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A REVIEW OF SILVICULTURAL RESEARCH IN JACK PINE

by
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A Review of Silvicultural Research in Jack Pine [1]

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PREFACE

The Department of Forestry and Rural Development and its predecessors have been carrying out silvicultural research in jack pine for over forty years. The program had its start in the 1920's in the Provinces of Manitoba and Saskatchewan and at the Petawawa Forest Experiment Station in Ontario. In the late 1940's it was extended into central and northwestern Ontario. In addition, a small amount of research is underway in Quebec, New Brunswick and Newfoundland.

At present most of the silvicultural research is done by a group of three officers, two working from the Manitoba-Saskatchewan Regional Office in Winnipeg and one from the Ontario Regional Office in Richmond Hill. Several other officers are concerned with the species but only on a part-time basis.

This report is an attempt to present the results of all jack pine silvicultural and related research that has been conducted in Canada by the Department and references to numerous reports, both published and unpublished, are included. The authors wish to emphasize that results of research undertaken by other agencies have not been included in the review; a summary of much of this information is available in P.O. Rudolf's report "Silvical characteristics of jack pine" which was published in 1958 by the Lake States Forest Experiment Station, Forest Service, United States Department of Agriculture.

Included in the present report is a compendium of research results and conclusions in Parts I and II, an index of all projects in Part III, and individual projects summaries in Part IV. Where applicable, reference is made in Parts I and II to the individual project summaries presented in Part IV. Within Parts I and II, abstracts are presented and each of these is followed by a more complete review of results and conclusions. The abstracts are printed in italics. Where individual projects deal with other species in addition to jack pine, only results pertaining to jack pine are presented.

Project summaries covering the work of the Tree Breeding and Genetics Section at the Petawawa Forest Experiment Station were prepared by M.J. Holst and C.W. Yeatman. The authors are grateful for this assistance.

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PART I– SILVICS AND ECOLOGY OF JACK PINE

General Habitat

Jack pine (*Pinus banksiana* Lamb.) is the most widely distributed pine species in Canada and extends from Nova Scotia and New Brunswick across Quebec, Ontario and the Prairie Provinces to northern British Columbia and the Mackenzie River Valley in the Northwest Territories (Figure 1). In northwestern Alberta its range overlaps that of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and in this area many of the trees have hybrid characteristics.

Most jack pine stands occur in areas characterized by warm to cool summers, very cold winters, and low rainfall. Within its natural range, average January temperatures are from -20° to 25° F and average July temperatures from 55° to 72° F; annual precipitation is usually from 15 to 35 inches, and the frost-free period between 80 and 120 days.

Natural stands of jack pine occur primarily on soils of the podzolic order. The species is capable of growing on very dry coarse and medium sands, and on gravelly soils, but it also occurs on fine sands, sandy-loams, loams and clay-loams (Figures 2-8). It is also found on relatively thin rock outcrop soils. Only rarely does it occur on poorly drained soils.

Throughout its range, jack pine grows in extensive, pure even-aged stands. Frequently, however, it is found in mixture with other species. Its common associates include trembling aspen (*Populus tremuloides* Michx.), white birch (*Betula papyrifera* Marsh.), white spruce (*Picea glauca* (Moench) Voss), black spruce (*Picea mariana* (Mill.) BSP.), and balsam fir (*Abies balsamea* (L.) Mill.); in the Great Lakes-St. Lawrence Forest Region additional associates include northern pin oak (*Quercus ellipsoidalis* E.J. Hill), bur oak (*Quercus macrocarpa* Michx.), red pine (*Pinus*

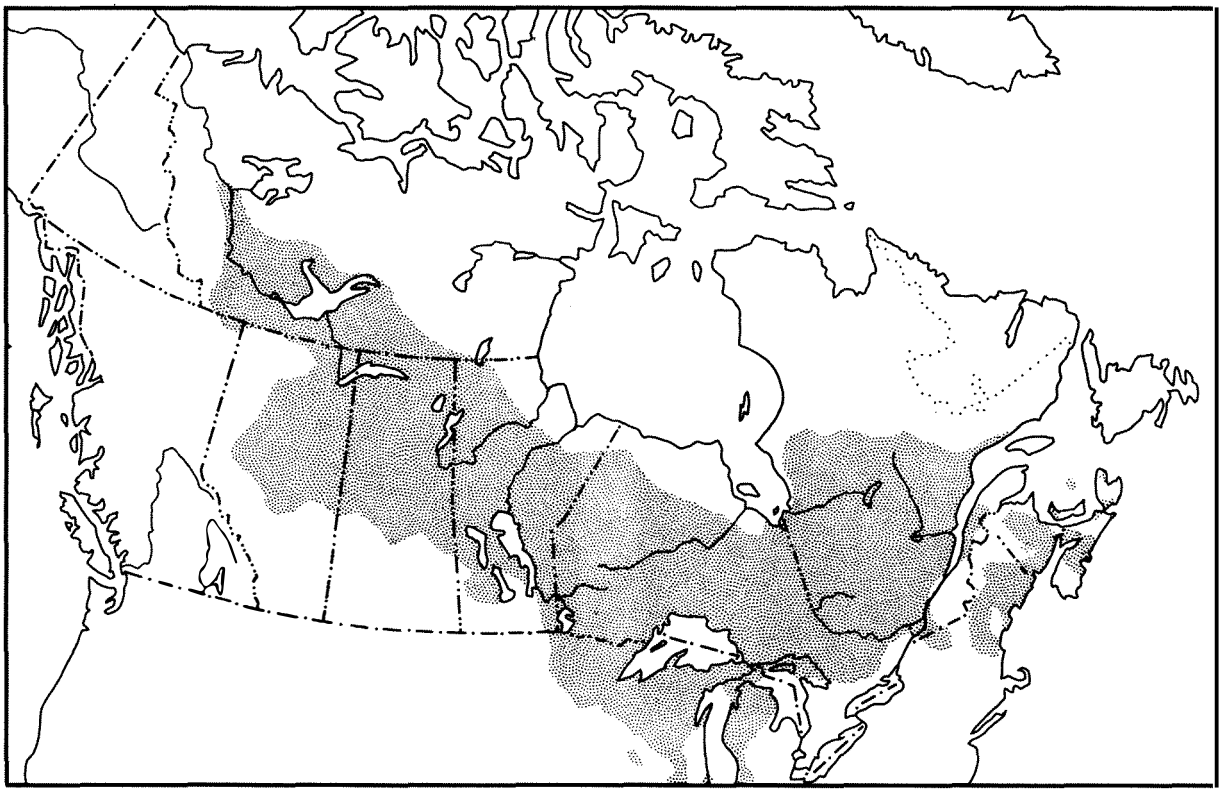

Figure 1. Botanical range of jack pine.

Figure 2. Mature jack pine in northern Ontario on very thin sandy soil overlying rock outcrop. Soil moisture regime 0.

Figure 3. Mature jack pine in northern Ontario on sand dune projecting above black spruce peatland. Soil moisture regime 0 to 1.

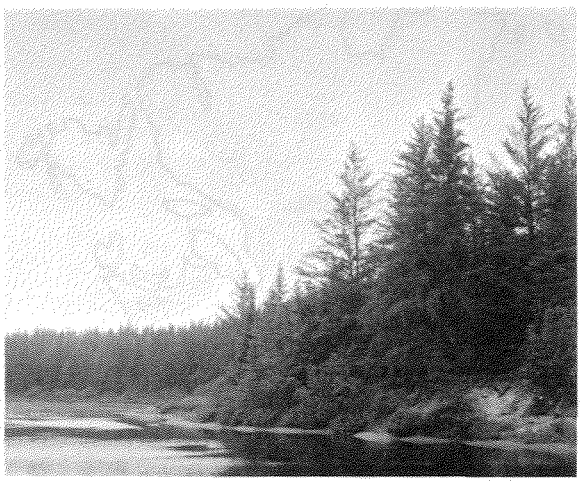

Figure 4. Immature jack pine in northern Ontario on sand and gravelly sand terraces of fluvial to glacio-fluvial origin. Soil moisture regime 1 to 2.

Figure 5. Mature jack pine and trembling aspen with white spruce, black spruce and balsam fir understorey in northern Ontario on loamy glacial till. Soil moisture regime 2 to 3.

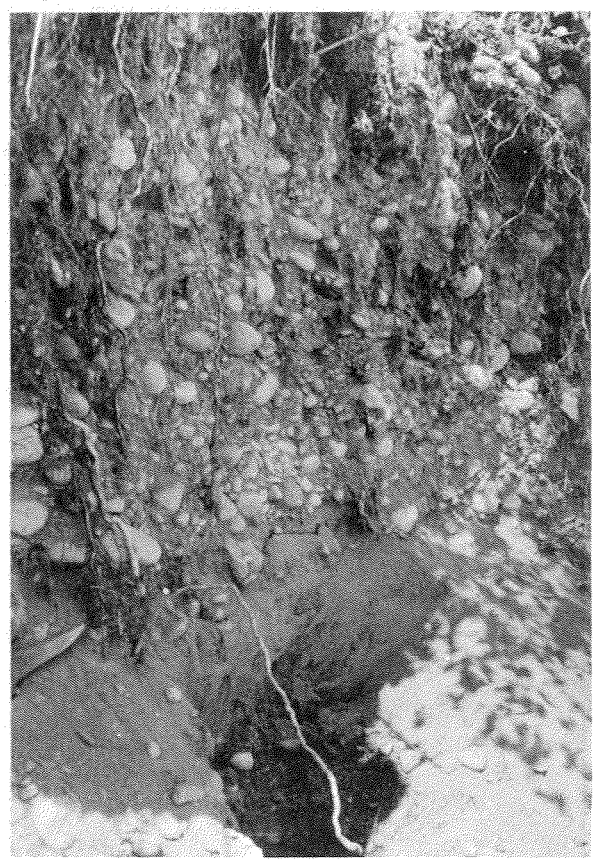

Figure 6. Roughly sorted gravelly and loamy sand overlying fine sand and very coarse sand and supporting jack pine in northern Ontario.

resinosa Ait.), and eastern white pine (*Pinus strobus* L.).

Jack pine usually occurs in a pioneer stage of succession; it will invade locations where mineral soil has been bared, and as a result many stands have followed fire. However, on very dry, sandy sites in the southwestern portion of its range it may regenerate itself in the absence of fire.

In the Boreal Forest Region[1] jack pine is succeeded by spruce-fir mixtures on all but the driest sites (Figure 9). Successional trends to both black and white spruce have been observed. In the northern part of the Great Lakes-St. Lawrence Forest Region jack pine is replaced by black spruce, white spruce and balsam fir, or by red and white pine followed in turn by the spruce-balsam mixture.

Sites and Productivity

Several studies of jack pine growth and productivity have been carried out within the Canadian range. In any particular locality, jack pine stands extend over a wide range of site conditions, and diameter, height and volume growth all differ between sites. In general, maximum jack pine growth has been found to occur on fresh to somewhat moist upland till slopes, that vary in texture from fine sand to clay. Moist sands are also productive jack pine sites in central Canada. Poor sites for jack pine include excessively dry and dry, weakly podzolized sands and wet, poorly drained soils. For the soils and climates studied, jack pine site indices at 50 years (total age) range from 35 to 70 feet. On comparable mineral soils, jack pine growth varies with regional climates and is adversely affected by the presence of ironpan formations in sandy podzols.

In the eastern portion of the Missinaibi-Cabonga Forest Section (B.7), Quebec, and in the Superior Forest Section (B.9), Ontario, growth and yield studies have been carried out in relation to site types that were derived from broad groupings of soil moisture regime and permeability. Best jack pine height growth in both sections occured on fresh to somewhat moist gentle

[1]Forest regions and sections according to Rowe, J.S. 1959. Forest regions of Canada. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, Bull. 123. 71 pp.

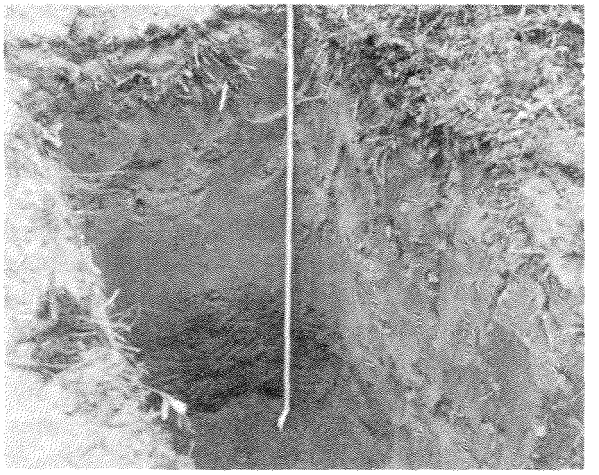

Figure 7. Uniformly sorted fine sand overlying very coarse sand and supporting jack pine in northern Ontario.

Figure 8. Bouldery clay loam supporting jack pine in northern Ontario.

Figure 9. Overmature jack pine with predominantly black spruce understorey on a fresh sand fluvial terrace in Ontario. In the absence of disturbance jack pine will be succeeded by black spruce.

upland till slopes, with textures varying from fine sand to clay. Much poorer growth was observed on excessively dry, very dry and wet soils occurring within a wide range of textural classes and physiographic situations. Based on heights of dominant trees of various ages, site indices at 50 years (total age) ranged from 35 to 55 in Quebec and from 38 to 56 in Ontario (Bedell and MacLean, 1952; Bedell, Brown and MacLean, 1953) (H-69, H-72). In Quebec, yields per acre of jack pine at 90 years ranged from 35 cords on gentle upland till slopes, to 30 cords on moderate upland till slopes, to 23 cords on dry outwash plains, tops of kames and eskers, dunes and steep till slopes (krewaz, 1962).

In an initial study in the western portion of the Rainy River Forest Section (L. 12), Manitoba, six soil profile types were recognized and preliminary ratings determined. The latter, based on heights of dominant trees, were derived from a set of available site index curves[2]. The best jack pine stands occurred on sandy gley podzols where site index at 50 years (total age) ranged from 52 to 58 (average 55)./ Poorest stands occurred on dry melanized and weakly podzolized soil profiles where site index ranged from 37 to 56 (average 44). Jack pine stands on grey-wooded soils and on podzols of fresh moisture status were intermediate in productivity (Ritchie, 1961) (MS-173B). In a more detailed study in the same section, five forest habitat types, which commonly supported jack pine stands, were recognized (Figures 10-13). Site indices in this study were determined from heights of dominant trees and standard site index curves[3]. The most productive habitat type was the oligotrophic moist type on beta-gley podzols, which had a site index at 50 years (total age) of 54. The least productive type was the oligotrophic very dry type on aeolian regosols, which had a site index of 40. The oligotrophic dry type on minimal podzols, the oligotrophic fresh type on low beta- and gamma-gley podzols, and the mesotrophic fresh type on bisequa podzols and bisequa and orthic grey-wooded soils were intermediate in productivity (Mueller-Dombois, 1964b) (MS-213).

In the eastern portion of the Mixedwood Forest Section (B. 18a), Saskatchewan, six site-types, based on groupings of soil moisture regime and permeability, have been recognized as commonly supporting jack pine (Jameson, 1961, 1965) (MS-176 and MS-198). Based on stem analysis of dominant trees, height-age curves were calculated from regression equations. Site indices read from these curves at 50 years (one-foot-stump age) were 58 on fresh sandy-loams, 53 on moist sands, 52 on fresh sandy clay-loams, 50 on fresh sands, 48 on dry sands, and 34 on very dry sands (Jameson, 1965) (MS-198).

