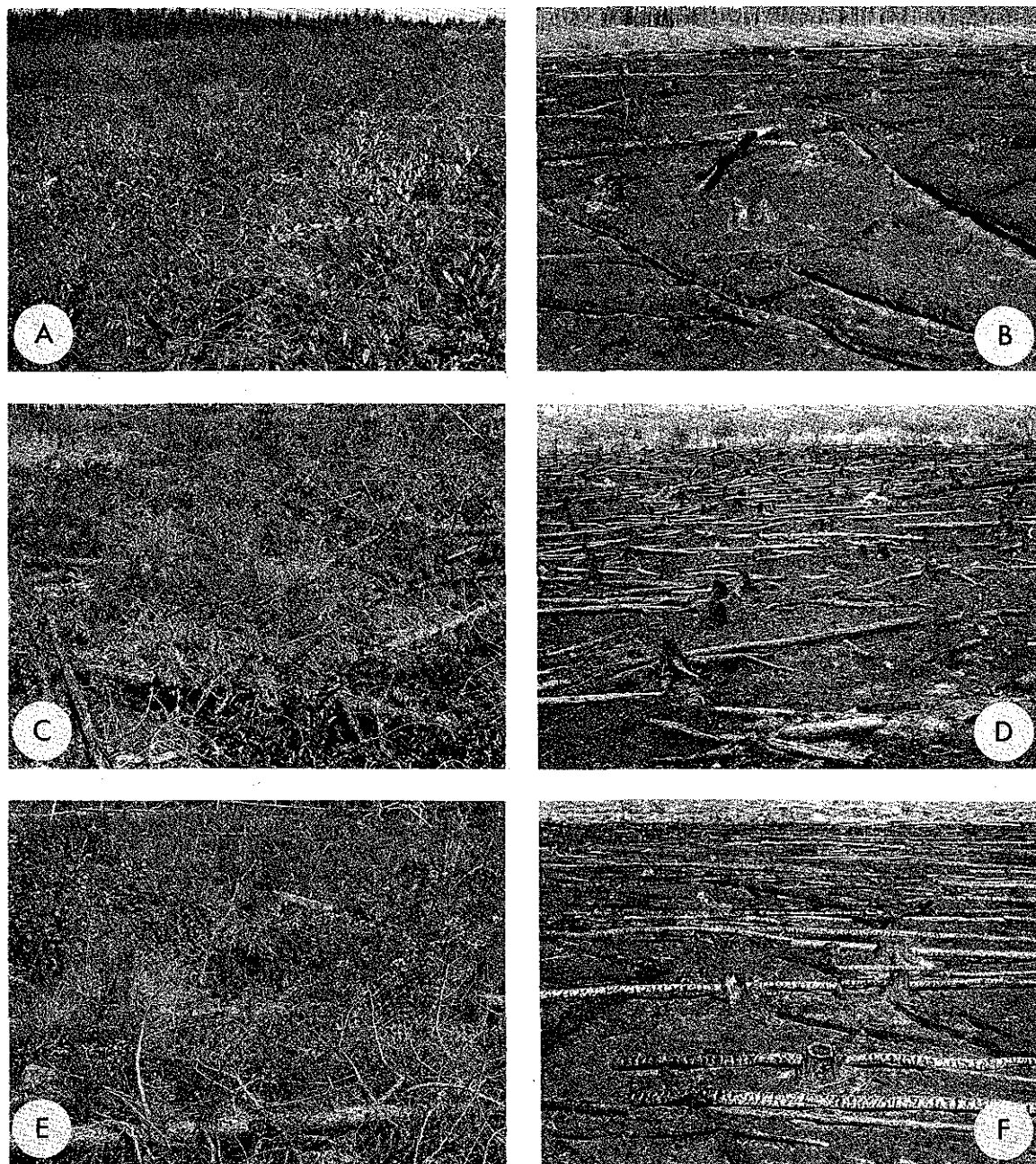


Figure 1. Typical examples of slash conditions before and after burning on fresh site (A, B), moderately moist site (C, D), and moist site (E, F).

