O.D.C. 232.213 (712.7)

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BY
JOHN L. ADAMS

Reprinted from
WOODLANDS REVIEW SECTION
PULP AND PAPER MAGAZINE OF CANADA
December, 1966.

Woodlands Section Index 2393 (F-3)

Prescribed burning techniques for site preparation in cut-over jack pine in southeastern Manitoba

JOHN L. ADAMS[1]

JACK PINE does not regenerate well after cutting in southeastern Manitoba because of a lack of suitable seedbeds and excessive competition from ground vegetation. However, regeneration can usually be obtained either naturally or artificially, provided mineral soil seedbeds are prepared. The present method of establishing regeneration on cut-over areas in southeastern Manitoba consists of furrowing with a fireline plow and planting, by hand or machine, in the furrows. In most instances this operation must be delayed for some years after cutting until the slash has broken down sufficiently to enable tractors to work effectively. Even then windrows of slash, stumps, and residual trees make the furrowing and planting operations difficult on some areas.

Studies in Ontario and the Lake States have demonstrated that prescribed burning can be a useful tool for site preparation in cut-over jack pine (Ahlgren, 1960—1964; Beaufait, 1962; Chrosciewicz, 1959, 1965). In these studies the fire has usually consumed the organic soil layer providing mineral soil seedbeds and has reduced competition from ground vegetation. Also, where seed trees have been left, the heat of the fire has been sufficient to open the serotinous jack pine cones and make available a supply of seeds. Chrosciewicz (1959) concluded that if fire is to be used for preparing seedbeds the organic layers must be very dry at the time of burning. More recently the same investigator has established guidelines outlining fire danger and drought index[2] conditions which are necessary for obtaining suitable seedbeds by burning in cut-over jack pine in northern Ontario. Beaufait (1962), working in Michigan, has also established guidelines for prescribed burning for jack pine regeneration in the Lake States region.

Conditions on jack pine cut-overs in southeastern Manitoba are in many ways similar to those in Ontario and in the Lake States. Since experience in the Lake States has shown that sites can be prepared at a lower cost per acre by burning than by mechanical means (Cayford and Sims, 1964) and since burning offers a second advantage in that it can be done immediately after cutting (no period of waiting for slash to break down), it was decided to conduct some experimental prescribed burning on cut-over jack pine areas in southeastern Manitoba. In 1964 research was initiated with two main objectives:

(1) to demonstrate the use of prescribed burning for reducing slash and vegetative competition and removing organic material to bare mineral soil; and
(2) to determine the conditions necessary for safe and effective prescribed burning.

This report presents the burning techniques followed and the results obtained after 2 years' experimentation.

1964 Test plots

In the spring of 1964 an area which had been cut the previous winter was selected for the initial burning trials. It was on dry, sandy terrain in the Sandilands Forest Reserve. Before cutting, the stand averaged about 280 trees and 50 square feet

[1]Formerly Fire Research Officer, Department of Forestry of Canada, Winnipeg, Man. Now Chief, Forestry Technology, Selkirk College, Castlegar, B.C.

[2]Fire danger index represents relative ease of ignition and spread on a scale of 0 to 16. It is an average for all fuel types over a region. Drought index is essentially a record of days since rainfall of more than 0.05 inches and represents deep drying of duff and logs.