In various areas of Ontario, other studies have been conducted to determine jack pine growth in relation to the following site factors: Five soil moisture regimes (0 to 4), three soil textures (very fine sand, fine sand, and medium sand), two soil petrographies (siliceous material with less than 10 per cent basic intrusive and effusive rock particles, and siliceous material with 30 to 40 per cent basic intrusive and effusive rock particles), and three regional macroclimates (mid-humid warm-boreal in Site Region 4E, moist-subhumid warm-boreal in Site Region 4S, and dry-humid mid-boreal in Site Region 3W[4]). The studies were restricted to deep, uniformly sorted, podzolized sandy soils supporting fully stocked and undisturbed jack pine stands. Based on growth curves plotted from stem analyses of dominant trees, jack pine site indices at 50 years (total age) ranged from 37 to 70 feet. Both the height growth and the diameter growth of such trees varied with the individual site factors and their combinations. Within the range of conditions studied, the optimum growth was associated with moisture regime 3 (moderately moist), with very fine sand, and with 30 to 40 per cent content of basic rock particles. As the individual site factors deviated from their respective optimums, the growth gradually diminished. This pattern of variation occurred in each of the site regions, and the growth varied with the associated macroclimates by the regions. It was best in the mid-humid warm-boreal climate of Site Region 4E, intermediate in the moist-subhumid warm-boreal climate of Site Region 4S, and poorest in the dry-humid mid-boreal climate of Site Region 3W

[2]Gevorkiantz, S.R. 1956. Site index curves for jack pine in the Lake States. United States, Dept. Agriculture, For. Serv., Lake States For. Exp. Sta., Tech. Note 463. 2pp.

[3]Kabzems, A. and C.L. Kirby. 1956. Growth and yield of jack pine. Saskatchewan, Dept. Natural Resources, Forestry Branch, Tech. Bull. 2. 66 pp.

[4]Forest site regions according to Hills, G.A. 1959. A ready reference to the description of the land of Ontario and its productivity. Ontario, Dept. Lands and Forests, Div. of Res., Prel. Rep.

Figure 10. A 60-year-old jack pine stand in Manitoba on the oligotrophic dry habitat type. The ground vegetation is dominated by bearberry with reindeer lichen.

Figure 11. A 60-year-old jack pine stand in Manitoba on the oligotrophic moist habitat type. Note the occurrence of Labrador tea and the black spruce understorey.

(Chrosciewicz, 1963b) (H-116). In the eastern portion of the Missinaibi-Cabonga Forest Section (B.7), Quebec, the height and diameter growth of dominant jack pine, and the average diameter and basal area per acre for trees over one-half inch, gradually decreased with each higher stage of ironpan formation that occurred on the sandy sites investigated (Chrosciewicz, 1962c) (H-119).

Associated with jack pine stands growing on different sites are various characteristic minor vegetation communities (Figures 14-15). In general, the very dry jack pine sites are characterized by reindeer lichen (*Cladonia* spp.), the dry

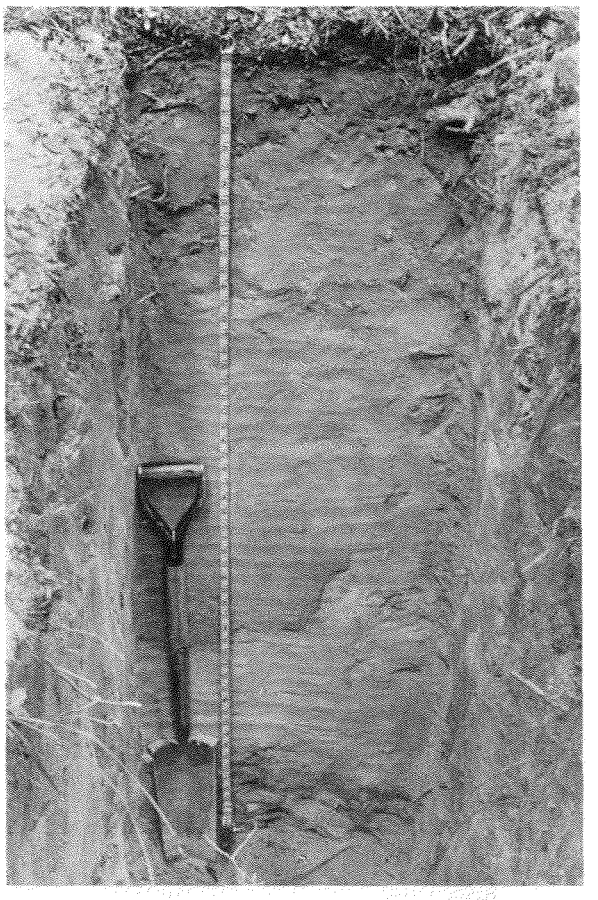

Figure 12. Soil profile on the oligotrophic dry habitat type. Note the weak development and the humus incorporation into the A horizon.

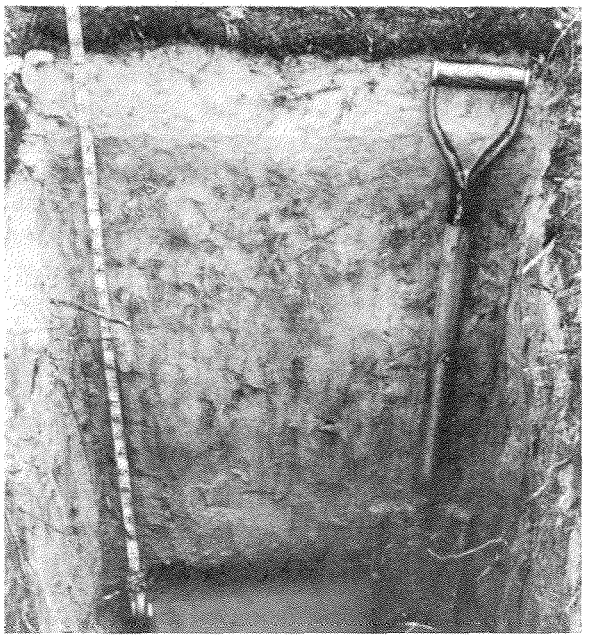

Figure 13. Soil profile on the oligotrophic moist habitat type. Note the strongly developed Ae horizon, and the mottled B and C horizons.

Figure 14. Minor vegetation under jack pine on a dry site in Manitoba. Dominant species include bearberry and wintergreen.

Figure 15. Minor vegetation under jack pine on a moist site in Manitoba. Dominant species include Labrador tea and bunchberry.

sites by ericaceous vegetation composed mainly of bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.), blueberry (*Vaccinium myrtilloides* Michx. and *Vaccinium angustifolium* Ait.), and wintergreen (*Gaultheria procumbens* L.), the fresh sites by a herbaceous cover of twinflower (*Linnaea borealis* L.), false lily-of-the-valley (*Maianthemum canadense* Desf.), bunchberry (*Cornus canadensis* L.), and bracken fern (*Pteridium aquilinum* (L.) Kuhn) with scattered shrubs, while moist sites are characterized by the presence of Labrador tea (*Ledum groenlandicum* Oeder), leatherleaf (*Chamaedaphne calyculata* (L.) Moench), and raspberry (*Rubus idaeus* L.) (Rowe, 1956b; Cayford, 1957a).

Regeneration Characteristics

Studies concerning the reproductive capacity of jack pine have been conducted mainly in terms of seed dispersal, germination, seedling survival and seedling growth. Cone opening and seed dispersal have been studied in relation to temperature, stand age and distance from the ground. Some studies have provided data on germination requirements pertaining to light, temperature, soil moisture and type of seedbeds, while one study has dealt with effects of various chemicals with which the seeds are usually treated. The remaining studies have dealt with effects of light, temperature, soil moisture, type of seedbeds and various biotic factors on both survival and early growth of seedlings.

(a) Seed Production and Dispersal

Most jack pine cones are serotinous and must be subjected to temperatures of at least 122° F (50° C) in order to open. More open cones and greater seed dispersal have been reported from 20-year-old stands than from older stands; over a four-year period the younger stands dispersed slightly more than one pound of seed per acre. Both in Ontario and in Manitoba, cones open and disperse seed readily when placed close to the ground. In Manitoba 9.3 pounds of seed were dispersed per acre during the first year after logging; dispersal was greatest during June, July and August.

Little work has been undertaken to determine jack pine seed production per acre. However, in Ontario a mature stand was found to have from 300,000 to 400,000 cones per acre (Noakes, 1946), while in Manitoba a mature stand averaging 11.1 cords per acre had approximately 77,000 cones per acre (Bruce and Walker, 1965) (MS-235). Yields of 20 seeds per cone have been reported by McLeod (1960) with an average of 134,000 seeds per pound.

Most jack pine cones are serotinous and open only after being subjected to high temperatures. Seeds are dispersed when the material that bonds the scales together melts, ruptures, or dissolves, and the scales flex outwards through desiccation. The melting point of the bonding material at the tips of jack pine scales has been found to be 122° F (50° C) (Cameron, 1953).

The serotinous nature of jack pine apparently varies with stand age. Observations in Saskatchewan have indicated that nearly all mature cones on seven- to ten-year-old trees were open, while in a 35-year-old stand only 10 per cent were open (Jameson, 1961). Seed dispersal

is being studied in open- and well-stocked 20-, 40- and 60-year old stands in Manitoba. Much greater dispersal has occurred in the 20-year-old stands than in the 40- and 60-year-old stands. Total seedfall from November 1960 to November 1964 averaged 147,000 seeds per acre in the 20-year-old stands and 35,000 per acre in the older stands. Seedfall in open stands has exceeded that in dense stands. There has been no consistent seasonal pattern of seed dispersal; peak seedfall periods for individual stands have occurred in the autumn, in the spring, and occasionally in the summer (Cayford and Sims, 1962; Walker, 1963, 1964a, 1965a) (MS-207).

Jack pine cones open and disperse seed readily when placed within a foot of the ground. Above this level cone-opening is reduced, until at four feet above the ground opening is negligible (Noakes, 1946; Jameson, 1961). Seed dispersal from scattered slash in a clear-cut area in Manitoba totalled over 1.2 million seeds or 9.3 pounds per acre during 1964, the first year after logging. Nearly all of the seed was dispersed from cones within seven inches of the ground (Bruce and Walker, 1965) (MS-235). In both Ontario and Manitoba, dispersal from scattered slash has been greatest during June, July and August; some dispersal also occurred during May, September and October (Noakes, 1946; Bruce and Walker, 1965) (MS-235).

Following dispersal, seeds may be consumed by various rodents or birds (Farrar, Gray and Avery, 1954).

(b) GERMINATION

Germination of jack pine is subject to light control and seed will not germinate in continuous darkness. However, once a moisture content of approximately 10 to 20 per cent is attained, a very brief exposure in light is sufficient to ensure germination. Conditions favouring a high moisture content in the seed favour germination; these include a fine-textured seedbed, early summer rainfall, shading, and sowing beneath the surface. Mineral soil seedbeds prepared either mechanically or by burning are generally favourable for germination while undisturbed litter and humus are very poor seedbeds. Germination is normally better on fresh and moist sites than on dry sites. It has been found that a number of fungicides and a rodent and bird repellent mixture are toxic to jack pine seed.

Germination tests of jack pine seedlots have indicated a considerable variation in seed quality. In Ontario, germination rates of from 75 to 85 per cent have been reported (Noakes, 1946), while results from New Brunswick have indicated germination percentages of from 70 to 94 per cent for full seed, and 37 to 55 per cent for all seed (McLeod, 1960). Germination of commercially cleaned seed collected in Ontario has averaged 91 per cent (Ackerman and Farrar, 1965) and for that collected in Manitoba over 95 per cent (Waldron and Cayford, 1964).

In Manitoba, soundness of seed dispersed from non-serotinous cones in a 20-year-old stand averaged 73 per cent for the period 1960-63, while in 40- and 60-year-old stands it ranged from 19 to 52 per cent (Cayford and Sims, 1962; Walker, 1963, 1964a). Seed from older cones was found to germinate more slowly than seed from younger cones, but no appreciable differences in germination percentages were found for various age classes. The age classes investigated were not reported (Noakes, 1946).

A series of experiments were undertaken using controlled environmental conditions to determine the existence and characteristics of photo-control on germination and its dependence upon temperature. Under continuous light, germination was complete at temperatures of 60°, 70° and 80°F. Germination was markedly reduced at all temperatures by excluding light. For example at 70°F, germination was 87 per cent in continuous light and only 16 per cent in continuous darkness. Light did not become effective in controlling germination until a threshold moisture content of approximately 10 to 20 per cent of dry weight was attained. When the threshold moisture content was attained an exposure of 2 to 4 minutes of light provided complete germination (Ackerman and Farrar, 1965).

Studies carried out at the Petawawa Forest Experiment Station in Ontario have demonstrated that conditions favouring a high moisture content in the seed -- fine-textured seedbed, watering, shading, and sowing beneath the surface -- resulted in good germination, whereas conditions favouring drought resulted in lower germination. Partial shade created conditions favourable for germination and its beneficial effects probably arose from the better moisture conditions that resulted. Degree of shade seemed to have little effect on germination and it was considered that

Figure 16. View of a furrow prepared with a Middlebuster plough. Four seedbed conditions are shown: (1) centre of furrow, (2) south side of furrow, (3) north side of furrow, (4) ridge.

Figure 17. View of seedspots located on furrow seedbeds on a dry site. Each skewer marks the location of a seedling.

complex shade patterns cast by slash and snags on burned-over areas contribute substantially to the good germination often observed on such areas (Fraser and Farrar, 1953a, 1953b) (P-366). In another study, germination decreased significantly when daily exposure to sunlight exceeded 4 hours; poorest germination occurred when seedbeds were exposed constantly (Fraser, 1959) (P-366).

Type of seedbed is an important factor affecting jack pine germination. Mineral soil seedbeds prepared either mechanically or by burning are generally very favourable for germination while undisturbed litter and humus are very poor seedbeds, (Farrar, Gray and Avery, 1954; Cayford, 1958; 1963a; Chrosciewicz, 1959, 1960b, 1964a; Jameson, 1961; Sims, 1963, 1964a, 1965a) (H-65A, H-65B, H-108, H-130, MS-157, MS-163, MS-176 and MS-222).

Results of a study of germination on four mineral soil furrow and ridge seedbeds prepared by a tractor-drawn Middlebuster plough have indicated that highest germination has occurred on the centre and south side of the furrow, intermediate germination has occurred on the north side of the furrow, and poorest germination has occurred on the ridge (Sims, 1963, 1964a, 1965a) (MS–222) (Figures 16 and 17). A greenhouse experiment has indicated that a mulch of pine needles can affect germination on a mineral soil seedbed (Cayford and Waldron, 1962) (MS–223A).

Jack pine germination on finely ground humus, both in the laboratory and in the field, was found to be satisfactory; in the field it was nearly as high as on mineral soil. These findings suggest that the reason humus is usually a poor seedbed can be explained in terms of moisture relations (Farrar and Fraser, 1953) (P–366). Results from a study to compare germination and early development on three seedbed types–mineral soil, mixed mineral soil-humus and humus–on fresh to moderately moist till soils in Manitoba (MS–227) have shown all three seedbeds to be favourable for germination in years of above-normal precipitation (Waldron, 1964b).

Site also affects germination, and in south-eastern Manitoba germination was best on a fresh site, intermediate on a moderately fresh site, and poorest on a dry site (MS–222). Germination percentages on the three sites were 31, 15 and 12 per cent in 1962, 13, 11 and 4 per cent in 1963, and 16, 20 and 2 per cent in 1964 (Sims, 1963, 1964a, 1965a). In an Ontario study, maximum germination was found to occur on a somewhat moist sandy soil, and germination decreased as moisture regime decreased (Chrosciewicz, 1960a) (H–81).

It has been found that a number of fungicides–Captan-50W, Arasan-75, Dexon, and Chemagro–and a rodent and bird repellent mixture of Arasan-75 and Endrin-75W are toxic to jack pine seed. The main effect of the chemicals is to cause defective germination. The Arasan-Endrin mixture, Captan and Arasan were the least phytotoxic, and the toxic effects of the latter two were much reduced by depth sowing (Waldron and Cayford, 1964) (MS–223B). It was also found

that seed treated with Arasan and Endrin may be stored at 35° F (1.7° C) for at least a year with little reduction in germination (Cayford and Waldron, 1966) (MS–223B).

