Scientific and Technical Articles/ Articles scientifiques et techniques

Jack Pine Regeneration Following Postcut Burning under Seed Trees in Central Saskatchewan

by

Z. Chrosciewicz¹

Abstract

An experimental burn in conjunction with a seed-tree system was successful in regenerating jack pine (*Pinus banksiana* Lamb.) on a fresh to somewhat moist upland, loamy till, cutover site in central Saskatchewan. About 20 well-formed, uniformly spaced seed trees per hectare were left standing during timber harvest. The ignition of logging slash was carried out under preselected weather and fuel conditions so that favorable seedbeds and adequate seed dispersal from the seed trees were produced. Four growing seasons after burning, jack pine stocking by 4-m² quadrats was 90% with 12 195 seedlings/ha. Aspen (*Populus tremuloides* Michx.), to a lesser degree black spruce (*Picea mariana* [Mill.] B.S.P.), and other companion tree species also regenerated with the pine. Various seedbed and regeneration characteristics as well as height growth rates are discussed.

Key words: *Pinus banksiana*, slash burning, seed-tree system, forest regeneration, growth rates, central Saskatchewan.

Résumé

Un brûlage expérimental, conjointement avec une disposition de semenciers, a permis de régénérer le pin gris (*Pinus banksiana* Lamb.) sur une station déboisée, de till limoneux frais à quelque peu humide, située sur des haute-terres au centre de la Saskatchewan. Environ 20 arbres semenciers à l'hectare, bien formés et uniformément espacés, ont été laissés sur pied lors de la récolte. Le brûlage des déchets de coupe a été effectué sous des conditions atmosphériques et de combustible choisies au préalable de façon à ce que le lit de germination soit propice et que les graines des arbres soient convenablement dispersées. Après quatre saisons de croissance, la proportion de pin gris sur pied dans les quadrats de 4 m² était de 90% avec 12 195 semis/ha. Le peuplier faux-tremble (*Populus tremuloides* Michx.), l'épinette noire (*Picea mariana* [Mill.] B.S.P.), dans une moindre mesure, et d'autres essences compagnes ont aussi été régénérés en même temps que le pin. Une discussion est présentée sur les caractéristiques des divers lits de germination et de la régénération ainsi que sur les taux d'accroissement en hauteur.

Mots clés: *Pinus banksiana*, brûlage de déchets de coupe, système d'arbre semencier, régénération forestière, taux de croissance, Saskatchewan centrale.

Introduction

Jack pine (*Pinus banksiana* Lamb.)² stands are common on upland till sites in central Saskatchewan. They are commercially very important pulpwood producers, and their prompt regeneration after harvest cutting is the prime managerial objective.

Practically all the pine stands that are now being harvested originated after fire. This is because wildfires

burning through jack pine stands often expose favorable mineral and organic seedbeds, reduce immediate plant competition, and trigger seed dispersal from the otherwise serotinous cones on parent trees above the seedbeds. Abundant pine regeneration nearly always follows such fires, and only when the available seed sources are completely destroyed as in burning young stands, for example, might the results be disappointing.

In view of these considerations it is reasonable to conclude that the use of slash fire in conjunction with some seed-tree system is perhaps the most natural, dependable method of regenerating jack pine after cutting. Generally, however, relatively little work has been done to date testing this method (Cayford *et al.* 1967), although controlled burning

¹Research Scientist, Northern Forestry Centre, Canadian Forestry Service, 5320 - 122 Street, Edmonton, Alberta T6H 3S5.

²Species' nomenclature follows Scoggan (1957) for vascular plants and Crum *et al.* (1973) for mosses.

under an open stand in central Ontario (Chrosiewicz 1959) and burning under designated seed trees on a cutover area in northern Minnesota (Ahlgren 1970) produced quantitatively desirable pine regeneration. Slash burning without seed trees is inadequate for regeneration purposes because the seeds in cones on the slash are either completely destroyed, or their viability is so drastically reduced that they become of little practical value (Chrosiewicz 1959). Unless these burns are followed by supplementary planting or seeding treatments, preferably in spring, the resulting jack pine regeneration is often not much better, and is occasionally even worse, than that on unburned and poorly reproducing clear-cut areas (Chrosiewicz 1987, 1988).

