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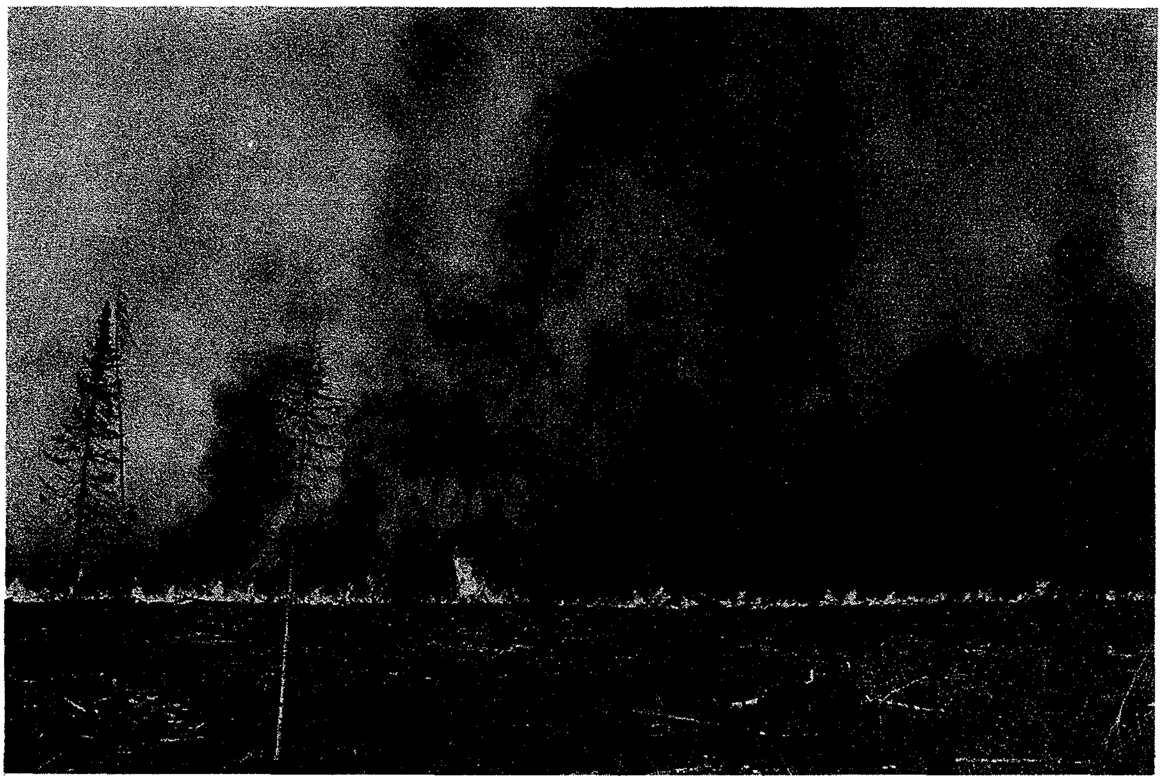

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# LARGE-SCALE OPERATIONAL BURNS FOR SLASH DISPOSAL

# AND CONIFER REPRODUCTION IN CENTRAL SASKATCHEWAN

BY

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## ABSTRACT

Four clear-cut jack pine (*Pinus banksiana* Lamb.) areas were burned over in central Saskatchewan to reduce slash-fire hazard and to create suitable seeding and planting conditions for conifer reproduction. The burns were carried out in midsummer when the surface fuels were dry. Slash, aerial parts of vegetation, all litter, and varying quantities of duff were consumed. Seeding and planting of different conifer species followed the burns; evaluation of results is continuing. This report presents the results of burning and lists guidelines for the safe, effective, and economic use of fire in future operations.