TABLE I *Summary of burning conditions and results — 1964*

Factor	*Plot Number*				
	1	*2*	*3*	*4*	*5*
Date of Burning	July 6	July 13	July 13	July 14	July 14
Time Ignition Started	1425	1450	1240	1525	1305
Time Burn Completed	1640	1540	1410	1615	1445
Stand Before Cutting:					
Number of trees per acre (1″ d.b.h.+	238	288	173	343	352
Basal area per acre (1″ d.b.h.+) (sq. ft.)	50.1	44.4	36.6	56.0	60.3
Average diameter (1″ d.b.h.+) (Inches)	6.2	5.3	6.2	5.5	5.6
Fire Weather:					
Danger Index	10	9	9	8	9
Drought Index	11	10	10	11	11
Slash Hazard Index[3]	16	15	15	15	15
Sky condition	Clear	Clear	Clear	Clear	Clear
Maximum Air Temperature (°F.)	86.5	89	89	86	90
Maximum Relative Humidity (%)	53	40	40	48	46
Minimum Relative Humidity (%)	39	34	36	46	36
Average Wind Speed (mph)[4]	8.5	6.3	4.9	3.8	3.8
Maximum Wind Speed (mph)[4]	15.0	13.1	10.8	5.2	5.5
Moisture Content (%) of:					
Dry Slash (Felled in winter)	11.7	11.0	13.3	7.3	9.4
Partially Green Slash (Felled in spring)	55.1	76.6	59.9	76.5	72.1
Duff and Humus (Covered by slash)	36.2	25.3	18.8	22.5	20.0
Duff and Humus (Exposed)	7.5	6.3	6.2	8.4	6.7
Average Depth of Duff and Humus (Inches)					
Before Burning	1.4	1.5	1.2	1.5	1.6
After Burning	0.56	0.38	0.36	0.32	0.34
Per cent reduction	60	75	70	79	79
Per cent of Area Burned	100	99	96	100	100
Per cent of Area with Bare Mineral Soil	27	15	25	33	36
Number of men in control Crew	17	10	10	12	12

[3]Slash hazard index represents the relative burning potential, i.e. ease of ignition and rate of spread, in slash fuels. As with fire nger index it is measured on a scale from 0 to 16.

[4]Wind speed measured as an average over a 2 minute interval. Individual gusts probably more than maximum indicated.

of basal area per acre. The average diameter of all trees greater than 1 inch d.b.h. was 5.8 inches. Logging removed about two-thirds of the trees; the remainder were left standing. Slash was left in windrows with intervening areas used as skidroads.

Five one-acre plots (four 5 × 2 chains and one 4 × 2½ chains) were established on a portion of the area and a bulldozed fireguard, 8 to 10 feet wide and cleared to mineral soil, was constructed around the area containing the plots. Firebreaks were made also between the plots with a "middlebuster" fireline plow. Except for 10 trees on one plot which were saved to provide a possible seed source, all residual trees were felled and lopped in early June. Felling was done so that tree tops would land on skidroads or in other openings in the slash cover, to increase the volume of slash and improve its continuity over the entire area (Fig. 1).

The plots were prepared and burned according to a prescribed burning plan. The plan specified that burning should be done when drought index and fire danger index were at least 10 and 8 respectively and that, if possible, each plot should be burned under a different fire danger-drought index combination. Weather data for computing fire danger and drought indexes were obtained from a fire weather station about 4 miles from the burn area. When the fire danger and drought indexes approached the minimum specified, special weather forecasts were obtained daily at 8:00 a.m. from the Department of Transport weather office in Winnipeg. If the forecast indicated favourable precipitation chance, wind and relative humidity on the day burning was proposed, the fire control crew and equipment were assembled.

All lighting and fire control measures were carried out by, and under the direction of, fire control personnel of the Manitoba Department of Mines and Natural Resources. Protection personnel at the burns consisted of conservation officers, fire rangers, patrolmen and labourers. Burning was done between 12:00 noon and 5:00 p.m. (Table I).

The strip fire method of ignition

Fig. 1. Typical fuel condition on the plots after felling of residual trees.

was used on all plots. In this method the downwind edge of a plot was ignited first and the fire allowed to back into the wind for a distance of about 1 chain providing a wide firebreak. The rest of the plot was burned with consecutive strip headfires (Fig. 2). Headfires were lit in a U-shape, the torchman starting from the backfire, lighting upwind along the side of the plot for 1 or 2 chains, across the plot, then down the other side to meet the backfire. Lighting was carried out by one man with a back-pack motor blower torch. Each new headfire was ignited only after the previous one had covered the prescribed strip and was reduced greatly in intensity.