In southern and central Manitoba germination of jack pine begins between the middle of May and early June and is largely completed by the end of June. Sporadic germination continues throughout the summer months (Sims, 1963, 1964a, 1965a; Waldron, 1964b). Germination may be delayed by spring drought (Bruce and Walker, 1965).

(c) Seedling Survival

Factors affecting seedling survival have been studied both in Ontario and in the Prairie Provinces. Optimum conditions for survival are provided by mineral soil and burned seedbeds, particularly in areas where competition from other vegetation is not severe. Severe losses may result from heat and drought; they may be particularly pronounced on dry sites during midsummer, but may be reduced in shaded locations and on north and east slopes. Frost may cause mortality of cotyledonous and one-year-old seedlings. A variety of insects, diseases, rodents and other mammals may also cause seedling mortality.

Optimum conditions for jack pine seedling establishment and survival are provided by mineral soil and burned seedbeds, particularly in areas where competition from other vegetation is not severe. In Saskatchewan, initial seedling survival ten weeks after germination was 98 per cent on mineral soil seedbeds and 65 per cent on undisturbed seedbeds (Jameson, 1961). The beneficial effects of mineral soil are demonstrated in the results of one study where second-year stocking on milacre quadrats increased as percentage of mineral soil increased; stocking was 8 per cent on quadrats containing less than 25 per cent mineral soil, and 65 per cent on quadrats containing more than 75 per cent mineral soil (Cayford, 1957b) (MS–163). In central Manitoba on a dry site, first-year survival of seedlings planted in furrows averaged 50 per cent, while on undisturbed ground it averaged 27 per cent (Cayford, 1961b) (MS–190). Similarly in Ontario, first-year stocking after seeding on one-quarter milacre quadrats was unsatisfactory on unscarified seedbeds (24 per cent); on freshly scarified seedbeds and on one-year-old scarified seedbeds it averaged 83 and 64 per cent, respectively (Horton, 1963) (H–124A). In a study in Manitoba survival of germinants after two growing seasons averaged 93 per cent on humus, 78 per cent on mixed mineral soil–humus seedbeds, and 72 per cent on mineral soil seedbeds. The reduced survival on the latter two seedbed types was a result of frost heaving (Waldron, 1964b).

On mineral soil seedbeds prepared by disking, most germinants occurred in furrow bottoms where moisture and temperature conditions are more favourable. However, these seedlings were subject to mortality caused by washing of soil into the furrows (Farrar, Gray and Avery, 1954; Jameson, 1961; Cayford, 1961a).

On mineral soil seedbeds prepared by a tractor-drawn Middlebuster plough, survival of germinants has generally been highest on the south side and in the centre of the furrow, intermediate on the north side of the furrow, and least on the ridge (Sims, 1963, 1964a, 1965a) (MS–222).

Aspect may also affect seedling establishment. In both Manitoba and Saskatchewan, east and north aspects are more favourable than south or west aspects, or level ground (Jameson, 1961; Cayford, 1963a).

Vegetative competition from shrubs and herbaceous vegetation, together with smothering by fallen leaves, were important causes of mortality following spot seeding on sandy soils in Ontario (Chrosciewicz, 1960a) (H–81). Similarly, competition from trembling aspen and hazel has been responsible for poor survival of jack pine planted on clay soils in Manitoba and Saskatchewan (Haig, 1956, 1959a) (MS–103–104 and MS–105). On similar soils in the Riding Mountain National Park, western Manitoba, competition from grasses has resulted in severe mortality to young jack pine following scarification and slash scattering (Cayford, 1958; Cayford and Waldron, 1963) (MS–157). In a study of the effects of various depths of blueberry leaf litter, it was found that a light covering (⅛ to ¼ inch) was beneficial to the survival of eight-week-old seedlings while a covering of from ½ to 1 inch had a detrimental effect (Curtis, 1964) (H–127C).

Heat and drought are important factors causing seedling mortality and severe losses from these causes have been reported both in natural stands and in plantations (Noakes, 1946; Johnson, 1953; Jameson, 1956a; Cayford, 1957b, 1963a; MacHattie and Horton, 1963; Sims, 1963, 1964a,

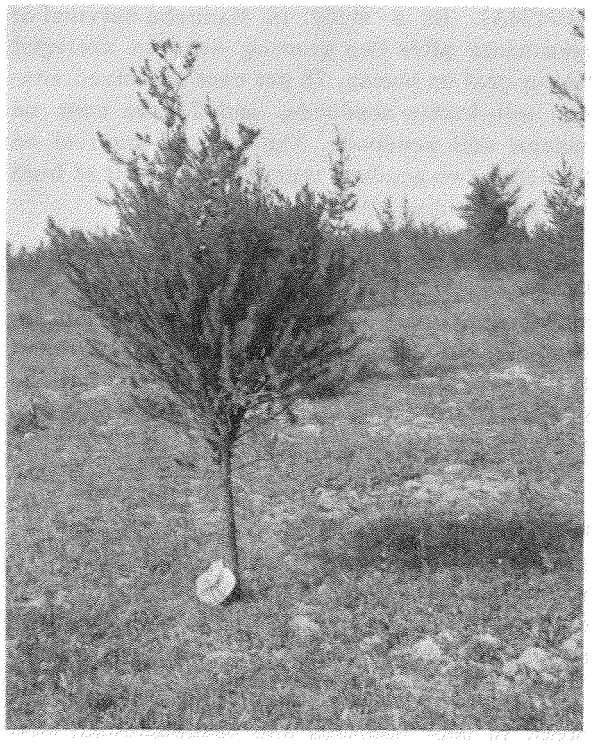

Figure 18. Damage to jack pine sapling caused by mistletoe infection.

1965a) (MS–100 *et al*, MS–113, MS–163, MS–188 and MS–222). Heat-caused mortality is particularly severe in cotyledonous seedlings and occurs most commonly during mid-summer; it is more important on dry and moderately fresh sites than on fresh sites (Sims, 1963, 1964a, 1965a). At the Petawawa Forest Experiment Station seedling mortality was correlated with maximum ground-surface temperatures (MacHattie and Horton, 1963). Shade is an important factor in reducing mortality caused by heat and drought (Cayford, 1957b). Flooding is not normally an important factor causing mortality but on moist sites may play its part (Waldron, 1964a) (MS–226).

Frost is another factor causing seedling mortality. At the Petawawa Forest Experiment Station, one- and two-month-old seedlings have been killed. Low-lying areas are particularly subject to unseasonable frosts because of cold air drainage (Fraser, 1953) (P–372). In Ontario, cotyledonous seedlings were killed by frost and one-year-old seedlings damaged. Older seedlings were not seriously affected (Farrar, Gray and Avery, 1954). Frost heaving has caused seedling mortality on mineral soil and mixed mineral soil-humus seedbeds on moist sites in Manitoba that tend to flood in the spring (Waldron, 1964b).

Figure 19. Extensive damage to 10-year-old pine regeneration in Saskatchewan. Caused by snowshoe hare browsing.

Depth of slash is an important factor affecting seedling survival. A single lopped branch may prevent drought conditions developing around seedlings by providing shade, but poor survival may occur where slash layers are deep because of insufficient light (Farrar, Gray and Avery, 1954; Jameson, 1961).

Damping-off has caused mortality of cotyledonous seedlings in southeastern Manitoba; most mortality from this cause occurred in the spring, shortly after germination (Sims, 1963, 1964a). Damping-off may be an important factor causing mortality to seedlings growing under thick layers of slash (Jameson, 1961). Minor damage to reproduction has been caused by stem rusts (*Cronartium* spp.) (Jameson, 1961). In areas which were heavily infected with mistletoe, it was observed that reproduction was also infected (Jameson, 1961) (Figure 18).

A variety of insects can either kill or damage jack pine seedlings. Grasshoppers are believed to have eaten cotyledonous seedlings and caused mortality in southeastern Manitoba and in Ontario. Most of the damage in the former area occurred in late-summer during a period of high grasshopper population (Farrar, Gray and Avery, 1954; Sims, 1964a). In Manitoba and Saskatchewan the jack pine budworm (*Choristoneura pinus* Free.), white pine weevil (*Pissodes strobi* (Peck)), and pitch nodule maker (*Petrova albicapitana* (Busck))

Figure 20. A jack pine seedling severely deformed by elk browsing, Riding Mountain National Park, Manitoba.

have caused damage to reproduction (Johnson, 1953; Cayford, 1959; Jameson, 1961).

The snowshoe hare *(Lepus americanus phaenatus* (Allan)) has caused extensive damage to jack pine reproduction (Johnson, 1953, 1955b; Haig, 1956, 1959a, 1959b; Jameson, 1956a; Cayford, 1964b) (MS–90, MS–100 *et al*, MS–103–104, MS–105, MS–113, MS–132 and MS–154) (Figure 19). Particularly severe damage occurred in the Prairie Provinces between 1924 and 1926, in 1933 and in 1943, and resulted in seeding and planting failures. Most severe damage has occurred in plantations set out under an aspen canopy. More recent damage to reproduction was observed in Saskatchewan in 1954; the form and vigour of damaged seedlings were so poor that their eventual development into sound, well-formed trees seemed unlikely (Jameson, 1961). In a small planting study set out in central Manitoba in the spring of 1962, 94 per cent of the planted trees were browsed within five weeks of planting. Of these, 5 per cent were killed, while the remainder survived and had developed new leaders by the end of the growing season (Waldron, 1964b).

White-tailed deer *(Odocoileus virginianus borealis* Miller) have caused considerable damage to young jack pine by eating twigs and foliage during winter months. Browsing has caused growth reductions, deformations and mortality (Stiell and Farrar, 1953; Cayford, 1956; McCormack and Berry, 1956; Horton, 1964) (P-235).

In Riding Mountain National Park in western Manitoba much damage is caused to jack pine seedlings by elk (*Cervus canadensis manitobensis* Millais). Planting of jack pine during periods of high elk population is considered by some to be hopeless (Rowe, 1956a) (Figure 20).

Figure 21. Mouse damage to jack pine seedling in Manitoba.

During the winter of 1958-59, field mice *(Microtus pennsylvanicus* Ord) caused a small amount of damage to jack pine growing in southeastern Manitoba (Figure 21). Damage consisted of the gnawing of bark on main stems and lower lateral branches; occasionally trees were completely girdled (Cayford and Haig, 1961).

(d) Seedling Growth

Seedlings grow very slowly for the first three or four years, and then begin to show a rapid increase. In Manitoba, about ten years are required for the average seedling to reach breast height. Maximum growth normally occurs on sites with favourable moisture supplies, and early growth tends to be greater on mineral soil and burned seedbeds than on undisturbed seedbeds. Competition from vegetation may adversely affect growth, and a direct relationship has been shown in Ontario between jack pine growth and exposure to sunlight.

Jack pine seedlings grow slowly in height for an initial period, and then begin to show a fairly rapid increase. Growth on mineral soil seedbeds in Manitoba on a dry site averaged

about 0.1 foot per year for the first three growing seasons, but by the sixth growing season increment averaged 0.8 feet (Cayford, 1961a). In a second Manitoba study, seedlings growing under a variety of conditions averaged 0.4 feet per year for the first eight years after which they grew rapidly; growth averaged 0.8 feet in the ninth year and 1.4 feet in the tenth year. Between nine and ten years were required for the average seedling to grow to breast height (Johnson, 1955a).

In a more recent study, average first-year growth of 1962 germinants on dry, moderately fresh, and fresh sites in southeastern Manitoba was 0.11 feet; average annual second- and third-year growth was 0.24 feet. First-year seedling growth averaged 0.11, 0.09 and 0.06 feet for the three years from 1962 to 1964; precipitation during these three years was above the long-term average (Sims, 1964a, 1965a).

Generally, maximum seedling growth occurred on sites with favourable moisture supplies. In southeastern Manitoba, dominant five-year-old seedlings on burned-over areas averaged 1.5 feet in height on dry sites, 3.3 feet on moderately fresh sites, and 3.8 feet on moist sites (Cayford, 1963a). In the same area, growth for the first three years was poorer on dry sites than on fresh or moderately fresh sites (Sims, 1964a, 1965a).

In Saskatchewan, ten-year-old seedlings growing in cut-over areas were tallest on dry sands, intermediate on fresh sands, and shortest on very dry sands. However, between 10 and 15 years, jack pine on the fresh site grew at an accelerated rate and at age 15 years, average seedling height was greatest on this site (Jameson, 1961).

A greenhouse study of the effects of the depth to water table on seedling growth was carried out on two different soils, a sand and a loamy sand. Jack pine height curves were mononodal in character indicating a definite optimum depth to water table. These depths ranged from 31 inches for 7-month-old seedlings to 39 inches for 14-month-old seedlings on the loamy sand, and from 24 to 30 inches for seedlings of the same ages growing on sand. Growth on the loamy sand was nearly double that on the sand (Mueller-Dombois, 1964a) (MS–218). However, when jack pine was grown in competition with grasses over the various depths to water table, its height growth was much less than when grown in the absence of competition. Growth trends in relation to depth to water table, however, were generally similar (Mueller-Dombois and Sims, 1965) (MS–218). In Ontario, dominant six-year-old seedlings averaged 15 inches in height on areas with grass or herbaceous vegetation and 6 inches on areas with shrub competition (Chrosciewicz, 1960a).

Seedling growth also varies with type of seedbed. In Saskatchewan, seedlings up to 15 years of age grew more rapidly on burned seedbeds than on undisturbed seedbeds. Data were not available concerning growth on mineral soil seedbeds, but seedlings appeared to be more vigorous than those on undisturbed seedbeds (Jameson, 1961). First- and second-year height growth of seedlings planted in central Manitoba was greater on mixed mineral soil-humus and mineral soil seedbeds than on humus seedbeds. The more intense vegetation competition on the humus seedbed was considered to have adversely affected seedling growth (Waldron, 1964b). In southeastern Manitoba first- and second-year growth after seeding was found to be generally greater on undisturbed seedbeds where organic matter was present than on mineral soil seedbeds. Third-year growth tended to be better on mineral soil (Sims, 1964a, 1965a).

Results from two studies carried out at the Petawawa Forest Experiment Station have demonstrated a direct relationship between jack pine growth and exposure to direct sunlight. After two growing seasons, seedlings in one study averaged 2 inches in height with 0 hours exposure and 11 inches with 12 hours exposure (Fraser, 1959) (P-366). In the second study, average heights of seedlings grown in the field under four levels of light intensity under natural day lengths for five years were as follows: 13 per cent light, 16 inches; 25 per cent light, 29 inches; 45 per cent light, 39 inches; 100 per cent light, 44 inches. Shoot weight, leader diameter and root collar diameter all increased with increase in light. Root weight of four-year-old seedlings was found to increase with increase in light; average weight at 13 per cent light was 1.0 gram and at 100 per cent light was 30.0 grams (Logan, 1966) (P–388).

Root development of jack pine growing on dry and fresh sands in Manitoba was confined mainly to the tap-root for the first one to three years, but lateral branching became increasingly common on three- and four-year-old seedlings.

Most lateral roots were located in the H, Ahe, and Ae horizons. Mycorrhizae were found on one-year-old seedlings (Sims, 1964b, 1965b) (MS–225).

Natural Variation

Results from several of the older provenance experiments, which contain Ontario provenances supplemented by a few from Quebec, have indicated that there are differences in height between the different provenances. Most of the variation is clinal and is highly correlated with both length of growing season and May to September mean monthly temperature. Comparisons of growth rate within and between western Ontario Site Regions[5] were rather inconclusive because of insufficient sampling, but the eastern Site Regions differed significantly in height and phenology (period of shoot growth). Provenances from western Ontario and northern Ontario have short growth periods, while provenances from middle and southern Ontario have longer growth periods (Holst and Yeatman 1961, Holst 1964) (P–156A). Preliminary results from Scottish nurseries show a very high correlation between growth rate and length of growing season of place of origin for provenances west of longitude 90° W, and variable results for provenances east of the same longitude. The growth rate of provenances from the western portion of the range of jack pine is closely related to climate (clinal variation) while from the extreme eastern portion of the range there seems to be a wider scatter as is associated with a disjunct distribution (Holst 1964) (P–156D).