## RESUME

Quatre stations de Pin gris (*Pinus banksiana* Lamb.) coupées à blanc furent brûlées dans le centre de la Saskatchewan afin de réduire les dangers d'incendie de rémanents et pour créer des conditions d'ensemencement et de plantation convenables à la reproduction des Conifères. Les brûlages eurent lieu à la mi-été, alors que les combustibles de surface étaient secs. Les rémanents, les parties aériennes de la végétation, toute la litière et diverses quantités d'humus brut furent consumés. L'ensemencement et le plantage de différentes essences de Conifères suivirent le brûlage; les estimations des résultats se poursuivent. Ce rapport présente les résultats des brûlages et conseille au lecteur comment effectuer des brûlages sûrs, efficaces et économiques.

## CONTENTS

## INTRODUCTION

Since 1967, substantial volumes of conifer pulpwood, mainly jack pine (*Pinus banksiana* Lamb.)[1], black spruce (*Picea mariana* (Mill.) BSP.), and some white spruce (*Picea glauca* (Moench) Voss), have been harvested annually in central Saskatchewan, and there was a general consensus that supplementary treatments were required if adequate postcut reproduction of these species was to be ensured. Mechanical scarification of the ground surface with simultaneous redistribution of cone-bearing slash is the most extensively tested treatment to date. It was made operational in 1969, and since then, large jack pine clear-cut areas have been scarified with considerable success (Ball 1975).

Parallel with this development, controlled burning was introduced in 1970 as an optional treatment to test its uses in reduction of slash fire hazard and preparation of sites for either planting or seeding pine and spruce. Following a series of experimental tests (Chrosciewicz 1978b), several large-scale operational burns were carried out in 1971 at latitudes 53°53′ - 53°55′N and longitudes 104°57′ - 104°58′W, some 31-36 km by road northeast of Candle Lake, Saskatchewan. The results of these operational burns are presented in this report.

## THE AREAS

### Physiography

The burns were conducted on four clear-cut jack pine areas, named Centre East, Centre West, South, and North (Fig. 1) and consisting of 15.6, 33.4, 27.6, and 17.5 ha, respectively. The mineral soil materials were deep, podzolized, loamy tills containing by volume 1-35% of stones. The tills varied in texture from sandy loam to sandy clay loam, with about 8-25 cm of silty sand in the upper soil horizons. With the exception of a few wet spots that occurred in occasional depressions, the predominant soil moisture regimes (Hills 1955) were 2 (fresh) on Areas Centre East and Centre West, and 2 (fresh) to 3 (moderately moist) on Areas South and North.

### Slash and Duff

The original stands were clear-cut between 1968 and 1971. They were over 80 years old, with pulpwood yields of about 190-270 $m^3$/ha. The slash ranged in depth from 0.1 to 0.7 m. It was randomly distributed and provided an intermittent ground cover totalling 78-85%. The duff consisted of semifermented moss and litter materials and ranged in depth on all four areas from 1 to 17 cm; most of it was undisturbed. Some mineral soil was exposed during logging operations, but this occurred mainly along skidways, landing sites, and access roads.

### Vegetation

Many plant species were common on all fresh to moderately moist sites. The main ones among these were Schreber's moss (*Pleurozium schreberi* (Brid.) Mitt.), bunchberry (*Cornus canadensis* L.), blueberry (*Vaccinium myrtilloides* Michx.), Labrador tea (*Ledum groenlandicum* Oeder), fireweed (*Epilobium angustifolium* L.), and grass (*Calamagrostis canadensis* (Michx.) Nutt. and some *Elymus innovatus* Beal). Common bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.) was present mostly on the fresh sites, while strawberry (*Fragaria virginiana* Duchesne), sweet coltsfoot (*Petasites palmatus* (Ait.) Gray), raspberry (*Rubus idaeus* L. var. *strigosus* (Michx.) Maxim.), and green alder (*Alnus crispa* (Ait.) Pursh) were more abundant on the moderately moist sites.

The total moss cover was consistently 80-90%. Above this, the other species provided a combined cover of about 30-50% on the fresh sites and 80-100% on the moderately moist sites. A few, small, widely scat-

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[1] Species' nomenclature follows Scoggan (1957) for vascular plants and Crum *et al.* (1973) for mosses.

