REGENERATION OF JACK PINE BY BURNING AND SEEDING TREATMENTS ON CLEAR-CUT SITES IN CENTRAL ONTARIO

Z. CHROSCIEWICZ

FOREST RESEARCH LABORATORY
ONTARIO REGION
SAULT STE. MARIE, ONTARIO

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Frontispiece. Burning for jack pine regeneration.

ABSTRACT

Eleven summer-burning and spring-seeding treatments were experimentally tested in central Ontario for the purpose of regenerating jack pine (*Pinus banksiana* Lamb.) on clear-cut sites. Burning was done under different drought conditions and the resulting seedbeds were then broadcast seeded at a rate of 16 ounces of seed per acre. In terms of pine establishment, the treatments were highly successful. The third-year stocking by 0.001-acre quadrats was 60 per cent on one plot and 80 to 99 per cent on 10 plots. The number of trees ranged from 2,564 to 27,638 per acre, and practical means for controlling regeneration density in future burning and seeding treatments were suggested.

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INTRODUCTION

Undisturbed surface-raw-humus materials seriously hinder the re-establishment of jack pine (*Pinus banksiana* Lamb.) after cutting, and treatments are often required to improve the overall habitat conditions for seed germination and seedling survival. Between 1949 and 1956, several attempts were made in central Ontario to determine whether favourable seedbeds could be produced by burning off the raw humus. The experiments were carried out in spring and autumn when the moisture content of humus seldom allowed the fire to burn much below the dry surface litter. This type of burning was satisfactory only in those few situations where the original raw humus was exceptionally thin. In all other situations, particularly where the humus layer exceeded 1.5 inches, the resulting burns were much too shallow for the improvement of seedbeds and pine regeneration. Therefore, further experimental work covering the summer-drought periods was required to define a more rational timing of burning operations, especially for the deeper raw-humus materials (Chrosciewicz 1959).

Between 1960 and 1963, several summer-burning and spring-seeding treatments were successfully tested on two 1957 clear-cut sites, both at latitude 47° 03'N and longitude 82° 15'W, north-northwest of Espanola, Ontario. Results pertaining to the physical aspects of burning are presented elsewhere (Chrosciewicz 1967, 1968). This report evaluates the burning and seeding treatments in terms of jack pine regeneration relative to seedbeds, soils and vegetation.

SITES

The experimental area consisted of two adjoining terraces, each at a different elevation. Soils were deep, well drained, siliceous, podzolized and acid. Raw humus was a coarse-textured jack pine mor on the upper terrace, and a fine-textured jack pine-black spruce (*Picea mariana* (Mill.) BSP.) mor on the lower terrace. Mineral materials underneath varied in texture from a pebbly and predominantly silty fine sand overlying fine sand on the upper terrace to a uniformly sorted fine sand on the lower terrace, and the soil moisture regimes (Hills 1955) were 1 (moderately dry) and 2 (fresh), respectively.

Vegetation cover was about 80 per cent. It consisted mainly of sweet-fern (*Comptonia peregrina* (L.) Coult.), bracken fern (*Pteridium aquilinum* (L.) Kuhn) and sour-top blueberry (*Vaccinium myrtilloides* Michx.) on the upper terrace, and of low-bush blueberry (*Vaccinium angustifolium* Ait.), trailing-arbutus (*Epigaea repens* L.), and Schreber's moss (*Pleurozium schreberi* (BSG.) Mitt.) on the lower terrace.

The author is a Research Scientist, formerly with the Forest Research Laboratory, Sault Ste. Marie, Ontario. His present address is Forest Research Laboratory, Edmonton, Alberta.

On both terraces, logging slash in 3-foot-high parallel windrows provided nearly 50 per cent of intermittent ground cover.[1] Some mineral soil was exposed during logging operations, but 78 to 98 per cent of the surface-raw-humus materials, ranging in depth from less than 1 inch to more than 6 inches, remained undisturbed. Jack pine regeneration was inadequate and restricted to a few seedlings on those mineral seedbeds that happened to be nearest to the seed source in slash.