TABLE 2. Duff conditions before and after burn

Duff Moisture Code	Plot No.	*Preburn duff moisture <sup>a</sup> %	Mean duff depth		Total duff cover		Total area burned <sup>c</sup> %
			Before burn <sup>b</sup> cm	After burn <sup>b</sup> cm	Before burn <sup>c</sup> %	After burn <sup>c</sup> %	
Thin duff over loamy till, soil moisture regime 2							
19	8	77	4.4	2.5	96.2	49.5	93.3
21	5	80	4.3	2.6	97.4	80.4	96.1
31	6	88	4.3	2.6	99.3	79.9	98.9
34	7	58	4.2	1.3	98.5	10.9	98.1
36	4	81	3.9	1.8	98.1	70.0	98.0
Thin duff over loamy till, soil moisture regime 3							
19	1	136	4.3	3.1	94.7	81.7	93.7
20	3	102	4.2	2.7	95.4	69.1	86.0
33	2	114	4.8	2.5	97.8	57.4	87.8
Mod. thick duff over loamy till, soil moisture regime 2							
21	19	114	6.5	3.6	98.8	87.5	97.9
29	11	97	5.4	2.3	98.1	85.5	98.0
31	9	96	6.5	3.5	96.6	84.8	95.7
32	14	94	6.2	3.0	95.9	78.0	95.0
36	12	78	5.1	2.4	99.3	87.1	98.4
42	10	148	6.2	3.4	99.2	91.2	99.2
43	13	91	5.6	2.2	96.1	74.7	96.1
Mod. thick duff over loamy till, soil moisture regime 3							
29	17	124	6.2	2.6	99.6	83.2	99.6
36	16	85	6.3	2.5	99.9	87.4	98.7
42	15	139	8.1	3.3	100.0	92.2	99.6
43	18	71	6.4	2.3	99.6	85.3	99.6
Mod. thick duff over loamy till, soil moisture regime 4							
18	22	151	7.6	5.3	98.0	83.1	94.6
19	25	134	7.7	5.7	98.2	86.1	94.9
29	20	282	7.4	5.5	99.2	95.4	90.0
30	26	205	7.1	5.9	99.4	92.6	92.6
31	21	166	8.0	5.0	99.5	88.3	98.9
33	23	164	6.6	4.5	98.0	83.6	97.4
34	24	198	5.5	3.4	97.9	78.3	95.1

<sup>a</sup> Values based on 20 duff samples per plot, 10 outside slash and 10 under slash - except, one-half this number of samples on Plots 21 and 24. Sampling depths: 5 cm on Plots 1 to 8, 7 cm on Plots 9 to 19, and 8 cm on Plots 20 to 26.

<sup>b</sup> Values based on 200 duff measurements per plot - except, one-half this number of measurements on Plots 21 and 24.

<sup>c</sup> Values based on mapping to scale duff areas - sampling 50%.

were eliminated from further analysis, and for the remaining data, common preburn duff-depth ranges were established by groups of burns to be compared. These ranges were 1.1-9.0 cm for the eight burns on the fresh and moderately moist sites with the thin duff, 1.1-11.0 cm for the nine burns on the fresh and moderately moist sites with the moderately thick duff, and 2.1-13.0 cm for the seven burns on the moist site with the moderately thick duff. Subsequently, only the preburn duff-depth values together with their post-burn counterparts within the predetermined ranges were used in computing the new means. The mean duff-depth values before and after burn so computed were then adjusted to the representative constant duff depths before burn, 4.0 cm on the fresh and moderately moist sites with the thin duff, 6.0 cm on the fresh and moderately moist sites with the moderately thick duff, and 7.0 cm on the moist site with the moderately thick duff. Similarly, the corresponding total duff-cover values after burn (Table 2) were adjusted to the constant 100% duff cover before burn.

By using the adjusted duff-depth and duff-cover values after burn as variables Y and the DMC's as variables X, linear regressions, correlation coefficients ( $r$ ), and standard errors of estimate ( $s_{y.x}$ ) (Snedecor 1956) were calculated and are shown in relation to the constants (Figs. 2, 3, and 4). No substantially better regressions were obtained when the BUI's were substituted as variables X. In fact, most of the correlation coefficients ( $r$ ) for both these types of X differed little and were significant, if at all, at identical probability levels. There was also no evidence that fire behavior, as rated by the ISI's and FWI's, had a differential effect on the reductions of duff depth and duff cover. The moisture content of duff was the controlling factor, with fire behavior assuming a subordinate position. This latter observation was consistent with findings from other experiments (Chrosiewicz 1959, 1967, 1978; Van Wagner 1966).