Marked differences in growth were found between seedlings from 50 Canadian and United States provenances that had been grown for three months in controlled environments. On an average, the southern sources grew more than the northern sources, and growing degree-days proved to be the best single index of variation. The difference in relative response between eastern and western populations was associated with the different relationship between latitude (day length) and growing degree-days in the eastern and western sections of the continent. Differences in cold hardiness and spring flushing due to latitude of origin were observed, with northern provenances hardier than southern ones (Yeatman 1964) (P–156E).

[5]Hills' Site Regions. See Footnote 4.

Natural Regeneration

Various observational studies have indicated that successful regeneration of jack pine rarely results after cutting, and that cut-over jack pine stands are normally succeeded by grass, shrubs or hardwoods (Figures 22–23). Is is also evident that most of the present-day jack pine stands have originated after fire in uncut stands. As a result of these observations a number of studies have been undertaken in the jack pine cover type to investigate the relative values of various silvicultural methods for reproducing jack pine. Techniques investigated have included various methods of cutting and slash disposal, and various methods of seedbed preparation.

(a) Cutting and Slash Disposal

Regeneration following clear cutting, seed-tree cutting and clear cutting in strips has been unsatisfactory both in Ontario and in the Prairie Provinces. Also, in trials using various methods of slash disposal, regeneration has been unsuccessful in all instances. Regeneration failures have been attributed to the scarcity of favourable seedbeds.

Clear cutting has been the most commonly employed cutting method in jack pine, and results from five experiments (Table 1) have demonstrated the inadequacy of regeneration from this method. Stocking[6] on cut-over areas has ranged from 2 to 16 per cent (Jameson, 1953; Farrar, Gray and Avery, 1954; Cayford, 1958, 1964a) (H–65A, MS–163, MS–181 and MS–212A). In Manitoba, three cutting methods – seed-tree cutting, clear cutting, and clear cutting in strips –were tried; regeneration three to four years after cutting was unsatisfactory regardless of cutting method, and maximum stocking was 13.5 per cent (Cayford, 1958) (MS–163).

In two studies the effects of various methods of slash disposal on regeneration have been investigated. In 1944, three methods – piling and burning, lopping and scattering, and no disposal –were compared at the Petawawa Forest Experiment Station and results after five years indicated that regeneration was unsatisfactory, even though large quantities of seed were dispersed following the three slash treatments. Stocking ranged from 13 to 28 per cent (Atkins and Farrar, 1950) (P–126). In southeastern Manitoba, regeneration was unsuccessful following six different slash disposal treatments (Johnson, 1955a) (MS–143). Regeneration failures, in both instances, were attributed to the infrequent occurrence of favourable seedbeds.

[6]In Part II of this report, all stocking values that pertain to natural regeneration and to artificial regeneration from broadcast seeding are based on sampling by 1/1000-acre quadrats, except where noted.

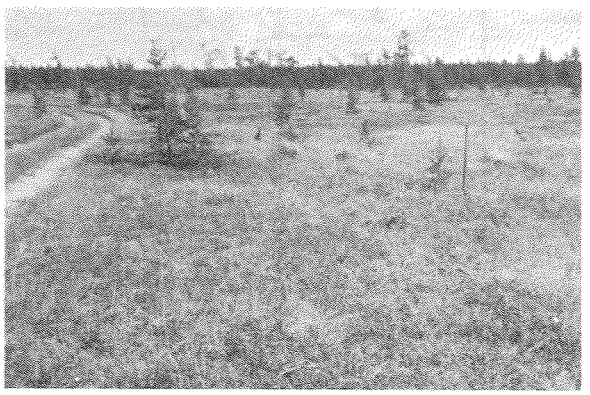

Figure 22. A non-reproducing jack pine cut-over in Manitoba.

Figure 23. A non-reproducing jack pine cut-over in Ontario. Reproduction is restricted to the few patches of mineral soil exposed by logging.

TABLE 1. JACK PINE REGENERATION STOCKING ON UNDISTURBED AND MECHANICALLY PREPARED SEEDBEDS

(CLEAR-CUT AREAS)

Project and reference	Treatment	No. of years between treatment and last remeasurement	Per cent stocking	Basis: quadrat size
H–65A Farrar, Gray and Avery 1954	1. Clear cutting	4	15	1/1000–acre
	2. Clear cutting, disking, scattering slash	4	44	
	3. Clear cutting, cable-skidding in tree lengths	4	36	
	4. Clear cutting, cable-skidding in tree lengths, scattering slash	4	38	
	5. Clear cutting, skidding in bundles	4	54	
	6. Clear cutting, skidding in bundles, scattering slash	4	58	
H–65B Chrosciewicz 1960b	1. Clear cutting (bundle yarding method), slash scattering on mineral soil			1/1000–acre
	(a) All seedbeds	2	20	
	(b) Mineral soil seedbeds only	2	90	
MS–157 Cayford 1958	1. Clear cutting	5	5	1/4000–acre
	2. Clear cutting, disking, slash scattering	5	31	
	3. Clear cutting, slash scattering, disking	5	6	
MS–163 Cayford 1958	1. Clear cutting	1	2	1/1000–acre
	2. Clear cutting, disking, slash scattering	1	71	
	3. Clear cutting	3	2	
	4. Clear cutting, slash scattering, disking	3	2	
MS–181 Jameson 1953	1. Clear cutting	2	4	1/1000–acre
	2. Clear cutting, slash scattering, disking	2	12	
MS–212A Cayford 1964a	1. Clear cutting	3	16	1/1000–acre
	2. Furrowing, clear cutting, slash scattering	3	42	

(b) Mechanical Seedbed Preparation

Mechanical seedbed preparation, generally carried out in conjunction with clear cutting, has been successful in improving jack pine regeneration after cutting. A stocking of 58 per cent, four years after logging, was obtained in Ontario following exposure of mineral soil by skidding logs in bundles and then logging and scattering cone-bearing slash on exposed soil. In Manitoba, mechanical seedbed preparation using a Rome Middlebuster plough prior to logging has exposed mineral soil on about 50 per cent of the treatment area, and preliminary results have shown a stocking of 42 per cent, three years after treatment.

Several studies have been undertaken to determine whether mechanical seedbed preparation, usually in conjunction with clear cutting, will increase the abundance of jack pine regeneration. Seedbed preparation has been undertaken in Ontario and in Manitoba using an Athens disk plough, and more recently in Manitoba using a Rome Middlebuster fire-line plough (Figures 24 and 25). Also, in one study in Ontario two logging methods which would prepare mineral soil seedbeds, were investigated. These involved cable skidding in tree lengths and tractor skidding of bundles of 4-foot logs. To provide a seed source, slash scattering was incorporated into the treatment, either before or after seedbed preparation. Results from these studies (Table 1) indicate that mechanical seedbed preparation can successfully be employed to improve jack pine regeneration after cutting. In Ontario, best stocking (58 per cent) resulted following exposure of mineral soil by skidding logs in bundles and then lopping and scattering cone-bearing slash on the exposed soil. Disking with an Athens plough and lopping and scattering of slash resulted in somewhat poorer stocking (44 per cent), while stocking after cable skidding in tree lengths and slash scattering resulted in 38 per cent stocking (Farrar, Gray and Avery, 1954) (H–65A). In Manitoba, disking before slash scattering was more successful than disking after slash scattering. Where slash was either windrowed or piled prior to disking, it was possible to expose mineral soil over much of the treatment area, and slash scattering then provided an adequate source of seed. However, when slash was scattered during logging and prior to seedbed preparation, the Athens disk tended to ride up over the slash and the only mineral soil exposed was where there was little or no slash present. Comparable trends were obtained both on sandy soils (Jameson, 1953; Cayford, 1958) (MS–163 and MS–181) and on clay-loam to clay soils (Cayford, 1958) (MS–157).

Figure 24. Seedbed preparation with an Athens disk plough in a cut-over stand in Manitoba.

In a current study in Manitoba, mechanical seedbed preparation is being carried out using a Rome Middlebuster plough prior to logging. Using this method, mineral soil has been exposed on about 50 per cent of the treatment area, and

Figure 25. Seedbed preparation with a Rome Middlebuster fire-line plough in an uncut stand in Manitoba.

preliminary results indicate that stocking with regeneration has been increased from 16 per cent on untreated areas to 42 per cent on treated areas (Cayford, 1964a) (MS–212A). However, prelogging seedbed preparation can only be satisfactorily done in understocked stands. If mechanical seedbed preparation is to be undertaken as an operational technique in well-stocked stands it should be done after logging, and with heavier equipment than that used in the research studies.

Clear cutting in strips has been carried out in two studies involving mechanical seedbed preparation. In both instances, stocking on the clear-cut strips has been less than on clear-cut areas. Stocking in the first study, one year after treatment were 46 and 71 per cent for clear-cut strips and clear-cut areas, respectively; in the second study three years after treatment they were 21 and 42 per cent, respectively (Cayford, 1958, 1964a) (MS–163 and MS–212A).

(c) Burning

If prescribed burning is to be effective when used for securing natural regeneration, it must prepare suitable seedbeds and also provide for adequate seed dispersal. Experimental burning in central Ontario has shown that to prepare seedbeds the humus must be dry, and where it is an inch or more in depth, prolonged periods of drought must occur prior to burning. Burning invariably destroys most of the seed in slash, but when carried out under open stands and in slash under seed trees it has provided adequate seed dispersal from standing trees. Satisfactory stocking resulted from burning an open stand in Ontario; other trials, including slash burning under seed trees, were unsuccessful because they were conducted under moist humus conditions.

The use of prescribed burning in securing natural regeneration has been investigated in Ontario and in Manitoba. The earliest burns, conducted in the spring of 1949 near Ramsay, Ontario, were in windrowed and scattered slash. As burning destroyed at least 90 per cent of the seeds in slash, and the seedbed conditions remained mostly unimproved, jack pine stocking was extremely poor (6 to 9 per cent) three years after the treatment (Farrar, Gray and Avery, 1954; Chrosciewicz, 1959) (H–65A). In other spring trials, carried out between 1949 and 1956 north of Espanola, Ontario, burning was done in an open stand and on cut-over areas where seed trees had been left. Burning under the open stand was successful in both seedbed improvement and seed dispersal, and the stocking two and five years later was satisfactory (60 per cent). Slash burning under seed trees resulted in adequate seed dispersal but, as the burning was done under moist humus conditions, seedbeds were not sufficiently improved and the stocking was generally poor (10 to 17 per cent) two years after the treatments (Chrosciewicz, 1959) (H–108).

Results obtained from these early burns have demonstrated that to prepare jack pine seedbeds, the raw humus must be dry and, where it is an inch or more in depth, prolonged periods of drought must occur prior to burning (Chrosciewicz, 1959). This conclusion led to a series of summer burns that were carried out on clear-cut areas north of Espanola, Ontario, between 1960 and 1962. The burns were conducted within a range of pre-selected site, fuel and weather conditions, and the results showed that both the humus moisture and the reduction of humus depth by burning correlated with the local weather conditions as represented by the corresponding combinations of drought and fire danger indices[7]. On this basis, the specific requirements for each of several intensities of humus disposal by burning in relation to the original types and depths of humus materials were ascertained (Chrosciewicz, 1961a, 1962a, 1963a, 1965) (H–130). Similarly, at the Petawawa Forest Experiment Station, it was found that the organic layer must be fairly dry before an appreciable portion of the mineral soil is bared (Van Wagner, 1966). Burning in a cut-over area on a dry sandy site in Manitoba in July of 1964, under drought indices of 10 and 11, and fire danger indices of 8, 9 and 10, resulted in reductions of humus depths by 60 to 79 per cent, and in exposure of mineral soil on from 15 to 36 per cent of the area (Cayford, 1965) (MS–245). Burning did not significantly affect the organic matter content of the A soil horizon or the infiltration rate of the soil (Sims, 1965c) (MS–243).

[7]Drought and fire danger indices according to: Anon. 1957. Forest fire danger tables, 1956, Ontario, Canada, Dept. Northern Affairs and National Resources, Forestry Branch.

Artificial Regeneration

Several studies of direct seeding have been undertaken to investigate the applicability of this technique in jack pine silviculture. Seeding has been on seedbeds prepared either mechanically or by burning (Figures 26-28), and two methods of seeding – broadcast seeding and spot seeding – have been employed. Many plantations have been established throughout the Canadian range, and also in Newfoundland, with the earliest dating back to the period 1913-1930. A number of investigations have been carried out to assess plantation development and to elucidate some of the reasons for success or failure.

(a) Mechanical Seedbed Preparation and Seeding

Broadcast Seeding

Various studies in Manitoba and Ontario have indicated that successful regeneration often results from broadcast seeding on areas where mineral soil seedbeds have been mechanically exposed. Although best suited for regenerating cut-over and other open areas, the method also shows promise for converting intolerant hardwood areas to jack pine.

The earliest broadcast seeding was on the Duck Mountain in Manitoba in 1920, on areas thoroughly disked. Initial results were successful, but stocking was reduced from an average of 4,217 stems per acre in 1929 to 7 stems per acre in 1957. Severe rabbit browsing was responsible for the mortality (Haig, 1959b) (MS–90). Between 1925 and 1928, experimental broadcast seeding was done in southeastern Manitoba following disking and harrowing; seeding was generally successful as most plots had more than 2,000 stems per acre in 1930 (Morison, 1931; Cayford, 1959) (MS–202–82).

Considerable broadcast seeding was carried out on mechanically prepared areas by the Manitoba Government between 1943 and 1955; in 1958 about one half of these areas were more than 40 per cent stocked and nearly 70 per cent supported stands exceeding 500 stems per acre (Cayford, 1959) (MS–202–82). Broadcast seeding on cut-over disked and undisked areas in Ontario in 1949 increased stocking by approximately 10 per cent (Farrar, Gray and Avery, 1954) (H–65A). More recent jack pine seedings on cut-over furrowed areas in southeastern

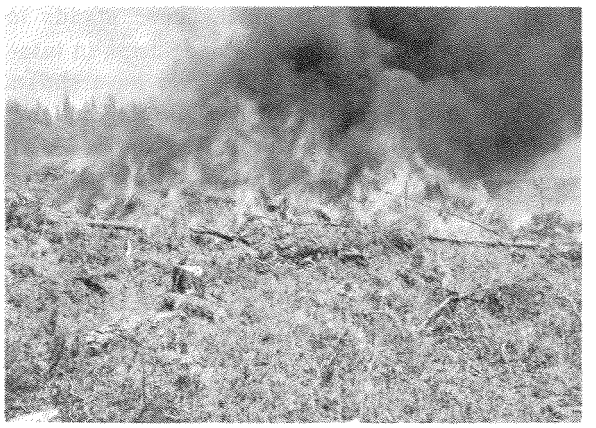

Figure 26. View of a summer prescribed burn headfire in jack pine cut-over, Manitoba.

Figure 27. View of a summer prescribed burn backfire in jack pine cut-over, Manitoba.

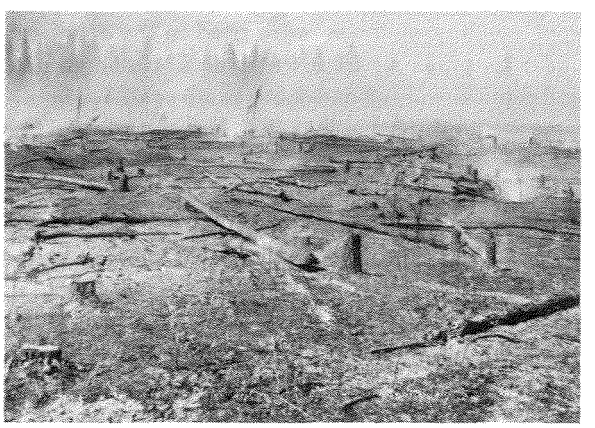

Figure 28. Effects of summer prescribed burning in jack pine cut-over in Manitoba.