In 1972, an experimental slash burning was tried in the presence of seed trees on an upland cutover till site at 53°52'N and 105°04'W, some 23.5 km by road northeast of Candle Lake, Saskatchewan. The main purpose was to demonstrate that controlled burning and seed-tree systems are compatible in producing ecologically sound and economically beneficial results in terms of jack pine regeneration. The outcome is reported in this paper.

The Site

Physiography

The site was nearly flat and had a slight south-southwest aspect. The soil material was a deep glacial till containing about 5-10% stones by volume. Its texture varied downward from sandy loam to sandy clay loam and was silty sand in the uppermost eluviated mineral horizon. This was topped by the mor-type forest-floor raw humus, or duff, and the soil profiles matched the descriptions of Orthic Gray and Gleyed Gray Luvisols (Anon. 1978). The raw humus together with its surface moss and litter averaged 7.1 cm in depth. It was strongly acid (pH 4.4-4.8), and from there the reactions gradually changed until at 1.2 m in the lower portion of the mineral parent material they became moderately alkaline (pH 8.3-8.4). The depth to groundwater ranged from more than 2.4 m to about 1.8 m, and the soil moisture regimes (Hills 1955), being between 2 and 3, were classified as fresh to moderately moist.

Stand Conditions

Originally, the site supported an 82-year-old jack pine stand that contained a small admixture of black spruce (*Picea mariana* [Mill.] B.S.P.) and a few clumps of aspen (*Populus tremuloides* Michx.). It averaged 1 710 trees/ha, with 31 m²/ha of basal area and a pulpwood yield of 330 m³/ha. About 95% of the forest floor was covered by moss (*Pleurozium schreberi* [Brid.] Mitt. with some *Lycopodium annotinum* L.), twinflower (*Linnaea borealis* L. var. *americana* [Forbes] Rehd.), and bunchberry (*Cornus canadensis* L.). Above this vegetation, green alder (*Alnus crispa* [Ait.] Pursh.) up to 2 m in height provided an additional cover of about 60%.

Methods

Cutting

The stand area designated for timber harvest consisted of 28 ha, of which 21 ha were cut over in such a way that 20 uniformly spaced seed trees/ha were left standing. The seed trees were marked and other timber was harvested by the tree-length method during the early part of 1972. All seed trees

had well-developed crowns, were 20 cm or more in breast-height diameter, and ranged in height from 18 to 21 m. The residual logging slash consisted of tree tops and branches; it averaged 0.3 m in depth and provided 71% of intermittent ground cover. A 5-m-wide fire guard, cleared down to mineral soil, enclosed the entire cutover area and served as a secondary access road in timber extraction.

Fuel Assessments

Quantitative fuel assessments were made on the seed-tree area by means of 12 randomly located 0.04-ha sample plots. The plots were 20 × 20 m, each containing five uniformly spaced transects that, in turn, were divided into 4-m² quadrats. With 50 quadrats per plot, this arrangement provided for sampling 50% of the plot area.

The 4-m² quadrats were used for estimations of slash depths and cover before and after burning, mapping to scale humus cover before and after burning, and measurements of humus depths before and after burning at randomly spaced steel observation pins, one per quadrat. The mapped humus covers were subsequently converted to numerical values by a dot-grid method.

The slash and forest-floor humus materials were also randomly sampled just before burning for moisture content determination. The slash samples consisted of 60 sheared branch segments, all 2.5 cm long and all from exposed locations at 0.6 m above the ground. By composite groups of 10 segments, they replicated twice the thicker-end branch diameters of 0.50, 1.25, and 2.00 cm. Composite samples of pine needles attached to the slash at 0.6 m above the ground were also replicated twice. The forest-floor humus samples consisted of 40 vertical cores, all collected with a 3.8-cm-diameter tubular auger; 20 were from exposed locations between slash, and 20 were from shaded locations under slash. The humus samples included moss and all organic litter down to mineral soil, and their depths averaged 8.8 cm between slash and 9.4 cm under slash. The sampled materials were transported to a field laboratory in airtight containers, and their moisture contents were determined by a gravimetric method in percent of oven-dry (100°C) weights.