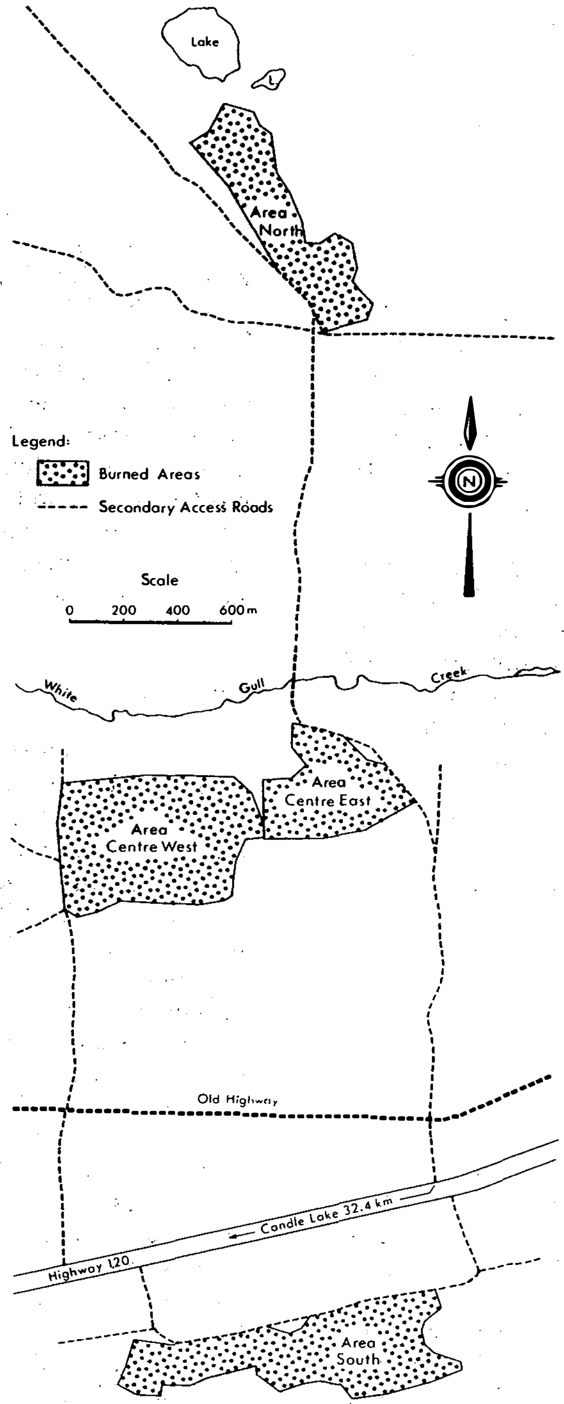


Fig. 1. Location of operational burns. Note variations in size and shape between individual areas.

tered clumps of trembling aspen (*Populus tremuloides* Michx.) were present within the areas, and these remained uncut.

## METHODS

### Fuel Assessments

To facilitate the assessments of fuels, twenty-four 0.04-ha plots were established. These were randomly located in groups of four plots per major site within the individual areas. Consequently, there were four plots each on Areas Centre East and Centre West and eight plots each on Areas South and North. The plots were 20 by 20 m, each containing 5 uniformly spaced transects. The individual transects were subdivided into sample quadrats with standard dimensions of 2 by 2 m. This resulted in 50 quadrats per plot, or 200 quadrats per major site, providing for a 50% sampling of the plot area.

The 200 quadrats per site were used for determination of slash depth and cover before and after burn, mapping duff cover to scale before and after burn, and measurements of duff depth before and after burn at 200 randomly spaced steel observation pins. The mapped duff-cover information was subsequently converted to numerical values by a dot-grid method. Changes in vegetative cover resulting from the burn were, in each case, estimated for the entire plot area.