METHODS

Burning

Eleven 0.26-acre plots were burned over on both terraces following different summer-drought periods in 1960, 1961 and 1962. The drought indices associated with the individual burns varied between 3 and 14; the rated fire danger was high (H) for 10 burns (danger index class 9 to 12) and moderate (M) for one burn (danger index class 5 to 8). All indices were determined from direct measurements of local weather with the aid of standard tables (Anon. 1957).

Seeding

The burned plots were broadcast seeded to jack pine at a rate of 16 ounces of seed per acre. All seeding operations were conducted on May 31 in 1961, 1962 and 1963. Seed originated from the same climatic region in which the plots were located. It was coated with rodent- and bird-repelling Endrin and Anthraquinone in Latex binder, and had a germinating capacity of 70+ per cent.

Sampling

On each plot, several single strips of 0.001-acre quadrats were systematically established across the original slash windrows. This resulted in 30+ per cent sampling of the plot area.

Raw-humus depths before and after burning were measured at randomly distributed observation points along centre lines of the sample strips, and the exposure of mineral soil first by logging and later by burning was mapped on the 0.001-acre quadrats themselves. Depending on whether the mineral soil exposed by logging was present or absent, the respective quadrats were collectively classified as either "scarified burn" or "unscarified burn".

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[1] Original stands: age 80 years, basal area 128 to 132 square feet per acre, volume 33 to 35 cords per acre.

Jack pine seedlings were counted on all 0.001-acre quadrats at the end of each growing season for 3 years after seeding, and the height of tallest seedlings, one per quadrat, was measured at the end of second and third season. Supplementary information on germination and seedling survival was obtained by means of periodic inspections of selected quadrats.

Other studies provided data on soil characteristics and on annual changes in vegetation cover after burning. Soil characteristics were ascertained mainly from profile descriptions, whereas changes in per cent of vegetation were determined from differences between sequential field estimates.

RESULTS

Stocking, Density and Growth of Jack Pine

In terms of jack pine establishment, the burning and seeding treatments were highly successful. Germination commenced within 2 weeks after seeding and continued at varying rates throughout the first, second and third growing seasons. Losses of young seedlings occurred (drought, frost, insects and rodents), but they were either substantially offset or exceeded by delayed germination. At the end of the third growing season (Table 1), the stocking by 0.001-acre quadrats was 60 per cent on one plot and 80 to 99 per cent on the remaining 10 plots. The third-year number of trees, 2,564 to 27,638 per acre, was more than adequate for future stand development[2], and the dominant trees had a good third-year height growth of 4.3 to 11.8 inches.

A comparison of scarified and unscarified burns (Table 2) indicated that scarification was unnecessary for the burning and seeding treatments to be effective. Scarification substantially increased the number of trees where it occurred, but this had little, if any, effect on the third-year stocking by 0.001-acre quadrats. Moreover, the dominant trees were somewhat taller and grew better where scarification was not the influencing factor. Examples of typical seedlings are shown in Figure 1.

EFFECTS OF SEEDBEDS

Slash, all surface litter and varying quantities of raw humus were destroyed, but stumps and some discarded logs remained in their mostly unburned state. Patches of exposed mineral soil were interspersed, and the overall improvement of seedbeds was directly related

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[2] When very young, about 2,000 uniformly spaced and freely growing trees per acre were considered adequate for normal development of pulpwood-producing stands (mortality-risk allowance up to 50 per cent included).