## RESULTS

### Consumption of Slash

The preburn moisture content of the finer <2.0-cm slash and of the attached needles was in most cases inversely related to the FFMC's 81-92. The ranges of this content were relatively low and narrow, 10-25% for the slash and 9-21% for the needles, jointly creating good burning conditions. Consequently, the burns were "clean" on all twenty-six plots, where slash, aerial parts of vegetation, and surface litter were destroyed (Fig. 1). The remaining organic materials included surface-charred stumps and other large pieces of wood, partially burned duff with some unburned plant roots, and occasional patches of unburned litter and duff over which the plants became scorched. The unburned patches occurred in those few places where localized lack of slash, exposed mineral soil, and seasonally lush vegetation created substandard burning conditions. However, the total area burned (Table 2) was consistently high, ranging by plots from 90.0 to 99.6%.

### Reduction of Duff Depth and Cover

Burning under the DMC's 18-43 (Table 2) was associated with a highly variable moisture content of the duff which, for all twenty-six plots, ranged from 58 to 282%. On each fresh and moderately moist site (soil moisture regimes 2 and 3), the moisture content showed mostly an inverse relation to the codes, although there were several instances in which this tendency was not maintained. The moisture content of duff during the two spring burns (Plots 10 and 15) was high and failed to fit the predominant patterns of variation that were established in the course of summer burning. However, on the moist site (soil moisture regime 4), the variation in the moisture content was erratic and completely unrelated to the codes. A longer retention of rainwater by the soil on this site was probably responsible. Otherwise, with few exceptions, the moisture content of duff increased both with the duff depth and with the soil moisture regime, all other conditions being equal, including the codes. The differentiation in the