Burning

The burning operations were conducted during the evening and early night hours of August 29, 1972. They began at 1715 Central Standard Time (CST) as a backfire and gradually proceeded against the wind with a two-sided perimeter ignition. By 2030 CST, the ignition around the seed-tree area was completed, and the fire was then allowed to burn out overnight. During the most active period of burning just after the ignition, the flame heights on the ground averaged about 1 m, and a few seed trees candled into the crowns. After normal mop-up operations next day, the burn was patrolled for several additional days.

As measured directly on the site, the weather during the ignition was as follows: cloud cover 5%, temperature 21-28°C, relative humidity 43-61%, plus wind speed 3-10 km/h at 1.2-m height and 5-16 km/h at 10.0-m height, from the southwest. Out of these values, the lower temperatures, higher humidities, and lower wind speeds occurred toward the end of ignition.

According to the Canadian Forest Fire Weather Index System (Anon. 1984), the burn was conducted when the Duff

Moisture Code (DMC) was 37 so that humus, or duff, consumption would be adequate for the desired improvement of seedbeds, while the relatively high Fine Fuel Moisture Code (FFMC) of 80 on that day ensured sustained ignition of the fine surface fuels. Other associated ratings included the Buildup Index (BUI) of 58, the Initial Spread Index (ISI) of 1.2, and the Fire Weather Index (FWI) of 4. All these ratings were based on daily 1300 CST weather observations at a master weather station (Chrosiewicz 1983b) some 4.5 km from the seed-tree area, with the rain being measured at several points within the seed-tree area.

Regeneration Surveys

Tree regeneration was surveyed in late September of 1976, four full growing seasons after burning. This was done by means of the same sample plots, transects, and quadrats as those previously used in fuel assessments. Pine and other tree seedlings, as well as aspen stems, were counted and recorded on all 4-m² quadrats. These tallies were supplemented with height measurements of dominant pine seedlings, one per stocked quadrat, and with overall estimates of mean dominant aspen height for each 0.04-ha plot. Seedbed conditions under each pine seedling were identified and recorded as "exposed mineral soil", "partially burned humus", or "undisturbed original humus". Decayed wood, if present, was included in the humus categories.

During the 1976 regeneration survey, the five tallest pine seedlings, one per transect, were selected and identified on each 0.04-ha plot by their respective 4-m² quadrats. Height measurements of the same seedlings late in 1978 facilitated comparisons of their growth during the intervening two years. Included in the 1978 assessments were also estimates of the mean dominant aspen heights.

Major changes in the development of competing vegetation were noted during all fuel and regeneration surveys.

Results

Effects of Fire

The preburn moisture content of the finer components of logging slash averaged 11% for the cured pine needles and 15% for the cured < 2.0-cm pine branches. This rather low and narrow range of moisture in the slash resulted in generally favorable burning conditions. Consequently, much of the original slash, averaging 0.3 m in depth and 71% in ground cover, was consumed by the fire, and only stumps, discarded logs, and some odd pieces of branchwood remained in their surface-charred state. The fire spread very well, and the mean area burned was 96% (Table 1).

The preburn moisture content of the forest-floor humus, or duff, averaged 95% in exposed locations between slash and 200% in shaded locations under slash. Burning in these conditions consumed most of the surface moss and litter and varying quantities of the coarse humus underneath the moss and litter, resulting in an assortment of different seedbeds (Table 1). The mean forest-floor humus depth for the area was 7.1 cm before burn and 4.2 cm after burn. Not counting areas occupied by tree stumps, the mean forest-floor humus cover was 99% before burn and 91% after burn, of which 88% became partially burned humus and 3% remained unburned. The mean exposure of mineral soil at nearly 1% before burn increased to 9% after burn (Table 1).

Table 1. Postburn inventory of seedbeds.