Manitoba, on scalped strips in aspen stands in central Manitoba, and on scalped strips in intolerant hardwood stands in Ontario have shown promising initial results (Horton, 1963; Cayford, 1964a; Walker, 1965b; Waldron, 1964a) (H–124A, MS–212B, MS–226). In a study carried out in southeastern Manitoba, broadcast seeding on mineral soil seedbeds was successful when done between the end of May and mid-June, but unsuccessful when done from mid-June to mid-September (Cayford, 1961a) (MS–177).

Spot Seeding

Results from a number of spot seeding studies in Manitoba, Ontario and Quebec, while more variable than those from broadcast seeding, do indicate that successful regeneration can be obtained by sowing on mineral soil scalps of sufficient size or in furrows, provided weather conditions are favourable for germination and initial survival. There are also indications that depth sowing is more successful than surface sowing and that young seedlings must be protected from competing vegetation.

The first trials of spot seeding were undertaken on small hoed scalps in southeastern Manitoba between 1925 and 1928 and results were generally unsatisfactory; in 1930, six of eight plots had stocking[8] of 17 per cent or less (Morison, 1931; Cayford, 1959) (MS–202–82). Several spot seeding trials have since been carried out, the first of which was on a cut-over jack pine site at the Petawawa Forest Experiment Station in Ontario. Eleven years after spot seeding on exposed mineral soil, over 70 per cent of the spots were stocked and mean seedling height was 6.2 feet (Logan, 1951) (P–33). In 1954, three spot seeding methods were tried in the open and under an aspen stand at Petawawa. Both surface and depth sowing on one-foot square scarified spots were generally unsuccessful. Maximum stocking (39 per cent) five to six years after establishment, was obtained by depth sowing under aspen (Horton and McCormack, 1961) (P–379). A trial of depth spot seeding on mechanically scarified strips in the Goulais River Research Area north of Sault Ste. Marie, Ontario, resulted in second-year stocking (based on one-quarter-milacre plots) of over 80 per cent for 1960 and 1961 sowing (Horton, 1963) (H–124A).

[8]Stocking values that pertain to spot seeding are based on sampling by individual spots.

A 1951 spot seeding on six-inch square scarified scalps in central Ontario was mostly unsuccessful. Six years after seeding, the stocking was moderate (44 per cent) on one plot and poor (below 29 per cent) on four plots. The failure was attributed in large part to plant competition and smothering of seedlings by fallen plant litter (Chrosciewicz, 1960a) (H–81). To study the environmental requirement in detail – mainly soil, vegetation, illumination and climate – a long-term factorial spot seeding experiment was established and thoroughly replicated on eight different clear-cut sites, north of Espanola, Ontario. The treatments, consisting of spot scarification and seeding 0.5-, 1.0- and 2.0–foot circular scalps, were carried out on each site over a three-year period between 1960 and 1963. Preliminary results have indicated that the initial stocking was increased by covering the seeds with a thin layer of soil, and that the stocking varied with the weather conditions following each year's seeding. The over-all initial stocking ranged from poor (19 per cent) in a very few cases to excellent (98 per cent) in many cases, and the three-year treatment averages varied by sites and scalp sizes between moderate (44 per cent) and good (79 per cent). Although measurements will continue until 1967, there are indications that the final stocking and seedling growth will vary with the different scalp sizes and the different site factors under investigation (Chrosciewicz, 1961b, 1962b, 1963c and 1964b) (H–127A).

In Quebec, four seed spot methods are being tested in two locations, one near the Sault-au-Cochon River and the other near the Little Pabos River. Best stocking has occurred on the mineral soil scarified seedbed followed in turn by mixed mineral soil-organic matter, mineral soil scraped bare, shallow furrow, and control. Only on the control plots was stocking always entirely unsatisfactory (Choquette, 1964a, 1964b, 1965a and 1965b) (Q–81, Q–101).

In the Sudbury District of Ontario, jack pine seed was sown in 1964 using a method which involved an adaptation of furrow seeding, using a modified corn seeding unit attached behind a bulldozer equipped with a front-mounted V–blade. Seeding rate was set at 2.5 seeds per foot and furrows were at 8–foot intervals. First-year results for jack pine were very good; stocking based on 6.6–foot lengths of furrow averaged 78

per cent on a dry site and 86 per cent on a fresh site (Horton and Flowers, 1965) (H–124C).

(b) Burning and Broadcast Seeding

Prescribed burning and broadcast seeding have been tested on a number of cut-over areas in central Ontario. Spring and fall trials from 1949 to 1954 were mostly unsuccessful because of insufficient improvement in seedbed conditions. Summer burns from 1960 to 1962 were, in most cases, highly successful, with an average stocking after one year of 75 per cent.

Burning and broadcast seeding have been tested on a number of cut-over areas in central Ontario. As a result of spring burning in 1949 near Ramsay, Ontario, jack pine stocking was increased by 9 to 17 per cent but was still inadequate due to little improvement in seedbed conditions (Farrar, Gray and Avery, 1954; Chrosciewicz, 1959) (H–65A). Following a fall burning in 1953 north of Espanola, Ontario, four seeding intensities were applied but poor (20 per cent)to moderate (55 per cent) jack pine stocking resulted. This was primarily because the fire was only partially successful in the preparation of favourable seedbeds (Chrosciewicz, 1959) (H–108).

Between 1960 and 1962, eleven plots were burned under various summer drought conditions north of Espanola, Ontario. In the spring following each burn the plots were broadcast seeded to jack pine at a rate of one pound per acre. The burning-seeding treatments were, in most cases, highly successful. Stocking on all plots after one year averaged 75 per cent; it was moderate (47 to 58 per cent) on three plots, good (64 to 75 per cent) on three plots, and excellent (86 to 99 per cent) on five plots. The first-year stocking on plots seeded in 1962 and 1963 varied inversely with the average depth of residual humus, whereas that on plots seeded in 1961 did not show this variation. This was mostly because of variations in weather following seeding. So far, no major changes in stocking have occurred between the first, the second, and the third growing seasons (Chrosciewicz, 1961a, 1962a, 1963a and 1964a) (H–130).

(c) Planting

Prior to 1957, jack pine plantations were set out in various locations from Newfoundland to Saskatchewan. In the Prairies Provinces successful plantations have been established on sandy soils when weather conditions were favourable subsequent to planting. Jack pine has also been successfully planted in various locations in Ontario and Quebec, particularly on sands, on a fresh site at the Acadia Forest Experiment Station in New Brunswick, and in sheltered locations on the Avalon Peninsula in Newfoundland. Plantation failures have resulted because of drought and heat, competition from vegetation, browsing by rabbits, poor planting stock, grazing by livestock, and extreme exposure to wind. Recent experimental plantations have indicated the need for pre-planting site preparation and control of vegetative competition.

Jack pine plantations have been set out in many locations from Saskatchewan to Newfoundland with varied success. Surveys of plantations set out in the Prairie Provinces between 1913 and 1930 have indicated that jack pine may be successfully planted on sandy soils provided that weather conditions are favourable for a few years subsequent to planting. Some of the more successful plantations are on the Spruce Woods Forest Reserve in southwestern Manitoba (Figures 29–30), on the former Pines Reserve in central Saskatchewan, and on the former Dundurn and Elbow Forest Reserves, located within the Grassland Area in Saskatchewan (Johnson, 1953; Jameson, 1956a; Haig, 1957) (MS–100 *et al* and MS–113).

Results from recent plantations set out in Manitoba suggest that (1) survival on dry sites, particularly in dry seasons, may be increased by furrowing (Cayford, 1961b) (MS–190) (Figures 31–32); (2) satisfactory survival cannot be obtained on clay-loam tills unless pre-planting site preparation is undertaken and vegetative competition is controlled after planting (Cayford and Waldron, 1963) (MS–160); (3) jack pine may be successfully planted on recently cut-over dry and fresh sands (Walker, 1964b, 1965c) (MS–212B); and (4) initial survival on scalped strips in an aspen stand (Figure 33) was better on fresh to moderately fresh sites than on moist or very moist sites (Waldron, 1964a) (MS–226).

Successful plantations have been established in Ontario at the Petawawa Forest Experiment Station on sandy soils both in open areas and under an aspen stand (Stiell, 1955; Horton and McCormack, 1961) (P–235 and P–379), in Forest Section B.9 (Superior) on a dry loamy

Figure 29. Jack pine planted in 1916, thinned and pruned in 1947, photographed in 1952 at age 36 years. Volume per acre, 1,225 cubic feet.

Figure 30. Jack pine planted in 1918, not thinned, photographed in 1952 at age 34 years. Volume per acre 1,002 cubic feet.

sand soil, and in Forest Section L.11 (Quetico) on moist silt- and clay-loams and on somewhat moist fine sands (Stiell, 1958) (H–91).

In Quebec, successful plantations have been established on dry, sandy abandoned farm land near Grand'Mère (Cunningham, 1953) (Q–11) and initial success has been encouraging in old field plantations on clay soils (MacArthur, 1964) (Q–80).

Jack pine has been successfully planted on a fresh site at the Acadia Forest Experiment Station in New Brunswick and in sheltered locations on barren lands and in openings in forest stands on the Avalon Peninsula in Newfoundland (Lewis, 1954; McLeod, 1956; Nickerson, 1962) (M–262, NF–5).

A variety of factors have affected plantation success. In the Prairie Provinces plantations have failed entirely because of drought and heat, competition from minor vegetation, suppression by aspen and shrubs, browsing by rabbits, fires, and poor planting stock (Johnson, 1953; Jameson, 1956a; Haig, 1956, 1959a) (MS–100 *et al*, MS–103–104, MS–105, and MS–113). Plantations set out between 1924 and 1927 on well-drained to wet clays in Forest Section B.4 (Northern Clay) in Ontario have failed because of rabbit browsing and unfavourable soil conditions (Stiell, 1958) (H–91). In Newfoundland the most frequent causes of plantation failure have been grazing by goats and horses and extreme exposure to wind (Lewis, 1954; Nickerson, 1962) (NF–5).

Growth of jack pine plantations has been good in many instances. One of the best plantations on the Spruce Woods Forest Reserve, Manitoba, was established in 1924; in 1952 total volume was 2,739 cubic feet per acre, basal area 182 square feet, average diameter 3.8 inches and average height 30 feet (Jameson, 1956a). Plantations set out between 1930 and 1946 in the same area have had a mean annual height increment since planting of more than one foot (Haig, 1957). The best plantation on the former Pines Forest Reserve in central Saskatchewan was established in 1918; in 1948, survival was 90 per cent with 1,087 stems per acre, average diameter was 4.2 inches and average height 29 feet (Johnson, 1953). In Quebec, one 1922 plantation had a basal area of 143 square feet and a volume of 2,960 cubic feet after 35 growing seasons. Although growth was vigorous, trees were poorly formed. Jack pine was also successful when planted in mixture with Scots pine (*Pinus sylvestris* L.), but developed very poorly when planted in mixture with white spruce (Cunningham, 1953; MacArthur, 1958) (Q–11). Jack pine planted on the Petawawa Forest Experiment Station, Ontario, in 1924 has developed well; in 1951, average heights of trees planted in a pure stand and in a mixed stand with Scots pine were 48 and 35 feet respectively (Stiell, 1955) (P–235). On the Avalon Peninsula in Newfoundland, survival of 2–2 Ontario stock was superior to that of 2–0 Ontario stock, but relatively few stems were well formed and there is little justification for planting jack pine as compared with Scots pine (Nickerson, Wilton and Tusko, 1964) (NF–11).

Figure 31. Site preparation by furrowing with a Middlebuster fire-line plough on a dry site in Manitoba.

Stand Tending

Several studies in the Prairie Provinces and in Ontario have shown that diameter increment of individual trees is increased by thinning and, generally, the heavier the thinning the greater the response. Thinning has usually increased merchantable volume production; maximum response in terms of board foot production resulted from thinning to 5– or 6–foot spacings.

Results of a number of jack pine thinning studies in the Prairie Provinces and in Ontario have generally shown that diameter increment of individual trees has been increased, even when thinning was delayed to age 58 years. In general, the heavier the thinning the greater the response (Best, 1933; Wilson, 1952; Jameson, 1956c; Chrosciewicz, 1957; Cayford, 1961c, 1963b, 1964b) (P–20, H–82, MS–19, MS–134, MS–154 and MS–189). Very light and light thinning from below in a 30-year-old stand did not affect diameter growth (Wilson, 1951) (MS–18). In 30-, 40-, and 60-year-old stands, thinning to various spacings was more effective in stimulating diameter growth than strip thinning. Only trees growing within four feet of the thinned strips responded to thinning (Jameson, 1956c).

In general, thinning has failed to increase height growth (Wilson, 1951; Johnson, 1955b; Jameson, 1956b; Cayford, 1964b) (MS–18, MS–132, MS–134 and MS–154), except in one study where growth of 1- and 2-inch trees was increased (Wilson, 1952; Cayford, 1961c) (MS–19). In two studies heavy thinning has reduced height growth (Chrosciewicz, 1957; Cayford, 1963b) (H–82 and MS–189).

Figure 32. Jack pine planted in furrow on a dry, sandy site in Manitoba.

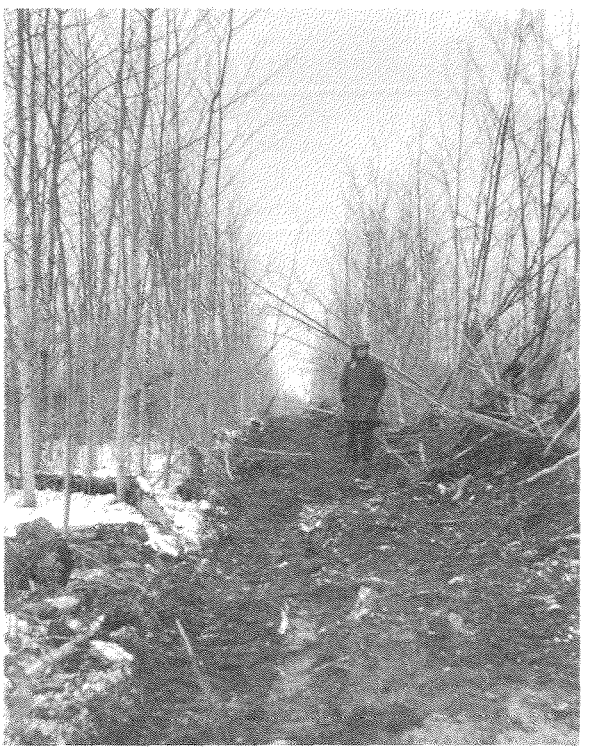

Figure 33. Site preparation by scalping in an aspen stand in central Manitoba.

Thinning has often resulted in increased merchantable volume production. Forty-year results of thinning in a 10-year-old stand indicated that thinning to a 6–foot spacing increased sawtimber volume by 1,200 board feet per acre or pole production by 80 poles per acre (Cayford 1964c) (MS–3). Thinning in an 18-year-old stand increased volumes by from 435 to 1,337 board feet per acre at 50 years, with the greatest increases resulting from thinning to 5- and 6-foot spacings (Cayford, 1961c) (MS–19). Low thinning in a 30-year-old stand increased merchantable volume production by approximately 2 cords per acre (Johnson, 1956) (MS–22).

Two thinning studies in which individual crop trees were selected and all competing trees removed were carried out in mixed stands of spruce and jack pine in western Manitoba. In both studies diameter increment of jack pine crop trees was increased, and there was an indication that height increment was increased in one of the studies (Waldron and Cayford, 1961; Steneker, 1962) (MS–7 and MS–9).

All studies, except one, are based on a single thinning and were often delayed until advanced ages and it is suggested that a series of light thinnings from below and begun early in the life of a stand would provide optimum growth conditions. However, because of economic considerations the most promising thinning techniques are either one single heavy thinning carried out at an early age or a thinning from below made as soon as the stand has reached merchantable size.