Large crews were present at the 1964 burns, ranging from 10 to 17 men plus the fire boss and research personnel. Four to six men equipped with back-pack pumps patrolled the downwind fireguard and adjacent timber during the initial backfire, then they moved down the sides of the plot as burning progressed, occasionally patrolling the downwind end. Two 500-gallon tanker trailers were used to dampen fuel outside the fireguard adjacent to portions of the plot being lit. One or two tanker trailers and a tractor with fireline plow attached were on standby during burning. After burning was completed the area was patrolled by two men until about 10:00 p.m. The next morning any fires in stumps or logs were extinguished.

The five plots were burned between July 6th and July 14th. Data on burning conditions and results are given in Table I. Little difficulty was experienced in controlling the fires. Some spotting occurred outside the firelines from sparks thrown from green trees adjacent to fireguards and also from radiational heating. However, all spot fires were quickly and easily extinguished by the patrolling back-pack pump men. During the burning on one plot a southwest wind changed to northwest causing a backfire to become a headfire for about half the length of the plot. A backfire was started at the south end of the plot and fuels outside the fireguard were dampened to prevent the fire from escaping.

These small controlled burns were judged to be an unqualified success. Mineral soil was exposed, vegetative competition reduced and the slash fire hazard eliminated. Almost 100 per cent of each plot was burned over; the small unburned portions were skid roads on which no slash was present. Exposed mineral soil occurred in well distributed patches and occupied from 15 to 36 per cent of the plot areas (Table I). Burned litter and humus occupied the remaining area (Fig. 3). The seed trees left on one plot were killed, the cones opened and seed was disseminated.

Fig. 2. Strip headfire burning on seed tree plot shortly after ignition. Note volume of fuel in foreground and fire in crown of seed tree.

Expanded burning trials in 1965

The work in 1964 showed that fire is a practical means of preparing mineral soil seedbeds on cut-over, dry, jack pine sites in southeastern Manitoba and that prescribed fires can be controlled with little difficulty. The next step was to determine if comparable results could be obtained on larger areas for reasonable costs.

Four areas ranging in size from 18 to 51 acres, were burned during the summer of 1965. Three (Areas 1, 3 and 4) were on dry to fresh sites (Mueller-Dombois, 1964) which had supported pure jack pine stands. Ground vegetation was mainly low ericaceous plants and scattered tall shrubs. The fourth (Area 2) was on a slightly moister site and had supported a mixedwood stand of jack pine, trembling aspen and white birch from which only the merchantable jack pine had been cut. Ground vegetation on this area was characterized by more tall shrubs and herbaceous plants and less low ericaceous plants than on the other areas. On all areas the parent soil was a medium stone-free sand. Topography was generally flat except on Area 1 which included a moderate slope.

Slash on Areas 1, 3, and 4 was predominantly in windrows but in some instances it had been scattered or piled. Area 2 had less slash than the other three and most of it was scattered or piled. Slash on all areas had been lopped during the cutting operation. On area 3 a 10-acre block had been marked prior to cutting to leave 10 seed trees per acre as a possible seed source for natural regeneration.

Preparation for burning was similar to that in 1964. A fireguard 8 to 10 feet wide was bulldozed around the perimeter of each cut-over area except where one already existed (Fig. 4). The areas were then divided into blocks of from 6 to 20 acres by double furrow firebreaks constructed with a fireline plow (Fig. 5). All fireguards

Fig. 3. Typical seedbed conditions after burning. Light areas are mineral soil, dark areas burned litter and humus.

Fig. 4. Bulldozed fireguards passable by 2-wheel drive vehicles.

Fig. 5. Single-furrow plowed fireline.

around the perimeter were passable for 2-wheel-drive vehicles and tanker trailers. All residual trees within approximately 100 feet of the perimeter and inside the fireguard were felled and limbed to reduce the chance of spot fires. No other residual trees were felled.

Weather records from nearby fire danger stations were used for computing the fire danger index for each area. Rainfall data from gauges set out on the areas several weeks prior to burning were used for computing the drought index. Special weather forecasts were again obtained from the Department of Transport in Winnipeg on the morning of the proposed burning day. It was necessary to postpone burning once after men and equipment were assembled when an unexpected low cloud cover developed at 11:00 a.m. and produced a trace of rain and consequent high humidity.