Table 1. JACK PINE REGENERATION ON SCARIFIED PLUS UNSCARIFIED BURNS BY YEARS, SITES AND TREATMENTS

Controlled Burning		Broadcast Seeding		Available Seedbeds					Jack Pine Regeneration											
				Av. Humus Depth[3]		Exp. Mineral Soil[4]					Trees Per Acre End of September			Quadrats Stocked End of September			Av. Dom. Tree Height End of September		
July-August	Drought Index-Fire Danger[1]	May 31	Seeds Per Acre[2]	Before Burn	After Burn	Before Burn	After Burn		0.001-Ac. Quadrats Sampled[5]	Dominant Trees Measured[6]	First Year	Second Year	Third Year	First Year	Second Year	Third Year	Second Year	Third Year	Growth
Year		Year	Ounces	Inches		Per Cent		Plot	Number		Number			Per Cent			Inches		
Upper Terrace, Coarse-Textured Mor over Silty Fine Sand, Soil Moisture Regime 1																				
1961	3H	1962	16	2.0	1.4	7	13	C	78	30	2,256	3,026	2,564	50	63	60	2.6	6.9	4.3
1960	9H	1961	16	2.7	1.2	12	22	B	78	57	5,218	5,718	6,282	77	89	92	2.4	7.4	5.0
1960	6H	1961	16	2.6	1.4	17	24	A	78	63	7,064	7,820	8,756	90	92	92	2.3	6.8	4.5
1962	7H	1963	16	2.7	1.2	3	14	D	78	52	3,769	7,077	6,449	64	94	89	5.2	14.4	9.2
1962	14M	1963	16	2.3	1.3	11	26	G	80	56	11,800	13,162	13,188	70	78	83	6.1	17.0	10.9
1962	10H	1963	16	2.6	1.0	17	46	E	80	69	12,050	17,100	16,775	93	95	96	5.8	16.9	11.1
1962	12H	1963	16	2.3	0.3	22	60	F	80	78	21,275	26,712	27,638	99	100	99	6.9	18.7	11.8
Lower Terrace, Fine-Textured Mor over Fine Sand, Soil Moisture Regime 2																				
1960	9H	1961	16	2.5	0.8	14	24	J	78	63	5,577	5,718	6,295	86	92	92	4.0	11.6	7.6
1960	6H	1961	16	2.4	1.1	22	29	K	80	72	4,550	5,712	6,212	93	93	96	4.2	13.6	9.4
1962	7H	1963	16	2.0	0.7	2	13	I	78	36	1,910	2,526	3,500	47	71	85	3.7	11.2	7.5
1962	12H	1963	16	2.2	0.5	20	37	H	78	40	2,705	4,077	4,705	58	72	80	4.6	15.0	10.4

[1] Symbols derived from numerical drought indices and associated classes of H (high) or M (moderate) fire danger on days of burning (see Anon. 1957).
[2] All seeds coated with bird-and rodent-repelling Endrin and Anthraquinone in Latex binder - germinating capacity 70+ per cent.
[3] Values based on 75 to 98 sets of direct raw-humus-depth measurements per plot - applicable to plot portions unscarified before burning.
[4] Values based on sequential mapping and direct measurements of exposed mineral soil from appropriate plot plans.
[5] Strips of 0.001-acre quadrats, sampling 30+ per cent - used for determinations of total trees per acre and quadrats stocked with one or more trees.
[6] Tallest trees, one on each of continuously stocked 0.001-acre quadrats - used for determinations of average dominant tree heights.

Table 2. JACK PINE REGENERATION ON SCARIFIED AND UNSCARIFIED BURNS BY YEARS, SITES AND IDENTICAL SERIES OF TREATMENTS

Controlled Burning		Broadcast Seeding		Available Seedbeds					Jack Pine Regeneration										
				Av.Humus Depth[3]		Exp.Mineral Soil[4]					Trees Per Acre End of September			Quadrats Stocked End of September			Av.Dom.Tree Height End of September		
July-August	Drought Index-Fire Danger[1]	May 31	Seeds Per Acre[2]	Before Burn	After Burn	Before Burn	After Burn		0.001-Ac. Quadrats Sampled[5]	Dominant Trees Measured[6]	First Year	Second Year	Third Year	First Year	Second Year	Third Year	Second Year	Third Year	Growth
Year		Year	Ounces[7]	Inches[7]		Per Cent[7]		Plots	Number[7]		Number[7]			Per Cent[7]			Inches[7]		
Upper Terrace, Coarse-Textured Mor over Silty Fine Sand, Soil Moisture Regime 1																			
Scarified Burn																			
1960 1962	6H, 9H 7H,12H	1961 1963	16	-	-	46	64	A,B D,F	22	20	15,349	16,480	18,576	89	99	94	3.7	11.2	7.5
Unscarified Burn																			
1960 1962	6H, 9H 7H,12H	1961 1963	16	2.6	1.0	0	17	A,B D,F	57	42	7,001	10,169	9,920	80	92	93	4.4	12.0	7.6
Lower Terrace, Fine-Textured Mor over Fine Sand, Soil Moisture Regime 2																			
Scarified Burn																			
1960 1962	6H, 9H 7H,12H	1961 1963	16	-	-	53	62	K,J I,H	20	14	6,852	7,296	8,016	73	85	88	3.4	11.2	7.8
Unscarified Burn																			
1960 1962	6H, 9H 7H,12H	1961 1963	16	2.3	0.8	0	12	K,J I,H	59	38	2,578	3,544	4,181	70	81	88	4.4	13.6	9.2