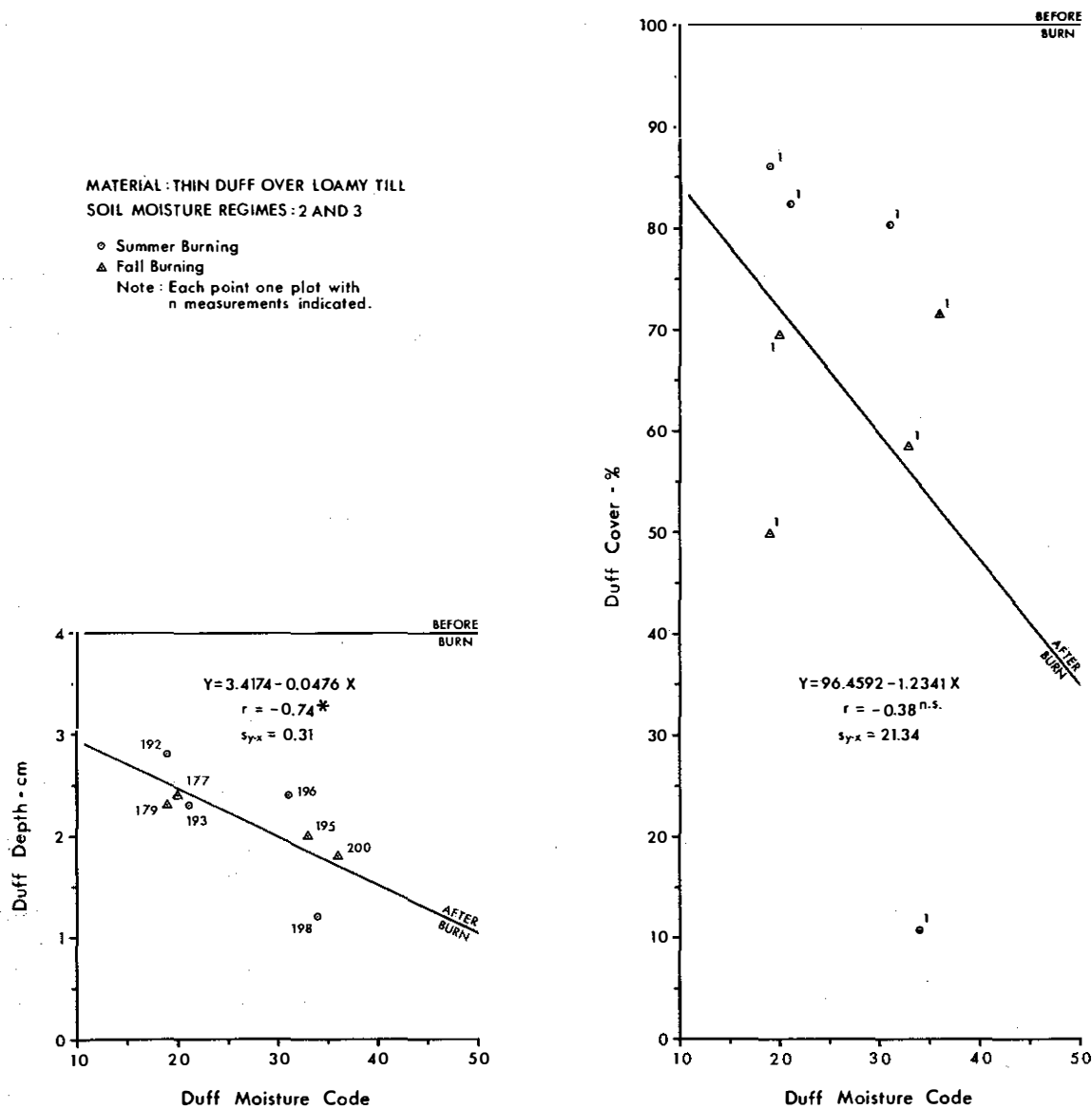


Figure 2. Reduction of duff depth (left) and duff cover (right) when burning thin duff on fresh and moderately moist sites. Coefficients of correlation ( $r$ ) with Duff Moisture Codes significant at 5% probability level (\*) for depth, and not significant (n.s.) for cover.