Procedures for conducting the prescribed burns were basically similar to those used the previous year. The strip-fire method was used on Areas 1 and 4 but the pattern of ignition was altered somewhat from that used the previous year. Instead of lighting a backfire on the downwind edge, a series of narrow headfires (approximately 10 feet wide) was used to burn out a protective strip about 1 to 1½ chains wide. This was less time consuming than burning out the downwind edge with a single backfire. The remainder of each area was burned in strips 2 to 6 chains wide with headfires (Figs. 6 and 7). Each strip was allowed to burn out before the next one was ignited. All lighting was done with drip torches.

On Area 2, partly because of the large proportion of hardwoods and brush and partly because of low wind and high humidity, fire would not spread much beyond slash covered areas. Therefore, perimeter ignition was tried in the hope that draft would be created to aid fire spread. This was not completely successful and many individual slash piles and windrows had to be ignited to effect as complete a burn as possible.

During the burning of Area 3, as with Area 2, low wind speeds precluded fire spread beyond slash when strip headfires were tried, so an area ignition technique was employed. After an initial protective strip had been burned out on the downward edge, torchmen crossed back and forth over the area continuously lighting parallel strips about 20—30 feet upwind of the last until the whole area was covered. With several strips burning at one time, drafts were created which drew the fire through ground vegetation between slash areas thus improving fire spread.

Each block within an area was burned as a unit. Burning operations ceased temporarily upon completion of a block, allowing the fire to cool down and the smoke to clear. During this period back-pack tanks and tanker trailers were refilled if necessary and the drop torches refuelled.

Burning crews on these fires varied from 12 to 19 men. They consisted of a fire boss, 3 to 7 back-pack pump patrolmen, two 3-man crews, each with a 500-gallon tanker-trailer, and a 2 to 5 man lighting crew. When the initial fireguard strip on the downwind edge was being burned out patrolmen with back-pack pumps were deployed in the adjacent uncut stand. As firing progressed windward, so

Fig. 6. Ignition of strip headfire on Area 1 by two torchmen equipped with drip torches.

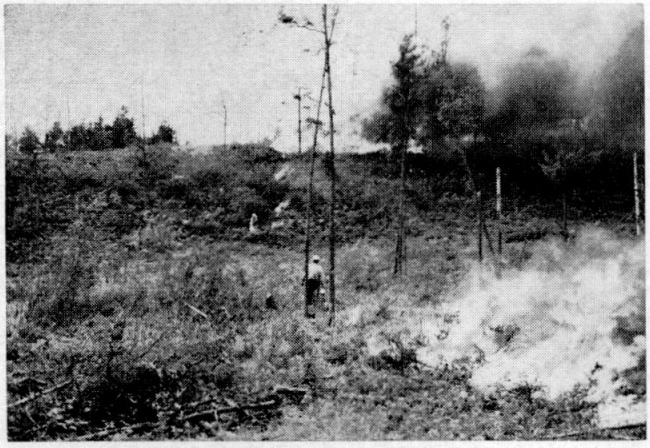
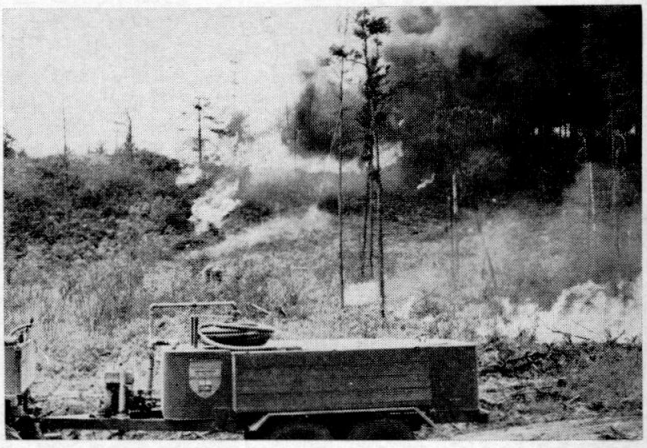


Fig. 7. Same headfire as in Fig. 6, 20 seconds later. Torchmen have met at base of slope. 500-gallon tanker trailer in foreground follows firing along fireguard.



did the patrolmen, but periodically a check would be made around the burned out section. Hazardous fuels outside the fireguard and adjacent to strips being lit were dampened, when necessary, to prevent spot fires. This was done with the tanker-trailers which followed along the fireguard with the burning. Small, portable, "walkie-talkie" type radios were used successfully for communication between fire boss, patrolmen, tanker-trailer operators, and the lighting crew. All personnel were provided with sketch-maps of the area being burned for orientation purposes (Fig. 8). These maps outlined fire breaks, roads, and reference points (trees outside the fireguards numbered with tree-marking paint).