[1-6]See Table 1.

[7]Rounded group averages.

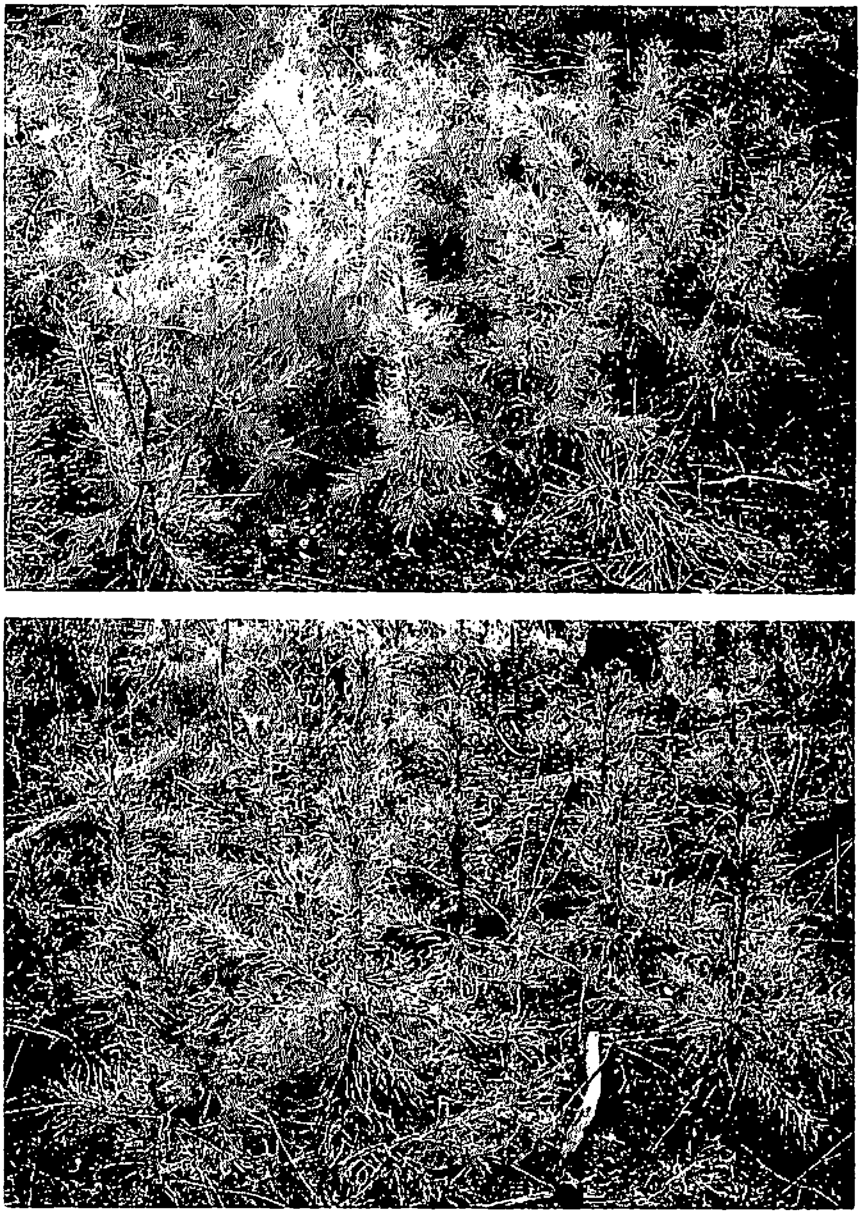

Figure 1. Examples of 3-year-old jack pine regeneration on scarified burn above (Plot F) and on unscarified burn below (Plot F). Note the fewer and better trees on seedbeds produced exclusively by fire.