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PART III – INDEX OF ALL PROJECTS BY THE OXFORD SYSTEM OF DECIMAL CLASSIFICATION FOR FORESTRY

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PART III – INDEX OF ALL PROJECTS BY THE OXFORD SYSTEM OF DECIMAL CLASSIFICATION FOR FORESTRY

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232.13	Artificial regeneration, trials of hybrids and other products of tree breeding.	P-156I
232.213	Artificial regeneration, preparatory work, pretreatment and preparation of site, burning	H-65A, H-108, H-130, MS-245
232.216	Artificial regeneration, preparatory work, pretreatment and preparation of site, mechanical soil preparation	H-65A, H-81, H-124A, H-124B, H-124C, H-127A, MS-82, MS-90, MS-177, MS-190, MS-202, MS-212B, MS-226, P-379, Q-80, Q-81, Q-101, Q-106
232.31	Seed; production, storage, treatment, and testing	MS-207, MS-223B, MS-235, P-154
232.328	Plant rearing. Vegetative propagation.	P-156I
232.33	Artificial regeneration, direct seeding	H-65A, H-81, H-108, H-124A, H-124B, H-124C, H-127A, H-129, H-130, MS-82, MS-90, MS-177, MS-202, MS-212B, MS-226, MS-245, P-33, P-379, Q-81, Q-101
232.4	Artificial regeneration, planting	H-91, M-262, MS-100, MS-103, MS-104, MS-105, MS-106, MS-107, MS-108, MS-110, MS-111, MS-113, MS-160, MS-190, MS-212B, MS-226, MS-245, NF-5, NF-11, NF-50, P-235, P-379, Q-11, Q-70, Q-80, Q-106, Q-113
233	Artificial regeneration, afforestation	MS-100, MS-106, MS-111, NF-5, NF-11

PART III – INDEX OF ALL PROJECTS BY THE OXFORD SYSTEM OF DECIMAL CLASSIFICATION FOR FORESTRY

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541	Based on height, diameter, volume, etc.	H-116, MS-176, MS-198
542	By ecological methods	H-69, H-72, MS-173A, MS-198, MS-213, Q-35
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PART IV

PROJECT SUMMARIES

Project MS-3 Intermediate cuttings in young jack pine, Riding Mountain.

Classification 242

Investigators Past: G.H.D. Bedell
Present: J. H. Cayford.

Objectives To study the effect of density on the mortality and rate of growth of naturally reproduced jack pine.

Location Riding Mountain National Park, Manitoba.
Latitude 50°35'N, longitude 99°45'W.

Work Done In 1921 the project was initiated in a dense 10-year-old stand of jack pine of fire origin, averaging 28,000 stems per acre. Soils were sandy-loam to loam in texture, and moderately fresh to fresh in moisture. Five one-quarter-acre plots were established; four were thinned to spacings varying from 3.6 to 6.1 feet, and the fifth was retained for control. Trees left on thinned plots were spaced at uniform intervals on regularly spaced rows. Plots were remeasured in 1926 and 1961.

Results In 1961, at age 50 years, the control plot had the greatest numbers of stems, basal area, and total cubic-foot volume of jack pine. The heavily thinned plots had the least numbers of stems and basal area, while the intermediately thinned plots had the least total cubic-foot volume (Table 1).

Production of cordwood was greatest on the control plot, and was reduced slightly by both intermediate and heavy thinning. Heaviest thinning resulted in an increase in sawtimber volume of 1,200 board feet per acre, or an increase in pole production of 80 poles (Table 2).

Comments Thinning to a 6-foot spacing increased sawtimber and pole production, but did not increase cordage production. Thinning to a 4-foot spacing did not increase cordage, sawtimber or pole production. Heavy thinning has resulted in the production, by 50 years, of 310 trees per acre 6 inches d.b.h. and larger. Comparable figures for control and intermediately thinned areas were 230 and 236 trees, respectively. Considerable post-thinning mortality, which occurred subsequent to 1926, has adversely affected the yields obtained on thinned plots. A second thinning might have increased the rate of growth of the largest trees, and it is possible that the spruce understorey may have reduced the growth rate of jack pine.

Status Continuing.

Reports *Published*

Cayford, J.H. 1964. Results of a 1921 jack pine thinning in western Manitoba. Canada, Dept. Forestry, Publn. 1077. 8pp.

TABLE 1. STAND STATISTICS PER ACRE – 1961[1]

(Cayford 1964)

Treatment	Number of trees 1921 A.T.	Spacing (ft.) 1921 A.T.	Number of trees				Basal area (sq. ft.)				Total volume (cu. ft.)			
			jP	bS	wS	Total	jP	bS	wS	Total	jP	bS	wS	Total
Control.....	27,877	1.3	1,476	4	0	1,480	151	0	0	151	2,805	0	0	2,805
Intermediate thinning	2,708	4.0	1,045	876	41	1,962	127	15	1	143	2,381	136	13	2,530
Heavy thinning.....	1,185	6.1	812	213	16	1,041	122	3	0	125	2,439	9	4	2,452

[1]One-inch d.b.h. class and greater.

TABLE 2. JACK PINE YIELDS PER AGE TO 1961 BASED ON THREE UTILIZATION STANDARDS

(Cayford 1964)

Treatment	Cordwood	Cordwood and sawtimber		Cordwood and poles	
	cords[1]	cords	b.f.[2]	cords	No. of poles[3]
Control.....	30.6	18.5	2,530	18.5	230
Intermediate thinning.....	27.6	15.4	2,408	15.4	236
Heavy thinning.....	28.4	11.5	3,723	11.5	309

[1]Stump height, 1.0 foot, top diameter outside bark, 3 inches.

[2]Stump height, 1.0 foot, top diameter inside bark, 5 inches.

[3]Class 5, 6, and 8 poles.

Project MS-7 Black spruce release cutting, Duck Mountain.

Classification 242

Investigators Past: R.T. Pike, R.M. Waldron, J.H. Cayford.

Objectives To study the results of a crown thinning in a very dense coniferous stand of mixed black spruce and jack pine.

Location Duck Mountain Forest Reserve, Manitoba. Latitude 51°35'N, longitude 100°40'W.

Work Done The project was established in 1936 in a 46-year-old stand of mixed black spruce and jack pine growing on a gravelly till soil of sandy clay-loam texture. Soil moisture regime was rated as fresh to moderately moist.

A one-fifth-acre plot was laid out in a 1.1-acre area selected for treatment. A similar-sized control plot was also established.

Thinning, which was carried out in 1936, was designed to favour the most promising of the largest jack pine in order to obtain earlier production of poles and ties. All competing trees were removed from around the selected jack pine (crown thinning), and the remaining portion of the stand was subjected to a heavy low thinning. Thinning removed 90 per cent of the jack pine trees and 65 per cent of the black spruce.

Plots were remeasured in 1946 and 1957, 10 and 21 years after thinning.

Results (1) In 1957 there were more jack pine stems and greater total and merchantable volumes on the control plot than on the thinned plot (Table 1).
(2) Net periodic annual increment per acre of jack pine for the period 1936-57 was 0.24 cords on the thinned plot and 0.35 cords on the control plot.
(3) Diameter increment of jack pine was greatly increased by thinning (Figure 1).

TABLE 1. JACK PINE STAND STATISTICS PER ACRE, THINNED AND CONTROL PLOTS

(Waldron and Cayford 1961)

Treatment	Number of stems			Total volume (cu.ft.)	Merch. volume (cords)	Merch. volume (b.f.)	No. of poles
	1936 B.T.	1936 A.T.	1957	1957			
Control	1,165	1,165	755	1,540	10.3	1,755	135
Thinned	1,615	175	160	697	6.6	1,735	120

Comments Thinning was not successful in increasing the production of jack pine poles and ties as was intended. Evidently, the jack pine component of the stand was reduced below the level at which increased production of poles and ties could occur.

Status Closed.

Reports *Unpublished*

Pike, R.T. 1947. Thinning in coniferous stands of mixed black spruce and jack pine. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS.

Waldron, R.M. 1958. Thinning in coniferous stands of black spruce and jack pine. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

MS-7

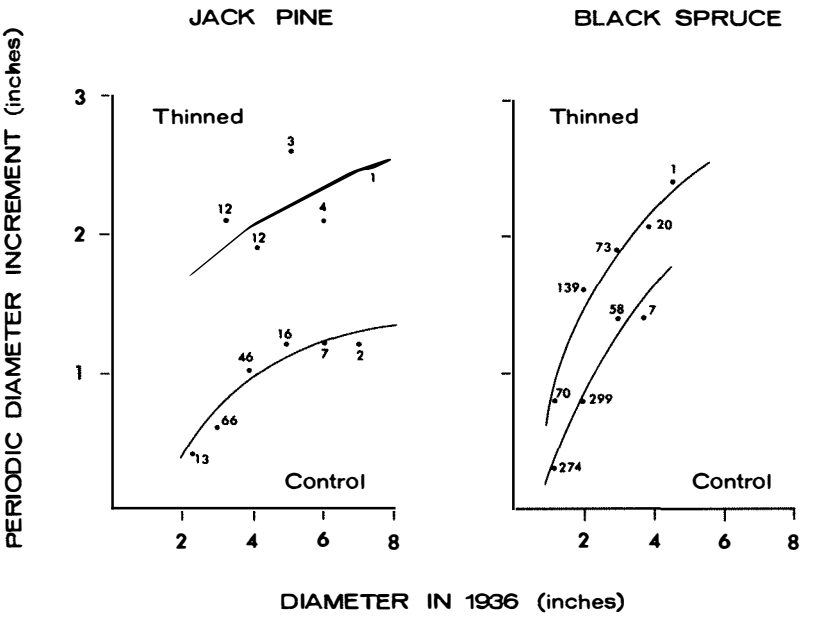

Figure 1. Effect of thinning on periodic diameter increment, 1936-57, jack pine and black spruce. (Waldron and Cayford 1961).

Reports

Published

Waldron, R.M. and J.H. Cayford. 1961. Results of a 1936 thinning in a two-storeyed stand of jack pine and black spruce in western Manitoba. Canada, Dept. Forestry, Forest Research Branch, Mimeo. 61-13. 10 pp.

Project MS-9 Thinning in stands of mixed black spruce, white spruce, and jack pine, Duck Mountain.

Classification 242

Investigators Past: R.T. Pike, R.M. Waldron, G.A. Steneker.

Objectives To determine the effect of partial release on the growth and development of a fixed number of selected crop trees per acre.

Location Duck Mountain Forest Reserve, Manitoba. Latitude 51°35'N, longitude 100°40'W.

Work Done In 1937 seven permanent sample plots, varying in size from 0.1 to 0.25 acres, were established in a 40-year-old mixed coniferous stand of black spruce, jack pine, and white spruce. On all sample plots 500 crop trees per acre were selected and marked. On three plots all surrounding trees, within a 4-foot radius (measured from stem to stem) of the crop trees, were cut. One plot was thinned to 1,500 trees per acre. On the other three plots no thinning was carried out; these plots were retained as controls. Sample plots were remeasured in 1946 and 1957. The plots were located on a clay-loam till soil; sites varied from dry to moderately moist.

Results Results refer to crop trees only, as they are the only ones for which complete data are available.

There were approximately 80 jack pine crop trees per acre on the four plots located on dry and moderately fresh sites. There were no jack pine crop trees on the moderately moist site.

Diameter increment of jack pine was increased by treatment (Figure 1). Maximum response resulted from heavy thinning on the moderately fresh site.

There was an indication that height increment of jack pine was increased by treatment, but evidence was not conclusive (Figure 1).

Comments The technique of clearing a specific area around selected trees may not always be of maximum silvicultural benefit. Large trees immediately outside of the cleared areas may offer more competition than small trees within the cleared area (Steneker, 1962).

Status Closed.

Reports

Unpublished

Pike, R.T. 1948. Thinning in stands of mixed black spruce, white spruce and jack pine, Duck Mountain Forest Reserve. Canada, Dept. Mines and Resources, Mines, Forests and Scientific Services Branch, Dom. For. Serv., Unpubl. MS

Waldron, R.M. 1958. Thinning in stands of mixed black spruce, white spruce and jack pine, Duck Mountain Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Steneker, G.A. 1962. Thinning in stands of mixed black spruce, white spruce and jack pine, Duck Mountain Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Man.-Sask. 62-9.

MS-9

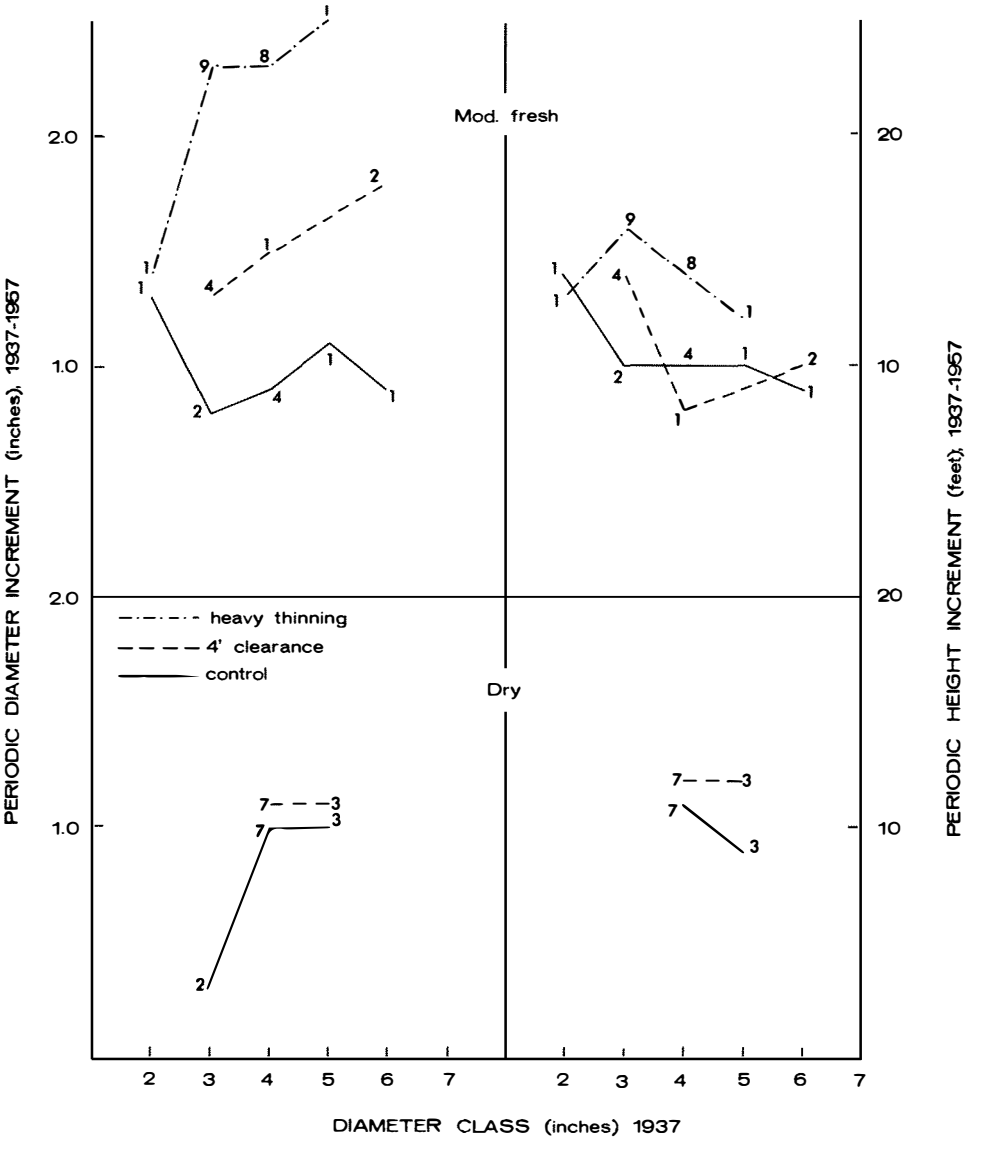

Figure 1. Periodic height and diameter increment of jack pine by diameter classes 1937-1957. (Steneker 1962).