Total 0.04-ha sample plots, n	12
4-m ² quadrats per plot mapped, n	50
Mean (± SD) area burned, %	96 ± 8
Mean (± SD) area by seedbeds:	
Exposed mineral soil ^a , %	9 ± 6
Partially burned humus ^b , %	88 ± 8
Undisturbed original humus ^b , %	3 ± 8
Humus depths per plot measured, n	50
Mean (± SD) humus depth ^b , cm	4.2 ± 0.7

^aContains nearly 1% of mineral soil exposed before burn.

^bMor-type raw humus, includes fractions of decayed wood.

All aerial parts of minor vegetation were completely destroyed. Even tall shrubs, such as green alder, and aspen saplings were burned almost to the ground, with only a few charred 5- to 20-cm stubs remaining. Many of the root systems both in and below the partially burned humus appeared healthy, however, and resprouting of at least some of the original vegetation was expected.

As usually happens (Chrosiewicz 1959), the seeds and cones on the pine logging slash were destroyed with the burning slash and other fuels, but the heat so generated opened the serotinous cones on seed trees. To melt the scale-bonding material in jack pine cones, a temperature of at least 50°C is needed (Cameron 1953). A good first indication of such temperature and cone opening was the visible brown foliar scorch on seed trees. More than 70% of the pine seed trees showed varying degrees of crown scorch almost immediately after the burn, and the few that still retained their green crowns were located mostly along the edges, where the fire was less intense. Some cones on the affected seed trees opened their scales within a day or two following the fire, while others tended to open them more slowly, depending on the degree of crown scorch and the cone locations within the crowns. The overall shedding of seeds by the parent trees was gradual, prolonged in time way beyond the initial postburn seed dispersal, and expected to last for up to three years (Ahlgren 1970). Eventually, most of the seed trees died as the result of fire, and in each of the following years there were fresh blow-down losses due to high winds.

Pine Regeneration

The postcut burning in the presence of residual seed trees resulted in successful jack pine regeneration (Figs. 1 and 2). At the end of the fourth growing season after burning, the mean pine stocking by 4-m² quadrats was 90%, while the number of pine at that stocking averaged 12 195 seedlings/ha (Table 2) and was more than adequate for future stand development (Chrosiewicz 1970, 1971). In terms of the mean distribution by classes of seedbeds, 80% of the seedlings grew on partially burned humus, and the remaining 20% grew on exposed mineral soil. They all looked healthy and in just four growing seasons their dominant representatives attained a substantial mean height of 0.47 m (Table 2).

The vigor of the postburn jack pine regeneration manifested itself best in the subsequent growth of the tallest seedling specimens sampled, five per 0.04-ha plot or 60 for the seed-tree area. Their overall mean height of 0.71 m at the end of the fourth growing season after burning more than doubled to 1.43 m in the next two seasons and thus showed a healthy mean annual height growth of 0.36 m.

Regeneration of Companion Tree Species

Burning had a stimulating affect on aspen root suckering, which generally increased with the proximity to parental trees

Figure 1. Burning under residual jack pine seed trees.

at the time of cutting. The resulting number of aspen, averaging 9 096 stems/ha four growing seasons after burning, varied considerably from place to place and had a clumpy appearance similar to that in the original stand. The dominant aspen stems had mean heights of 1.68 m four growing seasons after burning, which more than doubled to an estimated mean value of about 3.42 m in the next two seasons.

Other tree species were present, but they occurred sporadically and, in most cases, had seeded in from the neighboring stands. Black spruce, averaging 70 seedlings/ha, was a welcome addition to the conifer regeneration. The regeneration also included a few widely scattered white spruce (*Picea glauca* [Moench] Voss), tamarack (*Larix laricina* [Du Roi] K. Koch), balsam fir (*Abies balsamea* [L.] Mill.), and paper birch (*Betula papyrifera* Marsh.), but their contribution to future stand composition was expected to be minimal.

In terms of combined regeneration of all tree species present, the number of seedlings and root suckers averaged 21 350/ha. The species distribution was 57% jack pine and 42% aspen, with the spruces, tamarack, and birch amounting to fractions of 1%. The resulting overall stocking by 4-m² quadrats for the combined tree species averaged 98%.