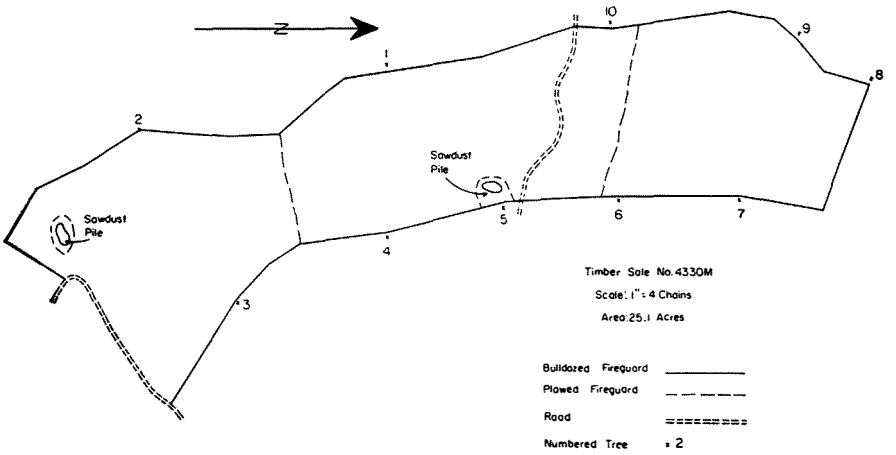


Fig. 8. Sketch map of Area 1.

Results of 1965 burning

The prescribed burns in 1965 eliminated the fire hazard resulting from slash on all areas. All slash fuels under 1-inch in diameter, and in some areas larger material as well, were consumed. Well over 80 per cent of Areas 1, 3, and 4 was burned over (Table II). Mineral soil exposure on these areas ranged from 13 to 19 per cent of the total area. The exposed mineral soil appeared in small, well distributed patches with burned litter and humus intervening. The best results were obtained on Area 4 where 99 per cent of the area was burned with 18 per cent mineral soil exposed. Only 69 per cent of Area 2 was burned over with 1 per cent of the area classified as mineral soil seedbed. The aerial portions of most of the herbs, shrubs, and trees were killed on this area.

Costs of burning ranged from $4.98 per acre on the largest area to $15.96 per acre for the smallest. The wide variation in costs is attributed chiefly to the varying sizes and shapes of the areas and the resulting differences in the ratio of length of fireguard to area burned. This factor is discussed later.

Control of the fires presented no problems. A few spot fires occurred during each burn mostly in debris on the immediate outside edge of the bulldozed firebreaks while a few were found farther back in the standing timber. All were extinguished early and quickly by back-pack pump patrolmen.

Discussion and recommendations

All burns were successful in improving the areas for planting by completely removing all except the