Project MS-18 Thinning jack pine, Nisbet Forest Reserve, Saskatchewan.

Classification 242

Investigators Past: G.M. Wilson

Objectives To study the effects of thinning on diameter growth, height growth, and volume growth in a 30-year-old stand of jack pine.

Location Nisbet Forest Reserve, Prince Albert Block, Saskatchewan. Latitude 53°15'N, longitude 105°45'W.

Work Done Four permanent plots, each approximately one-quarter acre, were established in 1924 in a 30-year-old stand averaging 2,500 stems per acre. The soil is a fine sand; the site index for dominant trees at age 50 is 43 feet. Plots were treated as follows: Control (Plot 1).

Dying trees removed -- Grade A low thinning (Plot 2).

Dying and suppressed trees removed -- Grade B low thinning (Plot 3).

Dying, suppressed, and a few dominant trees removed (Plot 3A).

Plots were remeasured in 1929, 1936, 1945, 1948, and 1959. A comprehensive report was prepared in 1950, outlining results for the 24-year period, 1924-1948.

Results (1) The treatment which removed a few of the dominant trees was the only one which resulted in any stimulation of diameter growth, and even this treatment had no effect on the growth of the largest diameter class (Table 1).
(2) Height growth following thinning varied from plot to plot, but was not related to treatment, and can probably be attributed to differences in site (Table 1).
(3) Total volume in 1948 was greatest on the control plot, and least on the most heavily thinned plot.

TABLE 1. MEAN PERIODIC DIAMETER AND HEIGHT INCREMENT – HARMONIZED

(Wilson 1951)

D.b.h. 1924 (in.)	Diameter increment (in.)				Height increment (ft.)			
	Plot 1	Plot 2	Plot 3	Plot 3A	Plot 1	Plot 2	Plot 3	Plot 3A
2.0	0.5	0.5	0.7	1.0	8	7	5	10
3.0	1.2	1.2	1.2	1.5	12	13	12	13
4.0	1.6	1.5	1.6	1.9	17	15	13	16
5.0	1.8	1.7	1.9	1.8	18	16	12	17
6.0	2.1		2.1		19		12	

Comments None of the treatments given this stand resulted in any worthwhile improvement in the stand. The thinnings on Plots 2 and 3 were too light to have any appreciable effect on growth while on Plot 3A a number of dominant trees capable of making the best growth were removed. A moderately heavy thinning removing intermediate and co-dominant trees to favour the dominants would probably have been preferable (Wilson, 1951).

Status Closed.

MS-18

Reports

Unpublished

Wilson, G.M. 1950. Thinning 30-year-old jack pine, Nisbet Forest Reserve, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Wilson, G.M. 1951. Thinning 30-year-old jack pine. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 52. 3 pp.

Project MS-19 Thinning jack pine, Nisbet Forest Reserve, Saskatchewan.

Classification 242

Investigators Past: G.M. Wilson
Present: J. H. Cayford

Objectives To study the effects of different intensities of thinning in an 18-year-old stand of jack pine.

Location Nisbet Forest Reserve, Holbein Block, Saskatchewan. Latitude 53°15'N, longitude 106°15'W.

Work Done In 1927 seven plots were established, of which four were one acre in area and the other three one-half acre in area. Four were located where stand density ranged from 3,300 to 4,400 trees per acre, while the other three were located where stand density ranged from 2,000 to 2,600 trees per acre. Two plots were retained for control and the other five plots were thinned to average spacings of between 5.2 and 7.7 feet. The plots were remeasured in 1948 and 1959. The soil on the experimental area is a weakly developed podzol of fine to medium sand. The area varies from dry to moderately fresh in moisture regime.

Results (1) In 1959 within each group of plots the controls had a greater number of stems, basal area, and total cubic-foot volume than the thinned plots. The heavier the thinning the greater were these differences. Merchantable volumes in both cords and board feet were generally greater on thinned than on control plots (Table 1).
(2) Mortality was appreciably reduced by thinning both for the 1927-48, and 1927-59 periods.
(3) Thinning increased diameter increment in all diameter classes. Increase was reflected by a larger number of trees per acre in the 6-inch and up diameter class on the thinned plots (Table 2).
(4) Height increment of trees one and two inches in diameter in 1924 was increased by thinning.

Comments In this experiment a single non-commercial thinning in dense young jack pine increased merchantable yield; board-foot increments on thinned plots were two to three times those on control plots. It is believed that earlier thinning, at least in the denser part of the stand, would have resulted in even greater productivity, as in 1959 its merchantable volumes, regardless of intensity of thinning, were considerably less than those in the less dense part of the stand.

Status Continuing.

Reports *Published*

Wilson, G.M. 1952. Thinning jack pine, Nisbet Forest Reserve, Saskatchewan. Canada, Dept, Resources and Development, Forestry Branch , For. Res. Div., Silv. Res. Note 99. 24 pp.

Cayford, J.H. 1961. Results of a 1927 jack pine thinning in Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Tech. Note 107. 13 pp.

TABLE 1. STAND STATISTICS PER ACRE 1927 AND 1959

(Cayford 1961)

Plot No.	Specified spacing (ft.)	Actual spacing (ft.)	No. of trees			Basal area (sq. ft.)		Total vol. (cu.ft.)		Merch. vol. (cords)[1]		Merch. vol. (b.f.)[2]	
			1927 B.T.[3]	1927 A.T.[4]	1959	1927 A.T.	1959	1927 A.T.	1959	1927 A.T.	1959	1927 A.T.	1959
Denser part of stand													
6	Control	3.1	4,408	4,408	2,027	50	128	462	2,517	0	19.4	0	443
4	4x4	5.2	3,352	1,634	1,294	22	119	210	2,466	0	23.6	0	878
5	5x5	5.9	4,115	1,236	1,124	16	116	149	2,399	0	24.2	0	1,129
7	6x6	6.6	4,406	1,001	897	14	104	128	2,067	0	22.9	0	1,360
Less dense part													
9	Control	4.1	2,562	2,562	1,390	44	128	448	2,783	0.1	24.7	0	1,750
8	5x5	6.3	2,436	1,082	952	24	120	243	2,529	0.1	25.9	0	3,087
10	6x6	7.7	2,022	732	698	15	106	142	2,194	0	24.7	0	2,922

[1]Stump height, 1 foot; top diameter outside bark, 3 inches.

[2]Stump height, 1 foot; top diameter inside bark, 5 inches. International ¼ Log Rule.

[3]Before thinning.

[4]After thinning.

TABLE 2. EFFECT OF TREATMENT ON NUMBER OF TREES PER ACRE, 6 INCHES AND GREATER, IN 1959

(Cayford 1961)

	Control	Average for thinned plots	Widest spacing
Denser portion of stand	51	126	151
Less dense portion of stand	150	238	250

Project MS-22 Thinning jack pine, Sandilands Forest Reserve, Manitoba.

Classification 242

Investigators Past: G.M. Wilson, H.J. Johnson.

Objectives To study the effects of low thinning on the diameter and volume growth of young jack pine stands.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitude 49°25'N, longitude 96°20'W.

Work Done In 1927, three one-acre plots were established in a densely stocked 30-year-old jack pine stand that averaged 2,500 stems per acre. One plot was left undisturbed to serve as a control while the other two were given Grade B and Grade C low thinnings. In the Grade B thinning, all dead and dying trees plus all suppressed and the poorest intermediate trees were removed; and in the Grade C thinning all dead, dying, suppressed, and intermediate trees were removed. The plots were remeasured in 1949.

Results (1) In 1949 both total and merchantable volume were slightly greater on the thinned plots than on the control. Differences in merchantable volume were 18 and 14 per cent for the C-thinned and B-thinned plots, respectively (Table 1).
(2) In 1949 the number of living trees on all three plots was similar; however, the thinned plots had somewhat more trees in the 4-inch class and above (Table 1).
(3) Diameter increment of 2- to 4-inch trees was increased slightly by thinning.

TABLE 1. STAND STATISTICS PER ACRE IN 1949

(Johnson 1956)

Plot	Treatment	No. of trees	No. of trees 4 inches d.b.h. and greater	Total volume (cu. ft.)	Volume of merch. trees[1] (cu. ft.)
3	Control	618	425	999	898
1	B-thinning	654	487	1,115	1,024
2	C-thinning	572	471	1,118	1,061

[1] Trees 4 inches and greater.

Comments It is doubtful if the increases in volume have been sufficient to justify thinning. The thinnings were much too light, and mortality has been high on all plots during the interval between treatment and remeasurement.

Status Closed.

Reports *Unpublished*

Johnson, H.J. 1956. Thinning jack pine, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Project MS-90 Reforestation by seeding, Duck Mountain Forest Reserve.

Classification 232.216
232.33

Investigators Past: P.B. Townsend, R.A. Haig.

Objectives To determine optimum amounts of jack pine (and white spruce) seed to sow on a mineral soil seedbed in order to establish well-stocked stands of these species.

Location Duck Mountain Forest Reserve, Manitoba. Latitude 51°20'N, longitude 100°40'W.

Work Done In May 1920 six adjacent one-quarter-acre plots were established on a site which before treatment supported a scattered stand of small aspen, willow, and birch. The soil is a sandy clay-loam; the moisture regime was rated as dry to moderately fresh.

Before seeding, brush and trees were removed and the plots disked six times to break up the sod and provide a mineral soil seedbed. Jack pine seed was broadcast by hand at rates of 2, 3, and 4 pounds per acre on three plots. The area was then harrowed twice to cover the seed. Regeneration has been tallied seven times since establishment, with the last remeasurement in 1957.

Results (1) Initial jack pine stocking was very heavy, but by 1957 plots sown to jack pine were seriously understocked (Table 1).
(2) Jack pine did not germinate in 1920, when May to September rainfall was 2 inches below normal, but germinated in 1921 when May to September rainfall was 2 inches above normal. Below normal precipitation was recorded in 1922 and 1923 and there was a sharp decline in jack pine density. It appears as if the 1933 peak in local rabbit population was responsible for the nearly complete disappearance of the jack pine.
(3) Surviving jack pine averaged 3.1 inches in diameter and 21.0 feet in height in 1957. The trees did not appear to be healthy; their foliage was thin and pale, and their trunks bore basal scars which were probably the result of previous rabbit damage.

TABLE 1. SURVIVAL OF JACK PINE SOWN IN 1920, DUCK MOUNTAIN FOREST RESERVE

(Haig 1959)

Plot	Seed sown (lb./acre)	Seedlings per acre						
		1921	1923	1924	1925	1929	1946	1957
1	2	43,560	4,840	970	6,290	3,190	30	20
2	3	12,000	4,840	970	2,050	4,070	0	0
3	4	20,000	4,840	14,520	11,130	5,390	0	0
All plots – average		25,187	4,840	5,487	6,490	4,217	10	7

Comments Under favourable conditions, dense stands of jack pine were established by broadcast seeding. Initial density did not appear to be correlated with the amount of seed sown. However, jack pine was virtually eliminated between 1929 and 1946; rabbit damage was believed to be the chief cause of the decline in jack pine.

Status Closed.

MS-90

Reports

Unpublished

Townsend, P.B. 1948. Artificial seeding and planting. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS.

Published

Haig, R.A. 1959. Result of an experimental seeding in 1920 of white spruce and jack pine in western Manitoba. For. Chron. 35: 7-12.

Projects *MS-100* Reforestation by planting, Keppel Forest Reserve.
MS-106 " " " , Elbow Forest Reserve.
MS-107 " " " , Nisbet Forest Reserve.
MS-108 " " " , Pines Forest Reserve.
MS-110 " " " , Big River Forest Reserve.
MS-111 " " " , Dundurn Forest Reserve.

Classification 232.4
233 (MS-100, MS-106, MS-111 only).

Investigators Past: H.J. Johnson, C.K. Smith.

Objectives To determine the feasibility of afforestation and reforestation with jack pine (and other coniferous species) in several Saskatchewan forest reserves.

Locations Keppel Forest Reserve, latitude 52°25'N, longitude 107°55'W. Elbow Forest Reserve, latitude 51°05'N, longitude 106°30'W. Nisbet Forest Reserve, latitude 53°15'N, longitude 106°55'W. Pines Forest Reserve, latitudes 52°45' to 53°05'N, longitudes 106°00' to 106°10'W. Big River Forest Reserve, latitude 53°50'N, longitude 107°05'W. Dundurn Forest Reserve, latitude 51°55'N, longitude 106°40'W.

The Pines, Nisbet and Big River Forest Reserves are located in the B.18 Section of the Boreal Forest Region, while the Keppel, Elbow, and Dundurn Forest Reserves are located in the Grassland Region. All are located within the province of Saskatchewan.

Work Done Experimental plantings were carried out by the Federal Forestry Branch on the various reserves from 1916 to 1930, while from 1934 to 1946 plantations were established on the Keppel Forest Reserve by the Saskatchewan Forest Service. Three planting methods were used: hole, T-notch, and T-notch in furrow. In 1948 a survey was made of all the plantations. One-half-acre plots were established in each and the diameter of all living trees and the heights of 50 dominants on each plot were recorded. Planting sites on the Pines, Nisbet and Dundurn Reserves were dry sands characterized by ericaceous shrubs or grass. Planting sites on the Keppel, Elbow and Big River Reserves were mainly loams and characterized by more luxurious lesser vegetation.

Results Survival and growth of the jack pine plantations to 1948 are shown in Table 1. Of a total of 32 jack pine plantations set out, only 10 of them had more than 150 surviving trees in 1948. Nine of these plantations were on sands; six on the Pines and three on the Dundurn Forest Reserve. Only one of 12 plantations set out on loamy soils had 150 surviving trees in 1948.

Comments Drought, heat and poor planting practices are reported to have been the major factors causing mortality. Rabbit browsing was severe in plantations adjacent to or under aspen stands. A profuse growth of minor vegetation of the loam sites was responsible for some mortality. Ground fires destroyed the plantations in the Nisbet Forest Reserve.

Results from the studies indicate that jack pine can be successfully planted on dry sands providing adequate fire and rabbit control can be maintained.

Status Closed.

TABLE 1. SURVIVAL AND GROWTH OF JACK PINE TO 1948

(Johnson 1953)

Number of plantations	Age of stock	Number planted per acre	Years since planting	Number per acre in 1948	Survival %	50 tallest trees	
						Avg. ht. (ft.)	Avg. diam. (in.)
Keppel Forest Reserve							
6	2-2, 3-2, 2-3	1,210	6-9	0	–	–	–
Elbow Forest Reserve							
2	2-0	1,350–2,700	32	86-143	5	12	2.8
2	2-2	2,700	24	32	1	4	–
Nisbet Forest Reserve							
4	4-0, 1-3	2,700	26-28	Destroyed by fire			
Pines Forest Reserve							
1	2-0	2,700	32	684	25	28	4.4
4	2-0	1,210	30	700	58	31	4.6
2	2-1, 2-2	2,700	22	342	13	14	2.8
Big River Forest Reserve							
1	2-1	2,800	22	274	9	20	5.2
1	2-2	900	19	16	2	25	6.3
Dundurn Forest Reserve							
1	2-0	2,700	32	72	3	17	4.4
1	2-0	2,700	31	100	4	21	4.0
1	-	2,700	26	569	21	19	3.8
3	2-2, 2-0	2,700	24	87	3	15	3.0
1	2-1	2,700	22	426	19	18	2.9
2	2-2, 2-1	2,200	19	66	3	10	1.7

Reports

Unpublished

Johnson, H.J. 1951. Afforestation and reforestation by coniferous seedlings, Elbow Forest Reserve, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Johnson, H.J. 1951. Afforestation and reforestation by coniferous seedlings, Keppel Forest Reserve, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Johnson, H.J. 1951. Afforestation and reforestation by coniferous seedlings, Pines and Nisbet Forest Reserves, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Johnson, H.J. 1951. Afforestation by coniferous seedlings, Dundurn Forest Reserve, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Smith, C.K. 1951. Afforestation and reforestation by coniferous seedlings, Beaver Hills and Big River Forest Reserves, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Johnson, H.J. 1953. Reforestation of forest reserves of Saskatchewan, 1916 to 1946. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., S. & M. 53–5. 22 pp.