On the outside of each group of plots, the slash and duff materials were sampled just before burning to determine their moisture contents. The per-site 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 at 0.6 m above the ground were also sampled. The per-site 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 duff samples were taken down to mineral soil, and they averaged 8.1-8.9 cm on the fresh sites and 9.1-9.6 cm on the moist sites. The sampled materials were transported in airtight containers to a field laboratory where they were weighed, dried at 100°C, and weighed again when completely dry. The resulting differences were expressed as moisture contents in percentage of net ovendry weights.

### Weather Measurements

Daily weather data for 13:00 Central Standard Time (CST) were obtained from a master weather station (Chrosciewicz 1978b), 10-15 km away from the areas to be burned. Included in the data were air temperature, relative humidity, and two wind speeds, one at the 1.2-m level and one at the 10.0-m level; rainfall was measured directly at a number of substations on each of the four areas. By using these data, various fuel moisture codes and fire behavior indices were determined from standard tables (Anonymous 1976). With the aid of portable instruments, the weather was also measured right on location during each burn.

### Burning Procedures

All four areas were burned between 21 July and 5 August 1971 (Table 1). On Areas Centre East, Centre West, and South, the burns commenced at 15:00 CST and were over in 3.0, 3.5, and 6.5 h. On Area North, the burn started at 17:00 CST and was over in 4.0 h. Cloud cover varied considerably (0-90%) during the burns, but the days were warm (20-30°C), with moderate humidities (36-66%) and moderate wind speeds (5-16 km/h).

The various codes and indices (Table 2) selected for the burns suggested improving conditions with each burn. First, the consistently high Fine Fuel Moisture Codes (FFMC 88-90) ensured that the finer slash and litter components were receptive to ignition. Secondly, the associated Duff Moisture Codes (DMC 20-40), the Drought Codes (DC 128-168) and the Buildup Indices (BUI 29-50) gradually increased from burn to burn, indicating that progressively greater amounts of the total fuels became combustible as a result of continued drying. Thirdly, even the Initial

TABLE 1. Weather during burns

| Area | Ranges | | | | Date of burn | Time of burn |
|---|---|---|---|---|---|---|
| | Cloud cover[a] % | Air temperature[b] °C | Relative humidity[b] % | Wind speed[b] km/h | — | CST |
| Centre East | 40-90 | 22-24 | 36-45 | 6-14 | 21 Jul.'71 | 15:00-18:00 |
| Centre West | 70-90 | 20-23 | 56-65 | 5-10 | 23 Jul.'71 | 15:00-18:30 |
| South | 0-20 | 20-27 | 36-66 | 6-16 | 3 Aug.'71 | 15:00-21:30 |
| North | 0-20 | 24-30 | 37-66 | 5-11 | 5 Aug.'71 | 17:00-21:00 |

[a] Ocularly estimated.

[b] Measured at 1.2 m above ground.

TABLE 2. Moisture codes and fire behavior indices during burns

| Area | Fine Fuel Moisture Code[a] (FFMC) | Duff Moisture Code[a] (DMC) | Drought Code[a] (DC) | Buildup Index[a] (BUI) | Initial Spread Index[a] (ISI) | Fire Weather Index[a] (FWI) |
|---|---|---|---|---|---|---|
| Centre East | 88 | 20 | 128 | 29 | 6 | 11 |
| Centre West | 88 | 25 | 142 | 35 | 7 | 15 |
| South | 90 | 32 | 149 | 42 | 12 | 23 |
| North | 90 | 40 | 168 | 50 | 10 | 21 |

[a] For definitions see Van Wagner (1974) and Anonymous (1976).

Spread Indices (ISI 6-12) and the Fire Weather Indices (FWI 11-23), by their gradual increases between the first three burns and then with only slight decreases for the last burn, showed predominantly a high potential for improving fire propagation and energy production.