TABLE II *Burning conditions and results* — 1965

Factor	*Timber Sale No.*			
	Area 1	*Area 2*	*Area 3*	*Area 4*
Area (acres)	25.1	17.9	50.8	22.0
Date of Burning	August 10	August 11	August 17	August 23
Time Ignition Started	12.00	1120	1155	1245
Time Burn Completed	1900	1645	1745	1615
Stand Before Cutting[5]				
Number of trees per acre (1" d.b.h.+)	272	242	322	292
Basal area per acre (1" d.b.h.+) (sq. ft.)	68.2	41.4	55.5	62.2
Average Diameter (1" d.b.h.+) (Inches)	6.8	5.2	5.6	6.3
When Cut	1963/64;64/65	1964/65	1964/65	1963/64
Per cent of area Covered with Slash	50	38	43	53
Fire Weather:				
Danger Index	10	7	10	12
Drought Index	10	11	11	16
Slash Hazard Index	15	15	16	16
Sky Condition	Clear	Clear	Partly Cloudy	Clear
Maximum Air Temperature (%)	87	92	71	86
Maximum Relative Humidity (%)	49	64	60	38
Minimum Relative Humidity (%)	36	36	38	28
Average Wind speed Speed (m.p.h.)	6.1	2.6	6.7	7.1
Maximum Wind Speed (m.p.h.)	11.6	5.2	10.0	9.5
Moisture Content (%) of:				
Fine Slash (½ diam.)	10.0	14.6	18.4	9.4
Duff and Humus (Covered by salsh)	20.3	32.2	35.2	20.9
Duf and Humus (Exposed)	7.5	15.6	8.5	9.6
Average Depth of Duff and Humus (Inches)				
Before Burning	1.3	1.2	1.3	1.4
After Burning	0.4	0.8	0.6	0.4
Per cent Reduction	69	33	54	71
Per cent of Area Burned	86	69	83	99
Per cent of Area with Mineral Soil Bared	19	1	13	18
Number of Men	17	17	19	12
Cost per acre	$13.53	$15.96	$4.98	$6.66

[5]Jack pine only. Area 2 was predominantly mixedwood with much small aspen and white birch in addition to the jack pine.

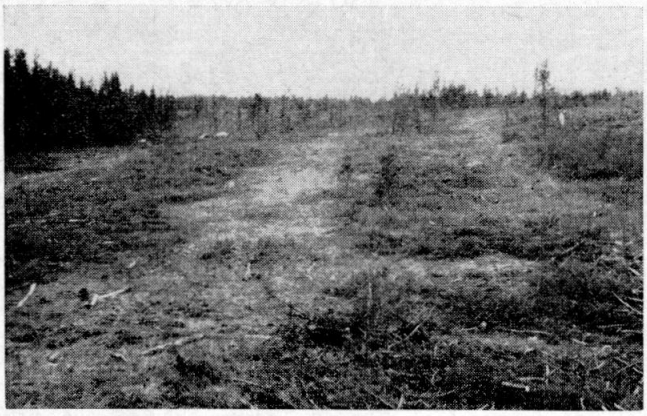


Fig. 9. Area 1 before burning, looking from north to south. Note slash windrows.

Fig. 10. Area 1 after burning.

larger pieces of slash and by removing aerial portions of ground vegetation. On all areas (between Area 2 in 1965) burning has resulted in the creation of a large number of well distributed mineral soil seedbeds.

Since the objective of prescribed burning was to produce conditions favouring regeneration, studies designed to follow changes in ground vegetation and to evaluate the success of planting, seeding, and natural regeneration have been initiated on the burned areas. Results of these studies are not yet available, but observations have indicated that vegetative competition was much reduced during the first growing season on the plots burned in 1964 as compared to that on the surrounding unburned areas.

Our experience so far has indicated that the initial criteria specifying a drought index of 10 or more and a fire danger index of not less than 8 will produce well distributed patches of bare mineral soil. Burning should not be attempted too early in the day when relative humidity is high. For example, when burning Area 2 the relative humidity did not drop below 40 per cent until 3:00 p.m., when the burn was about half completed. Burning was less successful on the portion burned before 3:00 p.m.

For successful controlled burning in southeastern Manitoba wind speeds should be at least 8 to 10 miles per hour during burning. Fires will rarely spread between windrows or piles of slash, except under extremely dry conditions, with wind speeds below this range. Also, stronger winds tend to be less variable in direction, an important safety factor.

Trees inside the fireguards within a band approximately 100 feet wide should be felled and as little slash as possible left immediately outside the fireguards. In 1964, trees left standing along the boundaries often crowned, throwing sparks across firebreaks into dry slash. In 1965, such trees were felled and little slash remained outside the fireguards, reducing the incidence of spot fires considerably, even with strong winds.