Competition from Shrubs and Aspen

Revegetation started within a few days after burning, and by the sixth growing season, green alder, willow (*Salix bebbiana* Sarg.) and aspen were the main broadleaf

Figure 2. Jack pine regeneration on seed-tree area six years after burning.

Table 2. Postburn jack pine regeneration.

Growing seasons since treatment, n	4
Total 0.04-ha sample plots, n	12
4-m ² quadrats per plot sampled, n	50
Mean (± SD) stocking by 4-m ² quadrats ^a , %	90 ± 7
Mean (± SD) total seedlings, n/ha	12 195 ± 3 804
Mean (± SD) seedlings by seedbeds:	
Exposed mineral soil, %	20 ± 11
Partially burned humus ^b , %	80 ± 11
Undisturbed original humus ^b , %	00
Dominant seedlings per plot measured ^c , n	41 – 50
Mean (± SD) height of dominant seedlings, m	0.47 ± 0.08

^aStocked with one or more seedlings.

^bMor-type raw humus, includes fractions of decayed wood.

^cTallest seedlings, one per stocked quadrat.

competitors on the seed-tree area. With heights ranging up to 2 m for the two shrubs and up to 4 m for the aspen, their combined ground cover varied by 0.04-ha plots from 25% to 80%. Most of the jack pine present then coped successfully with other vegetation, including the shrubs and aspen, and only in the few portions of the seed-tree area where dense canopies of aspen suckers overtopped the pine was its ability to withstand competition seriously curtailed. The latter manifested itself in generally retarded jack pine height growth.

Discussion

The results clearly demonstrated that controlled burning in conjunction with a seed-tree system can be successful in regenerating jack pine on upland cutover sites. The fire improved the seedbeds, and the heat generated by burning much of the unwanted logging slash, the aerial parts of vegetation, the surface moss and litter, and the varying amounts of coarse humus underneath the moss and litter was quite adequate for causing seed release from cones on the seed trees. Because the fire exposed relatively little mineral soil and the predominant seedbeds on the area were organic seedbeds of partially burned humus, most of the pine seedlings were found growing on the organic seedbeds, with only a somewhat disproportionately larger number of them occurring on the mineral soil. Favorable weather conditions (especially adequate precipitation) during the growing seasons following the seed dispersal by parent trees were responsible for this successful pine regeneration on all postburn seedbeds, including the partially burned humus seedbeds. It was shown previously that both a deficit of rainfall (Chrosciewicz 1983a) as well as a surplus of rainfall (Chrosciewicz 1983b) can have profound, though opposite, effects on the quality of the various classes of seedbeds for pine regeneration.

In future operations of a similar nature, provision could be made for harvesting all seed trees soon after they fulfill their seeding function, which normally takes about three full growing seasons after burning. This was not done in the present case, and consequently that portion of merchantable timber had to be written off.

Generally, the method of conducting slash burns under seed trees is not only applicable to jack pine but also to black spruce (Chrosciewicz 1976) and lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) (Smithers 1961). All three species produce and store to varying degrees large quantities of seeds in their tightly closed, serotinous cones until fires cause their opening. Other tree species do not possess this capacity, but instead they develop and then

freely disperse their mature seeds at irregular intervals. This differentiation in both production and storage of seeds must be considered when the uses of burning and seed-tree systems are contemplated.

At present, mechanical scarification of the ground surfaces with simultaneous redistribution of the cone-bearing jack pine slash is the most widely used postcut regeneration treatment in central Saskatchewan. The method became operational in 1969 (Ball 1975), and since then some of the more recent clear-cut areas have been regenerated to pine in the course of its application. There are, however, indications that, when properly planned and expertly executed, postcut burning with seed trees can be much less expensive to use than mechanical scarification. Added benefits with no extra costs normally include abatement of slash fire hazard on treated sites and a high degree of sanitation on pest-infested areas, neither of which can be effectively realized by mechanical means. Nevertheless, extensive operational trials with the burning and seed-tree systems are required to determine precisely their economic feasibility at that level of implementation.