The individual areas were enclosed by bulldozed fire guards 5-6 m wide. The burns on Areas Centre East, South, and North began with a U-shaped backfire that was then followed by a progressive two-sided perimeter ignition with several successive strip headfires, two for Area Centre East and five each for Areas South and North. In contrast, the burn on Area Centre West commenced as a U-shaped backfire that was then followed by a continuous two-sided perimeter ignition with one major headfire. The type of ignition was dictated by general accessibility of all portions of the individual areas, by their size, and what is perhaps most important, by their principal shape as reflected in the ratios between their average lengths and widths (Fig. 1 and Table 3). The flames averaged in height 1-3 m for the backfires and 2-6 m for the headfires. After normal mop-up operations, the burned areas were patrolled for several days.

## RESULTS

### Rates of Burn

The various types of ignition, and particularly the number of headfires used, had a profound effect on the rates of burn (Table 3). Within their overall range of 4.25-9.54 ha/h, the highest rate resulted from the use of a single headfire on Area Centre West. Area Centre East, with two strip headfires, had an intermediate rate, while Areas South and North, both with five strip headfires, had similar low rates.

### Consumption of Slash and Duff

The preburn moisture content of the finer components of slash (Table 4), including cured needles and cured <2.0-cm branches, ranged by areas and sites from 10 to 18%. This rather low and narrow range resulted in generally good burning conditions. Consequently, the original slash (Table 4), averaging 0.3 m in depth and totalling 78-85% of ground cover, was destroyed by the fires; only stumps, discarded logs, and some odd pieces of branchwood remained in their surface-charred state. In effect, the slash hazard was completely eliminated, and all four areas became relatively free of major physical obstructions.

The preburn moisture content of duff (Table 5) varied by areas and sites from 50 to 142% in exposed locations outside slash, and from 132 to 198% in shaded locations under slash. Within each of these two classes and on comparable sites, the duff moisture showed mostly an inverse relation to the DMC's (and the DC's etc.) (Table 2), and it generally increased with the soil moisture regime (Table 5).

Burning under these moisture conditions consumed litter and varying quantities of duff underneath the litter. The mean duff depth (Table 5) ranged by areas and sites from 6.4 to 7.9 cm before burn, and from 2.0 to 3.8 cm after burn. Similarly, the total duff cover (Table 5) ranged by areas and sites from 99 to 100% before burn, and from 76 to 90% after burn. Generally, the reduction of duff depth was substantial, and this in turn resulted in a considerable reduction of duff cover with the consequent exposure of mineral soil. On the fresh sites (soil moisture regime 2), the exposure ranged from 0 to 1% before burn, and from 15 to 24% after burn. On the moderately moist sites (soil moisture regime 3), the exposure was 1% before burn, and 10% after burn.

### Consumption of Vegetation

The aerial parts of vegetation, including moss, grasses, and shrubs up to an intermediate size, were completely destroyed. Even tall shrubs, such as the green alder and aspen saplings, were burned almost to the ground, with only a few charred 5- to 16-cm stubs remaining. However, many of the root systems both in and below the partially burned duff appeared healthy, and resprout-

TABLE 3. Types of ignition and rates of burn

| Area | Length to width ratio | Type of ignition | Total burn ha | Total time h | Rate of burn ha/h |
|---|---|---|---|---|---|
| Centre East | 1.2 | Backfire plus progressive two-sided perimeter ignition with 2 strip headfires. | 15.6 | 3.0 | 5.20 |
| Centre West | 1.5 | Backfire plus continuous two-sided perimeter ignition with 1 major headfire. | 33.4 | 3.5 | 9.54 |
| South | 4.7 | Backfire plus progressive two-sided perimeter ignition with 5 strip headfires. | 27.6 | 6.5 | 4.25 |
| North | 4.2 | Backfire plus progressive two-sided perimeter ignition with 5 strip headfires. | 17.5 | 4.0 | 4.38 |