to the amount of raw humus burned. Both the reduction of raw-humus depth and the increase of mineral-soil exposure were substantial and varied with the drought index-fire danger combinations at the time of burning. The data presented (Table 1) show these variations by sites and years of treatment in order of increasing mineral-soil exposure.[3]

The third-year number of trees per acre (Table 1) showed predominantly consistent patterns of variation, direct with the exposure of mineral soil and inverse with the depth of residual humus. The per cent stocking by 0.001-acre quadrats tended to vary in a similar way, but the relationships were much less pronounced. The increasing improvement of seedbeds by burning was in most cases beneficial to the third-year height growth of dominant trees.

EFFECTS OF SOILS

Generally, the mineral soil on the upper terrace was of a considerably better quality than the soil on the lower terrace. This was mainly due to the existing textural difference and the associated variation in the content of silt plus clay. The soil moisture regime, being somewhat better on the lower terrace than on the upper terrace, indicated the prevailing availability of moisture in the deeper soil horizons, but it had no modifying effect on the post-burn conditions at the soil surface. The texture of raw-humus materials was no longer of consequence, because the original variation in this respect was almost completely nullified in the process of burning.

The third-year number of trees per acre (Table 2) varied directly with the silt-plus-clay content, greater in silty fine sand on the upper terrace and smaller in fine sand on the lower terrace. The per cent stocking by 0.001-acre quadrats varied exactly the same way, but the differentiations attributed to the soil texture were in this case much less than those in the number of trees per acre. The third-year height growth of dominant trees varied directly with the soil moisture regime.

EFFECTS OF VEGETATION

The fires destroyed all aerial parts of vegetation, but many roots and rhizoms in and below the residual humus remained unharmed. Sweet-fern, bracken fern and the blueberries resprouted, and fireweed (*Epilobium angustifolium* L.) was the most abundant seeding-in newcomer on the upper terrace. Varying inversely with the reduction of raw-humus depth and the corresponding exposure of mineral soil (Table 1), the

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[3] It is of interest to note from Table 1 that the burn at 14M fitted well between the burns at 7H and 10H. This indicates a partial compensation for the decline in fire danger by the relatively high drought index of 14.

third-year vegetation cover after burning ranged by plots from 30 to 90 per cent on the upper terrace, and from 40 to 80 per cent on the lower terrace. The cover-rated plant competition was considerably more severe within the multispecies vegetation (*Comptonia*, *Pteridium*, *Vaccinium* and *Epilobium*) on the upper terrace, and it was less severe within the monospecies vegetation (*Vaccinium*) on the lower terrace.

The fact that most of the pine regeneration (Table 1) increased with time, in spite of the developing vegetation, indicated that the competition after all was not too serious or detrimental. Only in one case (Plot C), where the reduction of raw-humus depth was minimal, the somewhat poorer pine regeneration might have resulted, at least in part, from an excessive competition (Figure 2). Otherwise, the numerically better or poorer regeneration (Table 2) was associated with a more severe multispecies competition (*Comptonia*, *Pteridium*, *Vaccinium* and *Epilobium*) on the upper terrace and with a less severe monospecies competition (*Vaccinium*) on the lower terrace, respectively. The third-year height growth of dominant trees (Table 1) was in most cases inversely related to the vegetation cover. Moreover, the growth (Table 2) tended to be generally better on the lower terrace where the monospecies competition (*Vaccinium*) was less severe than on the upper terrace where the multispecies competition (*Comptonia*, *Pteridium*, *Vaccinium* and *Epilobium*) was more severe.

DISCUSSION

The experiment demonstrates that burning and seeding treatments can be fully effective, providing they meet two basic requirements. The first of these is the selection of a suitable drought condition best fitting the desired reduction of raw-humus depth. Means for making such a selection are already available (Chrosciewicz 1967, 1968). The second requirement is the regulation of seeding intensity in relation to the quality of fire-produced seedbeds and the type of soil present, taking into consideration the desired number of trees per acre at full or nearly full stocking by 0.001-acre quadrats. The following example can be used as a general guide in this regulation.