Acknowledgments

P.G. Etheridge, then Forester with the Saskatchewan Department of Parks and Natural Resources, and B. Meckleburg, Camp Foreman with Prince Albert Pulpwood Ltd., cooperated on the project, the former by marking the seed trees to be left standing and the latter by supervising the subsequent harvest and extraction of the unmarked timber. A Fremont, Conservation Officer, and A. Hanson, Assistant Conservation Officer, with the provincial department were in charge of the departmental crew of men and equipment during burning operations. R.G. Gordey, former Research Technician at the Northern Forestry Centre, participated in the acquisition of data.

References

- Ahlgren, C.E. 1970. Some effects of prescribed burning on jack pine regeneration in northern Minnesota. Univ. Minnesota, Agric. Exp. Stn., St. Paul, Minn. Misc. Rep. No. 94, For. Ser. 5.
- Anon. 1978. The Canadian system of soil classification. Can. Dept. Agric., Res. Branch, Can. Soil Surv. Comm., Ottawa, Ont. Publ. No. 1646.

- Anon. 1984. Tables for the Canadian Forest Fire Weather Index System. Environ. Can., Can. For. Serv., Hull, Que. For. Tech. Rep. No. 25 (4th ed.).
- Ball, W.J. 1975. An appraisal of natural regeneration on scarified jack pine cutovers, Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alta. Inf. Rep. NOR-X-136.
- Cameron, H. 1953. Melting point of the bonding material in lodgepole pine and jack pine cones. Can. Dep. Resour. Dev., For. Branch, Div. For. Res., Ottawa, Ont. Silv. Leaflet No. 86.
- Cayford, J.H., Z. Chrosiewicz and H.P. Sims. 1967. A review of silvicultural research in jack pine. Can. Dep. For. Rural Dev., For. Branch, Ottawa, Ont. Publ. No. 1173.
- Chrosiewicz, Z. 1959. Controlled burning experiments on jack pine sites. Can. Dep. North. Aff. Natl. Resour., For. Branch, For. Res. Div., Ottawa, Ont. Tech. Note No. 72.
- Chrosiewicz, 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., For. Res. Lab. Ont. Reg., Sault Ste. Marie, Ont. Inf. Rep. 0-X-138.
- Chrosiewicz, Z. 1971. The growth response of young jack pine to moderate and extreme stand densities. Bi-Mon. Res. Notes 27(1): 6.
- Chrosiewicz, Z. 1976. Burning for black spruce regeneration on a lowland cutover site in southeastern Manitoba. Can. J. For. Res. 6: 179-186.
- Chrosiewicz, Z. 1983a. Jack pine regeneration following postcut burning and seeding in southeastern Manitoba. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alta. Inf. Rep. NOR-X-252.
- Chrosiewicz, Z. 1993b. Jack pine regeneration following postcut burning and seeding in central Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alta. Inf. Rep. NOR-X-253.
- Chrosiewicz, Z. 1987. Evaluation of postburn seeding of jack pine in central Saskatchewan. Can. For. Serv., North. For. Cent., Edmonton, Alta. For. Manage. Note No. 41.
- Chrosiewicz, Z. 1988. Forest regeneration on burned, planted, and seeded clear-cuts in central Saskatchewan. Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-293.
- 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.
- Hills, G.A. 1955. Field methods for investigating site. Ont. Dep. Lands For., Res. Div., Maple, Ont. Site Res. Man. No. 4.
- Scoggan, H.J. 1957. Flora of Manitoba. Can. Dep. North. Aff. Natl. Resour., Natl. Mus. Can., Ottawa, Ont. Bull. No. 140.
- Smithers, L.A. 1961. Lodgepole pine in Alberta. Can. Dept. For., Ottawa, Ont. Bull. No. 127.

Erratum

Our apologies are owing to C.E. Van Wagner for an error in printing his article "The historical pattern of annual burned area in Canada" in the June '88 (p. 183) issue of The Forestry Chronicle. The captions of Figures 2 and 3 are in the right place, but the bodies of the figures are switched.

Reprints of Wildlife Symposium

A limited number of reprints of the proceedings of the forestry and wildlife management workshop held in Thunder Bay, Ontario, December 7-9, 1987 are available. Price in Canada \$5.00 including postage. Please contact the CIF Head Office.