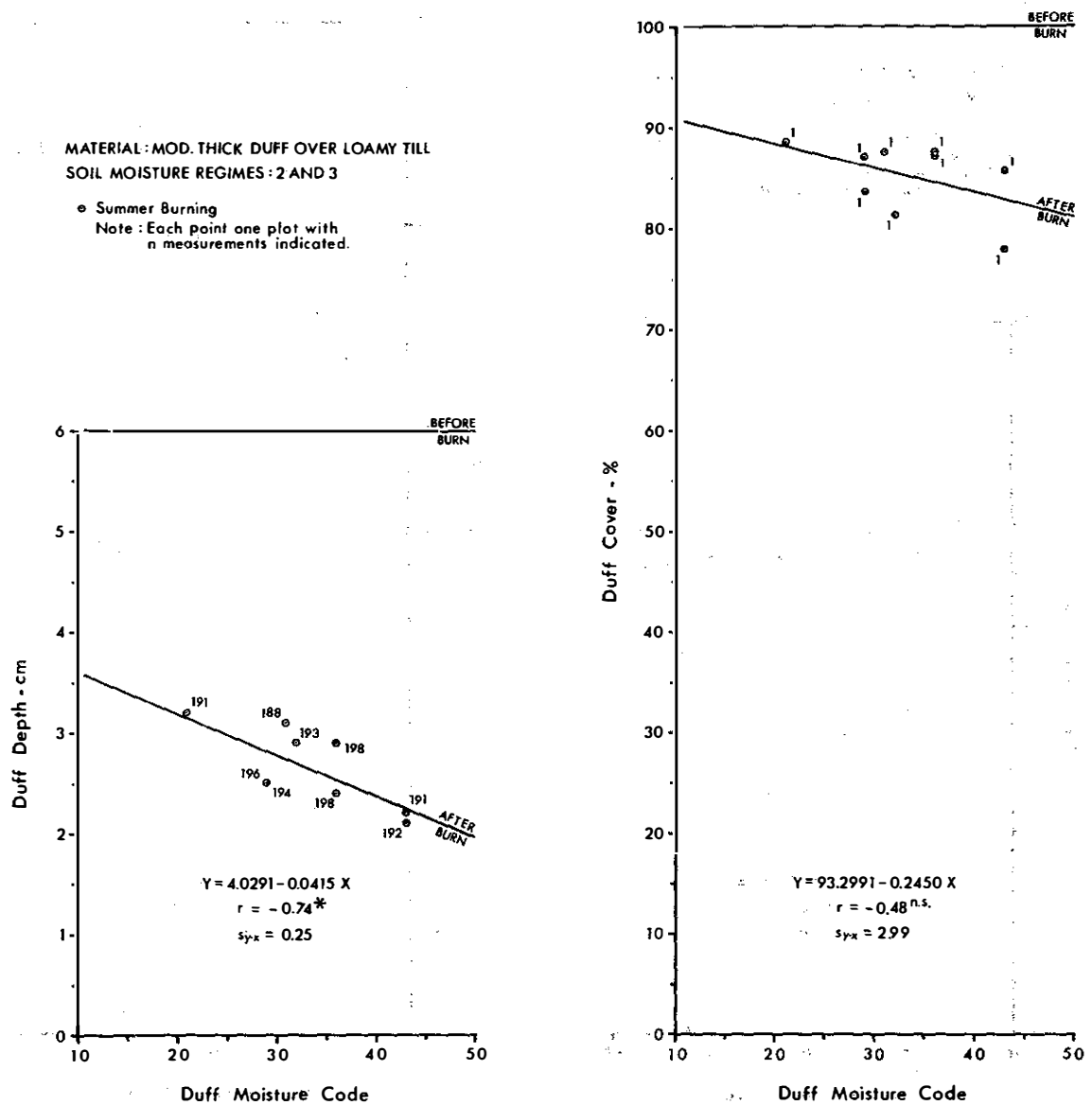


Figure 3. Reduction of duff depth (left) and duff cover (right) when burning moderately thick duff on fresh and moderately moist sites. Coefficients of correlation ( $r$ ) with Duff Moisture Codes significant at 5% probability level (\*) for depth, and not significant (n.s.) for cover.