TABLE 4. Slash conditions before and after burn

| Area | Soil moisture regime | Preburn slash moisture[a] | Mean slash depth | | Total slash cover | |
|---|---|---|---|---|---|---|
| | | | Before burn[b] m | After burn[b] m | Before burn[c] % | After burn[c] % |
| Centre East | 2 | 13-18 | 0.3 | 0 | 80 | 0 |
| Centre West | 2 | 12-16 | 0.3 | 0 | 84 | 0 |
| South | 2 | 10-13 | 0.3 | 0 | 85 | 0 |
| South | 3 | 10-13 | 0.3 | 0 | 81 | 0 |
| North | 2 | 10-12 | 0.3 | 0 | 83 | 0 |
| North | 3 | 10-12 | 0.3 | 0 | 78 | 0 |

[a] Each first value based on 1 composite sample of cured needles; each second value based on 3 composite samples of cured, <2.0-cm branches.

[b] Each value based on 200 direct measurements of slash depth by 4-m$^2$ quadrats; surface-charred stumps, logs, and odd pieces of branchwood not included.

[c] Each value based on 200 direct estimates of slash cover by 4-m$^2$ quadrats; surface-charred stumps, logs, and odd pieces of branchwood not included.

TABLE 5. Duff conditions before and after burn

| Area | Soil moisture regime | Preburn duff moisture[a] | Mean duff depth | | Total duff cover | |
|---|---|---|---|---|---|---|
| | | | Before burn[b] cm | After burn[b] cm | Before burn[c] % | After burn[c] % |
| Centre East | 2 | 114-160 | 6.4 | 2.8 | 99 | 76 |
| Centre West | 2 | 50-164 | 7.1 | 2.5 | 100 | 85 |
| South | 2 | 66-132 | 6.9 | 2.0 | 99 | 81 |
| South | 3 | 67-159 | 6.4 | 2.0 | 99 | 90 |
| North | 2 | 89-136 | 6.9 | 2.3 | 99 | 77 |
| North | 3 | 142-198 | 7.9 | 3.8 | 99 | 90 |

[a] Each first value based on 10 duff samples from outside slash; each second value based on 10 duff samples from under slash--all taken to mineral soil.

[b] Each value based on 200 direct measurements of duff depth at randomly marked observation points.

[c] Each value based on 200 direct mappings of duff cover by 4-$m^2$ quadrats.

ing of at least some of the original vegetation was expected.

## DISCUSSION

The burns were successful. The slash fire hazard was eliminated, and the areas became suitable for supplementary treatments. Starting in the fall of 1971, several seeding and planting treatments were tested on these areas over the next 2 years. Various pine and spruce species were involved, and evaluations are continuing. The results of these tests will be reported as they become available.

In addition, the burns provided a wealth of information on the basic requirements for the safe, effective, and economic use of fire in future operations. This information is presented as the following guidelines:

1. Select preferably square, or nearly square, cutover areas of sufficiently large size to justify the burning effort.

2. Utilize the existing roads as fire guards, and keep the construction of new ones to a minimum.

3. If occasional flattening of slash piles is required, do this job as a part of normal logging operations.

4. Select sufficiently dry conditions for burning the desired amount of fuels involved[2].

5. Start the ignition under stable wind conditions when no major changes in weather are expected for the next few hours.

6. Following an adequate backfire and, if necessary, a perimeter ignition, burn the remaining area with a headfire.

7. Guard the adjoining areas during the burn, and thoroughly mop-up the residual fire by noon of the next day.

8. Use relatively small crews of well-trained and experienced fire fighters.

9. To reduce costs, avoid hiring heavy equipment such as bulldozers or skidders, solely on a stand-by basis.

10. Do not hire aircraft, but instead wait for safer and more stable conditions. Only when the burn is very large may the cost of hiring an aircraft for any given purpose (aerial patrol, aerial ignition, etc.) be justified.

## ACKNOWLEDGMENTS

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[2] See Chrosciewicz (1976) for black spruce peat sites and Chrosciewicz (1978a and b) for jack pine duff sites.

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