Seeding 16 ounces of seed per acre resulted in a large third-year number of trees throughout the experiment and particularly at the 80 to 99 per cent levels of stocking (Table 1). Moreover, the number of trees was not constant but did vary with the combined seedbed and soil conditions as defined by the depth of residual humus and the exposure and texture of mineral soil materials. This suggested a possibility of regulating the intensity of seeding to such an extent that similar numbers of trees per acre could be obtained at full or nearly full stocking. Assuming that the desired number of trees at an early age was about 2,000 per acre, the regeneration would have approached this number if the amount of seed had been varied betweeen 1 and 10 ounces in

Figure 2. Examples of vegetation 3 years after burning on 1.4-inch residual humus above (Plot C) and on 0.3-inch residual humus below (Plot F). Note the resulting differences in plant competition.

order of decreasing seedbed and soil quality. It was unlikely that the smaller number of trees per acre would have resulted in a less favourable stocking, providing the seed had been treated with bird- and rodent-repelling chemicals. This means that designation of seeding intensity can be done even at the time when drought conditions for future burning operations are considered (see Chrosciewicz 1968), and the data presented in Table 1 should help to do this without too much difficulty. The final seeding prescription, however, should be checked and, if necessary, adjusted in relation to the actual results of burning and the soil materials present.

Apart from these considerations, the experiment provided useful information on the ecology of young jack pine following the burning and seeding treatments. The effects of seedbeds, soils, and vegetation on the establishment and growth of pine were demonstrated, and they should aid in both planning and application of similar treatments elsewhere. Ahlgren (1959, 1960) has studied the effects of wild and controlled fires in northeastern Minnesota, and his data pertaining to tree regeneration, plant succession and soil nutrients warrant attention. On the basis of experimental burning in Michigan, Beaufait (1962) has described field methods that can be helpful in the use of fire for pine regeneration.

There were indications that the application of burning and seeding should be considerably less expensive than any other set of treatments serving the same purpose. The savings will be mostly in the costs of site preparation by burning as contrasted with the costs of scarification by mechanical means. Following a series of burns in southeastern Manitoba, Adams (1966) has suggested several ways by which the costs of burning could be substantially reduced. However, extensive operational trials with the burning and seeding treatments are needed to evaluate their economic feasibility on a large scale. Some such trials, incorporating post-burn aerial seeding, are already underway in Ontario.

SUMMARY

Between 1960 and 1963, 11 summer-burning and spring-seeding treatments were experimentally tested on two clear-cut jack pine sites in central Ontario. Burning was carried out under different drought index-fire danger combinations, and the plots so burned were then broadcast seeded to jack pine at a constant rate of 16 ounces of seed per acre. The seed was treated with bird- and rodent-repelling chemicals and had germinating capacity of 70+ per cent. The development and the ecology of pine regeneration were studied during three consecutive growing seasons after seeding. Information pertaining to the physical aspects of burning is published elsewhere, and this report evaluates the treatments in terms of pine regeneration relative to seedbeds, soils and vegetation.

Briefly, the main results were as follows.

1. The third-year pine stocking by 0.001-acre quadrats was 60 per cent on one plot and 80 to 99 per cent on the remaining 10 plots. The number of trees ranged from 2,564 to 27,638 per acre, and the dominant trees grew in height 4.3 to 11.8 inches during the third growing season.

2. The principal factors affecting the establishment of pine regeneration included the depth of residual humus plus the exposure and texture of mineral soil materials. The height growth of well-established trees depended primarily on the type of vegetation and the soil moisture regime.

In addition to presenting results, this report stresses the importance of two treatment requirements. The first requirement is the selection of a suitable drought condition for the desired reduction of raw-humus depth by burning. The second requirement is the regulation of seeding intensity in relation to the quality of fire-produced seedbeds and the soil materials present, taking into consideration the desired number of trees per acre at full or nearly full stocking by 0.001-acre quadrats. Practical means for meeting both these requirements are described.

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