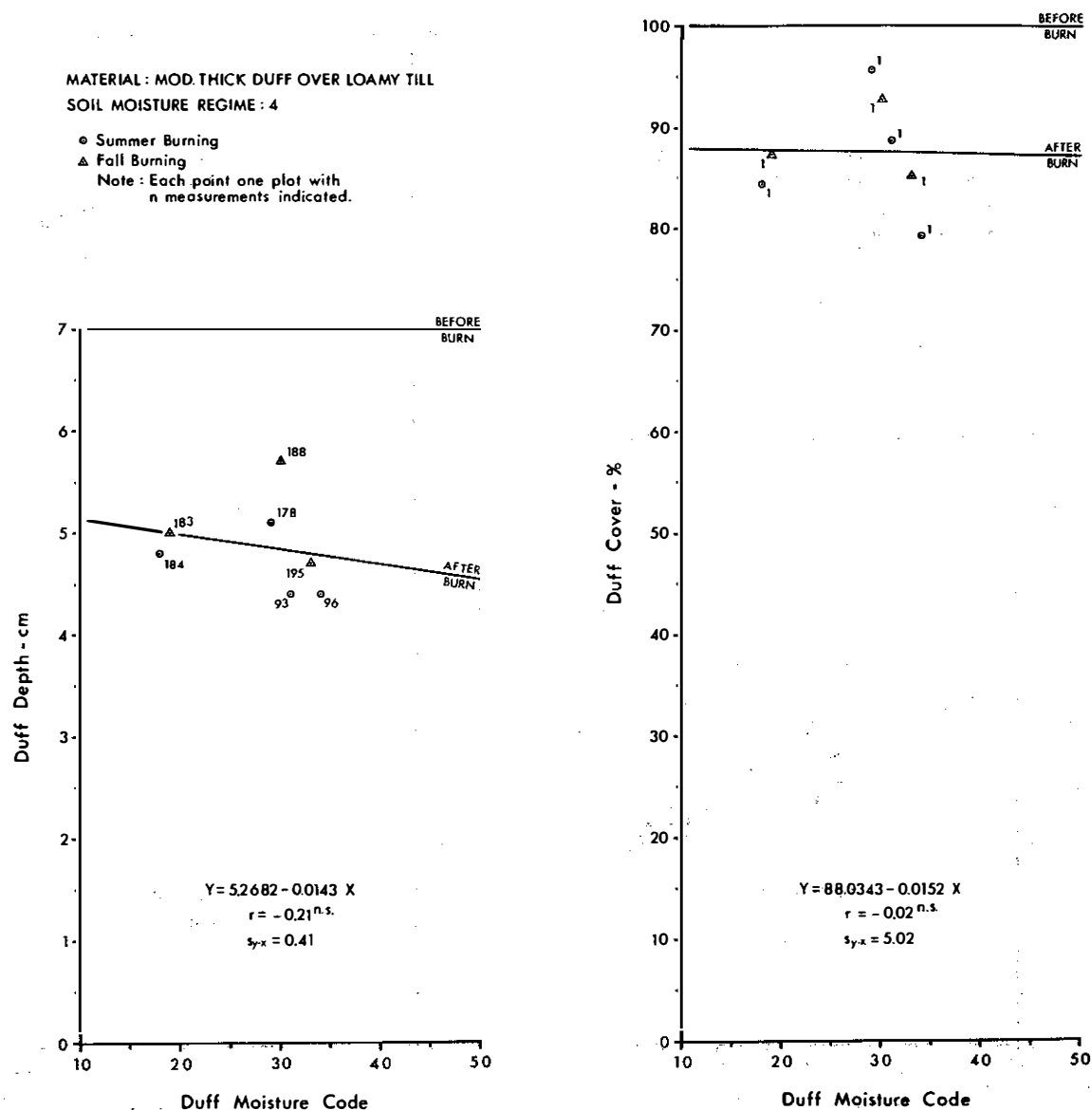


Figure 4. Reduction of duff depth (left) and duff cover (right) when burning moderately thick duff on moist site. Coefficients of correlation (r) with Duff Moisture Codes not significant (n.s.) for both depth and cover.

moisture content of duff was much less pronounced between the fresh and moderately moist sites (soil moisture regimes 2 and 3) than between the moderately moist and moist sites (soil moisture regimes 3 and 4).

The results of burning the duff were strongly affected by these moisture conditions. The mean duff depth (Table 2) ranged by plots from 3.9 to 8.1 cm before burn, and from 1.3 to 5.9 cm after burn. Similarly, the total duff cover (Table 2) ranged by plots from 94.7 to 100.0% before burn, and from 10.9 to 95.4% after burn. Figures 2, 3, and 4 show the duff reductions for twenty-four summer and early fall burns by means of calculated regressions of the postburn depths and covers over the corresponding moisture codes, all in relation to the preburn constants.

The regressions for burning thin duff on the fresh and moderately moist sites (Fig. 2) showed rectilinear relationships that were moderately strong between the DMC's and the postburn duff depth, and rather weak between the DMC's and the postburn duff cover. The associated  $r$  values of -0.74 and -0.38 were significant (5% probability level) and not significant, respectively. A similar situation existed in the regressions for burning moderately thick duff on the fresh and moderately moist sites (Fig. 3). Here again the rectilinear relationships were moderately strong between the DMC's and the postburn duff depth, and rather weak between the DMC's and the postburn duff cover. The  $r$  values of -0.74 and -0.48 characterized these relationships and were also significant (5% probability level) and not significant, respectively. Finally, the regressions for burning moderately thick duff on the moist site showed generally weak rectilinear relationships between the DMC's and both the postburn duff depth and the postburn duff cover. The low  $r$  values of -0.21 and -0.02 were not significant.

## DISCUSSION

It is evident from this experiment that some results of burning are more predictable than others and that, under comparable slash conditions, major site differences in terms of

duff depth and duff moisture must be recognized to make the predictions accurate. Essential to the predictions are adequate measurements of local weather and daily determinations of moisture codes by a standard method (Anonymous 1976). Next, one should determine whether the fuels to be burned are on sites similar to those studied, and whether the duff materials are of similar depths. If they are, then the burning operations may be conducted on some summer or early fall afternoon with a preselected DMC best fitting the desired reduction of duff depth and duff cover. For the fresh to moderately moist sites, the selection can be made from Figs. 2 and 3, either directly by interpreting the regression lines, or by solving the regression equations for variables  $X$ . Both these figures show that the reductions of duff depth are considerably more predictable than the reductions of duff cover, and therefore the selections of appropriate code values should be made primarily on the basis of duff depth. The regressions in Fig. 4 are at best rough approximations, and as such, unsuitable for making similar selections for the moist sites. Further research to solve this problem is needed.