A record of costs was not kept for the 1964 burning because fires were overmanned and costs per acre for fireguard construction were disproportionately high. Considering the experimental nature of the burning, costs (ranging from $5.00 to $16.00 per acre) for 1965 were satisfactory. They include machine time for fireguard construction and standby during burning, all wages paid to personnel for area preparation, burning, and night patrol, fuel for torches, and other supplies purchased specifically for the burns.

It should be possible to reduce costs to an average of about $5.00 per acre. If controlled burning is to be used for site preparation, measures to reduce burning costs can be incorporated into the cutting plans. These are:

(1) Cut and burn large units to reduce cost of fireguarding per acre and man-hours per acre. From 15 to 20 men are sufficient to burn areas several hundred acres.
(2) Locate and lay out timber sales to take advantage of existing roads and trails for possible use as firebreaks.
(3) Lay out timber sales in regular, compact blocks to reduce the length of fireguard to area ratio. For example, if the 25 acres of Area 1 (Figs. 9 and 10) had been contained in a 16-chain square instead of a strip approximately 7 by 36 chains, the cost of fireguarding would have been one-third less.
(4) Near the boundary of the cutting area, fell all trees inward to facilitate fireguard construction.
(5) Locate millsites outside the cutting areas so that sawdust and slab piles will not require special fireguarding.

Many side benefits have been realized during the burning program in southeastern Manitoba. First, the fires have provided training and experience for fire control personnel in the operation of fire control equipment under actual fire conditions. Second, they have provided an opportunity for fire control personnel to familiarize themselves with prescribed burning technique. Third, the fires have served as a useful check on the detection system in the area. Finally, the fires have made possible close observation and measurement of fire behaviour and weather-fuel-fire behaviour relationships—an important aspect of controlled burning research.

It is planned to continue the burning program in southeastern Manitoba on larger areas and to extend the work to other parts of the province where jack pine is being logged.

Summary

The results of controlled burning on cut-over jack pine sites in southeastern Manitoba can be summarized as follows:

(1) The fire hazard resulting from jack pine slash was eliminated on all the areas burned.
(2) On most areas a good proportion of the organic material was removed and aerial portions of competing ground vegetation destroyed.
(3) Fire control, even under high

fire danger conditions, presented no problems.

(4) Costs as low as $5.00 per acre were achieved.

(5) Under conditions of fuel moisture content, drought index, and fire danger index that have prevailed so far, the success of burning has been governed mainly by wind and relative humidity. With relative humidity about 40 per cent, strong winds (over 10 miles per hour) are needed to spread the fire; below 40 per cent relative humidity lighter winds are sufficient. ●●

Acknowledgement

The initiative, interest, and support of personnel in the Manitoba Department of Mines and Natural Resources have contributed much to the success of the controlled burning research program in southeastern Manitoba. Particular thanks go to A. W. Braine, Director of Forest Protection, A. O. Jardine, formerly Regional Supervisor, E. G. Wong, former Regional Forester, C. D. Rannard, Regional Forester, M. Kaye, Extension Forester and H. C. Tirschman, Chief Ranger, Southeastern Region.

REFERENCES

AHLGREN, C. E. 1960, 1961, 1962, 1963, 1964. Annual Reports. Quetico-Superior Wilderness Research Centre, Wilderness Research Foundation, Chicago, Ill.

BEAUFAIT, W. R. 1962. Procedures in prescribed burning for jack pine regeneration. Michigan College of Mining and Technology, Ford Forestry Centre, *Tech. Bull. No.* 9, 37 pp., illus.

CAYFORD, J. H. and SIMS, H. P. 1964. Personal Correspondence, November 3, 1964.

CHROSCIEWICZ, Z. 1959. Controlled burning experiments on jack pine sites. Canada, Dept. of Northern Affairs and National Resources, Forestry Branch, Forest Research Division, Tech. *Note No.* 72, 19 pp., illus.

CHROSCIEWICZ, Z. 1965. Experimental burning for humus disposal on clear-cut jack pine sites in central Ontario. Department of Forestry, Canada, Mimeo. 65-0-11, 25 pp., illus.

MUELLER-DOMBOIS, D. 1964. The forest habitat types in southeastern Manitoba and their application to forest management. *Canadian Journal of Botany*, 42:1417-1444, illus.