As a rule, slash burning requires much lower drying regimes than does duff burning. In fact, this experiment shows that satisfactory results are obtained when the slash is burned under FFMC's as low as 81. Provided that the slash goes through an adequate period of curing, it can then be burned almost anytime, even on the third day or so after a heavy rainfall. Surface winds of about 8 km/h are sufficient to propagate the fire in dry slash.

Various methods of ignition and other aspects of burning are discussed in the literature (Chrosiewicz 1959, 1967, 1968, 1970, 1974, 1978; Beaufait 1962; Adams 1966; Cayford 1966; Van Wagner 1966; Ahlgren 1970; Sando *et al.* 1970; Sims 1976), and they all warrant careful study. This report gives additional information on the uses of fuel moisture codes (Van Wagner 1974; Anonymous 1976) for predicting the results of burning on jack pine cutover areas.

## ACKNOWLEDGMENTS

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## REFERENCES

- Adams, J.L. 1966. Prescribed burning techniques for site preparation in cutover jack pine in southeastern Manitoba. *Pulp. Pap. Mag. Can.* 67 WR:574-584.
- Ahlgren, C.E. 1970. Some effects of prescribed burning on jack pine reproduction in north-eastern Minnesota. *Agric. Exp. Stn., Univ. Minnesota. Misc. Rep. No. 94.*
- Anonymous. 1976. Canadian forest fire weather index tables. *Can. Dep. Environ., Can. For. Serv. For. Tech. Rep. No. 13.*
- Beaufait, W.R. 1962. Procedures in prescribed burning for jack pine regeneration. *Michigan Coll. Mining Tech., Ford. For. Cent. Tech. Bull. No. 9.*
- Cayford, J.H. 1966. Some aspects of jack pine regeneration on prescribed burned areas. *Can. Dep. For. Rural Develop., For. Br. Bi-Mon. Res. Notes 22(5):7.*
- Chrosciewicz, Z. 1959. Controlled burning experiments on jack pine sites. *Can. Dep. North. Aff. Natl. Resour., For. Br., For. Res. Div. Tech. Note No. 72.*
- . 1967. Experimental burning for humus disposal on clear-cut jack pine sites in central Ontario. *Can. Dep. For. Rural Develop., For. Br. Publ. No. 1181.*
- . 1968. Drought conditions for burning raw humus on clear-cut jack pine sites in central Ontario. *For. Chron.* 44:30-31.
- Chrosciewicz, Z. 1970. Regeneration of jack pine by burning and seeding treatments on clear-cut sites in central Ontario. *Can. Dep. Fish. For., Can. For. Serv., Ont. Reg. Inf. Rep. O-X-138.*
- . 1974. Evaluation of fire-produced seedbeds for jack pine regeneration in central Ontario. *Can. J. For. Res.* 4:455-457.
- . 1978. Slash and duff reduction by burning on clear-cut jack pine sites in south-eastern Manitoba. *Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-199.*
- Crum, H.A., W.C. Steere, and L.E. Anderson. 1973. A new list of mosses of North America north of Mexico. *Bryologist* 76:85-130.
- Hale, M.E., Jr. and W.L. Culberson. 1970. A fourth checklist of the lichens of the continental United States and Canada. *Bryologist* 73: 499-543.
- Hills, G.A. 1955. Field methods for investigating site. *Ont. Dep. Lands For., Res. Div. Site Res. Man. No. 4.*
- Sando, R.W. and R.C. Dobbs. 1970. Planning for prescribed burning in Manitoba and Saskatchewan. *Can. Dep. Fish. For., Can. For. Serv. Liaison Serv. Note MS-L-9.*
- Scoggan, H.J. 1957. Flora of Manitoba. *Can. Dep. North. Aff. Natl. Resour., Natl. Mus. Can. Bull. No. 140.*
- Sims, H.P. 1976. The effects of prescribed burning on some physical soil properties of jack pine sites in southeastern Manitoba. *Can. J. For. Res.* 6:58-68.
- Snedecor, G.W. 1956. Statistical methods. Iowa State Coll. Press, Ames, Iowa.
- Van Wagner, C.E. 1966. Three experimental fires in jack pine slash. *Can. Dep. For. Publ. No. 1146.*
- . 1974. Structure of the Canadian forest fire weather index. *Can. Dep. Environ., Can. For. Serv. Publ. No. 1333.*