Projects MS-103 Reforestation by planting, Duck Mountain Forest Reserve.
MS-104 Reforestation by planting, Riding Mountain.

Classification 232.4

Investigators Past: R.A. Haig, P.B. Townsend, C.B. Gill

Objectives To determine on what sites and under what conditions plantations of jack pine (and other coniferous species) could be established successfully.

Locations Duck Mountain Forest Reserve, Manitoba. Latitude 51°15'N, longitude 101°00'W; and latitude 52°00'N, longitude 101°00'W. Riding Mountain National Park, Manitoba. Latitude 50°45'N, longitude 101°15'W; and latitude 51°00'N, longitude 100°00'W.

Work Done Between 1919 and 1930 a total of 19 jack pine plantations were set out, 12 in the Riding Mountain National Park and 7 in the Duck Mountain Forest Reserve. Planting was by hand, usually without site preparation.

In 1957 all surviving plantations were examined and living trees were tallied by 1-inch diameter classes. Sufficient height measurements were made to prepare a height/diameter curve for each plantation.

Results Results of jack pine planting are shown in Tables 1 and 2. Only in three of the jack pine plantations were there any survivors, and only in one of these were there more than 350 trees surviving in 1957. The one successful jack pine plantation had a mean annual height increment of 1.0 feet.

TABLE 1. JACK PINE PLANTATION ESTABLISHMENT AND SURVIVAL

(Haig 1959)

Location	Number plantations established	Surviving plantations 1957		Successful[1] plantations 1957	
		No.	%	No.	%
Riding Mountain	12	1	8	0	0
Duck Mountain	7	2	29	1	14

[1]Successful plantations were arbitrarily determined as those with 350 trees per acre.

TABLE 2. GROWTH OF JACK PINE PLANTATIONS

(Haig 1959)

Plantation number	Years since planting	Trees/acre	Average d.b.h. (in.)	Average height (ft.)	Mean annual height increment (ft.)
33-22	36	215	5.6	25.1	0.70
8-20	38	4	9.0	38.0	1.00
16-22	36	1,076	5.0	36.0	1.00

Comments Planting of jack pine was generally unsuccessful. Its failure was due in large part to rabbit damage. In addition, drought during the first growing season and suppression by either an aspen or brush overstorey contributed to the high mortality rate.

MS-103,104

Status Closed.

Reports

Unpublished

Gill, C.B. 1930. Summary of results obtained to date on Duck-Porcupine experimental plantations. Canada, Dept. Interior, Forest Service, Unpubl. MS.

Townsend, P.B. 1948. Artificial seeding and planting. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS.

Haig, R.A. 1958. Reforestation by planting, Duck Mountain Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Haig, R.A. 1958. Reforestation by planting, Riding Mountain National Park. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Haig, R.A. 1959. Reforestation by planting, 1918-1930, Riding and Duck Mountains, Manitoba and Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Mimeo. 59-3. 12 pp.

Project MS-105 Reforestation by planting, Porcupine Forest Reserve, Saskatchewan.

Classification 232.4

Investigators Past: R.A. Haig, G.M. Wilson.

Objectives To determine the most suitable species and planting methods for reforesting burned-over areas in the Porcupine Forest Reserve.

Location Porcupine Forest Reserve, about 20 miles north of Pelly, Saskatchewan. Latitude 52°05'N, longitude 101°45'W.

Work Done In 1945 and 1946 a total of 145,050 jack pine were planted near the Maloneck fire tower on the Porcupine Forest Reserve. Planting was by the T-notch method using 2-2 stock; the spacing was about 6 by 6 feet. Following planting, permanent sample plots (½-acre) were established in the plantations. The plots were re-examined in in 1948.

Results Results for jack pine plantations are summarized in Table 1.

TABLE 1. SURVIVAL AND GROWTH OF JACK PINE PLANTATIONS

(Haig 1956)

Year of planting	Number planted per acre	Survival 1948		Average height tallest trees (ft.)
		No. per acre	%	
1945	1,141	210	18.3	1.4
1946	1,043	411	39.4	1.7

Comments The poor survival of jack pine, which averaged about 30 percent, was attributed to unfavourable soil conditions. The species was planted only on heavy soil where there was a dense cover of hazel and small aspen, and most survivors were located in small grassy openings. It is thought that jack pine would have been suitable for planting on the sandy loam soils that occured in the vicinity of the plantations (Haig, 1956).

Status Closed.

Reports

Unpublished

Haig, R.A. 1956. Reforestation by planting, Porcupine Forest Reserve, Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Project MS-113 Reforestation by planting, Spruce Woods Forest Reserve.

Classification 232.4

Investigators Past: R.A. Haig, J.S. Jameson, C.L. Kirby, G. Tunstell.
Present: I.E. Bella

Objectives To study survival, rate of growth, and causes of mortality of jack pine (and other coniferous species) set out under various planting conditions.

Location Spruce Woods Forest Reserve, Manitoba. Latitudes 49°45' to 49°55'N, longitudes 99°05' to 99°40'W.

Work Done Between 1904 and 1929 a total of 18 pure jack pine plantations and 4 plantations of jack pine mixed with other species were set out on sandy soils of the Black-earth type. Most stock came from nurseries located at Indian Head, Saskatchewan and Shilo, Manitoba. Planting was done in the spring mainly by spade in east-west furrows. In a few plantations, seedlings were set out without ground preparation in young aspen, in grassland, and in ground-cedar (*Juniperus horizontalis* Moench) patches. In 1952 the surviving plantations were surveyed. On plantations of one acre or less a 100 per cent tally was made; for larger plantations randomly selected rows were tallied. In addition a number of permanent sample plots were established in the plantations. Six of these plots were remeasured in 1964.

Between 1930 and 1946, about 2½ million jack pines were planted on the Reserve. These trees were all hand planted in ploughed furrows, using 2-1 and 2-2 stock. A survey of these plantations was made in 1956.

Results Of the 22 plantations set out between 1904 and 1929, 10 had no survivors by 1952. A summary of the survival and growth of the other 12 plantations is shown in Table 1. Development of two plantations to 1964 is shown in Table 2. It is evident that good growth and full stocking of jack pine can be achieved in this area.

TABLE 1. RESULTS OF 1952 SURVEY OF JACK PINE PLANTATIONS ESTABLISHED IN THE SPRUCE WOODS FOREST RESERVE, 1904-1929

(Jameson 1956)

Plantation number[1]	Age of stock	Plantation area (acres)	Number trees planted per acre	Survival, 1952		Average height 1952 (ft.)
				%	No./acre	
5-13	3-0	0.10	4,800	40	1,930	24
7-16	3-3	3.75	2,700	61	1,658	31
10-16	3-3	1.53	1,325[2]	35	468	30
11-16	4-0	1.80	2,700	14	390	29
20-18	3-0	10.00	2,700	13	360	33
22-18	2-0	4.00	2,700	5	142	21
47-22	–	0.25	2,600	28	736	27
56-24	–	0.67	3,100	74	2,288	30
57-24	–	0.67	3,100	57	1,776	32
58-24	–	0.33	3,100	48	1,473	33
63-24	–	0.10	4,000	79	3,150	24
85-25	2-0 2-2	4.00	3,000	28	833	22

[1]The second figure indicates year of planting.

[2]Jack pine and caragana planted in alternate rows. No caragana survivors.

TABLE 2. STAND STATISTICS PER ACRE 1952 AND 1964 FOR JACK PINE PLANTATIONS 20-18 AND 7-16

(Bella 1964)

Plantation number		20-18	7-16
Year of planting		1918	1916
No. of trees –	1952	760.0	1720.0
	1964	695.0	1207.5
Mortality	1952-64	65.0	512.5
Basal area (sq. ft.)	1952	111.5	151.0
	1964	144.2	162.5
Increment	1952-64	32.7	11.5
Avg. diam. (in.)	1952	5.2	4.0
	1964	6.2	5.0
Avg. ht. (ft.)	1952	32.0	31.0
	1964	47.5	43.2
Total vol. (cu.ft.)	1952	1699.9	2324.8
	1964	3298.2	3395.9
Merch. vol. (cu.ft.)	1952	–	–
	1964	2454.6	1894.3
Merch. vol. (b.f.)	1952	–	–
	1964	3790	155

TABLE 3. RESULTS OF 1956 SURVEY OF JACK PINE PLANTATIONS ESTABLISHED IN THE SPRUCE WOODS FOREST RESERVE 1930-1946

(Haig 1957)

Year of planting	Plantation area (acres)	Number of plantations	Number trees planted per acre	Survival 1956		Average d.b.h. (in.)	Average height (ft.)
				%	No./acre		
1930	54.4	4	–	–	709	4.8	28.5
1938	139.6	10	–	–	1,570	3.1	23.7
1942	77.2	3	–	–	1,889	2.8	20.3
1943	105.7	12	2,732	–	1,834	2.4	17.7
1944	44.1	4	2,573	88.8	2,286	2.1	16.0
1946	20.1	3	1,816	22.8	415	2.0	12.9

Major causes of mortality were heat and drought. Rabbits, gophers, and competition from grass caused additional losses. Underplanting in poplar was a failure because of excessive rabbit browsing. Tree form was fair with plantations suitable for pulpwood and sawtimber production, but not for poles.

Results of the 1930-1946 planting are presented in Table 3. Average survival of jack pine was 61.8 per cent, with a range of 22.8 to 88.8 per cent. The plantations exhibited rapid growth and were well-formed. Plantation damage was localized.

Status Continuing.

Reports

Unpublished

Tunstell, G. 1927. Interim report on experimental planting done on the Spruce Woods Forest Reserve during the period 1904-1926. Canada, Dept. Interior, Forest Service, Unpubl. MS.

Kirby, C.L. 1953. Planting of conifers in the Spruce Woods Forest Reserve, Manitoba. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Jameson, J.S. 1954. Planting of conifers in the Spruce Woods Forest Reserve, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Haig, R.A. 1957. Spruce Woods plantations, 1930-1946. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Bella, I.E. 1964. Development of some jack and Scots pine plantations in the Spruce Woods Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-29.

Published

Jameson, J.S. 1956. Planting conifers in the Spruce Woods Forest Reserve, Manitoba, 1904-1929. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 28. 29 pp.

Project MS-114 Natural area – jack pine, Riding Mountain National Park.

Classification 228.81

Investigators Past: A.L. Best, J.H. Cayford.
Present: H.P. Sims

Objectives To study natural development within a jack pine stand.

Location Riding Mountain National Park, Manitoba. Latitude 50°40'N, longitude 99°40'W.

Work Done In 1939 a jack pine natural area of 57 acres was established. At that time its boundaries were marked and the stand was cruised. In 1961 the area was re-marked, and forest sub-types, cut-over areas and topography mapped.

In 1963 the area was again cruised. In addition, fifteen one-fifth-acre permanent sample plots were established and measured. A 10-milacre regeneration transect was located in each plot. Sufficient heights and diameters of jack pine and black and white spruce were taken to derive height/diameter curves for each species.

Results Three major types have been distinguished on the area. These include jack pine, jack pine-white spruce, and jack pine-spruce. Jack pine constitutes the bulk of the timber volume in each type. Volumes by species for each type are presented in Table 1.

Per cent stocking with advance growth in 1964 is shown in Table 2. Jack pine is not present in any of the types, and it is evident that it will be succeeded by other species.

The number of trees per acre, 6 inches d.b.h. and up, of all species decreased by 43 per cent between 1939 and 1963. During this period jack pine decreased by 47 per cent; hardwoods by 6 per cent, while white spruce increased by 7 per cent and black spruce by 3 per cent.

TABLE 1. TOTAL VOLUME PER ACRE BY TYPE

(Bruce 1965)

Type	Jack pine	White spruce	Black spruce	Other	Total
	(Total volume per acre – cu. ft.)				
Jack pine	4,612.6	46.9	17.4	35.5	4,712.4
Jack pine-white spruce	2,111.4	906.8	16.9	176.4	3,211.5
Jack pine-spruce	2,089.6	824.2	234.8	126.4	3,275.0

TABLE 2. STOCKING WITH ADVANCE GROWTH IN 1964 BY TYPE[1]

(Bruce 1965).

Type	Species						
	jP	tA	bF	wS	bS	bPo	All
Jack pine	0	2	14	8	2	24	46
Jack pine-white spruce	0	4	2	0	0	0	6
Jack pine-spruce	0	4	2	2	0	4	10

[1]Based on 50 one-milacre quadrats per type.

MS-114

Status Continuing.

Reports

Unpublished

Sims, H.P. 1962. Natural area – jack pine, Riding Mountain National Park. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Man.-Sask. 62-8.

Sims, H.P. 1963. Natural area – jack pine, Riding Mountain National Park. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-28.

Bruce, N.G. 1965. Natural area-jack pine, Riding Mountain National Park. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-15.

Project MS-132 Thinning jack pine, Duck Mountain Forest Reserve, Manitoba, 1948.

Classification 242

Investigators Past: G.W. Robb, J.J. English, R.T. Pike, H.J. Johnson.
Present: J.H. Cayford

Objectives To study the effect of thinning on diameter and height growth in an 11-year-old stand.

Location Duck Mountain Forest Reserve, Manitoba. Latitude 51°35'N, longitude 100°50'W.

Work Done In 1948, five one-fifth-acre plots were established in a stand that had developed following a fire in 1937, and varied in density from 15,000 to 30,000 stems per acre. Two plots were maintained for control, two plots were thinned to spacings of 7 by 7 feet and 5 by 5 feet, and one plot was thinned in alternate 20-foot-wide strips. Thinning reduced stand densities to between 1,000 and 13,000 stems per acre. In 1953 the plots were remeasured.

Results Diameter increment at breast height was not determined for the period 1948-53, because trees had not reached breast height in 1948. It is doubtful whether thinning had any effect on height growth. Extensive mortality occurred on the control plots while the thinned plots suffered relatively small losses. Rabbits were responsible for much of the mortality.

Comments Because of rabbit damage and lack of replication in the experimental design, definite results cannot be expected from this project.

Status Continuing.

Reports

Unpublished

Johnson, H.J. 1955. Thinning jack pine, Duck Mountain Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Project MS-134 Row thinning, Saskatchewan.

Classification 242

Investigators Past: M. Kaye, J.S. Jameson.
Present: G.A. Steneker

Objectives To compare spaced-thinning with row-thinning in dense natural stands of jack pine (and black spruce), in terms of costs and effects on residual stands.

Location Nisbet Forest Reserve, Saskatchewan. Latitude 53°20'N, longitude 106°00'W.

Work Done Nine one-acre plots were established in 30-, 40-, and 60-year-old jack pine during the summer of 1950. Plots were established in series of three: one spaced-thinned to 7 by 7-foot or 9 by 9-foot spacing, one row-thinned by power machinery, and one control. Complete time records of each part of the thinning operation were kept. Measurements were taken both of trees cut and not cut.

Trees were uprooted in 10-, 15-, and 20-foot strips by a tractor-powered winch and cable arrangement. Uprooted trees were bunched on the strip and dragged to a conveniently located landing. Drawbar power only was utilized to uproot trees; the winch was used only to regulate the length of cable required at a particular time.

In 1954 the plots were remeasured.

Results (1) The number of man-hours required per unit basal area removed was less for row-thinning than for spaced-thinning. The difference between the costs of the two systems increased as the size of material increased. Both systems showed a definite trend towards fewer man-hours per square foot of basal area with increase in size of material being removed.
(2) In 1954 there was more volume on the control plots than on the treated plots, although in the younger stands there was a larger percentage of the volume of controls in trees less than 4 inches in diameter (Table 1).
(3) Diameter increment was increased by both methods of thinning, with the greatest increase in the spaced-thinned plots. Diameter growth stimulation was relatively greater in the smaller than in the larger classes (Figures 1-3).

TABLE 1. TOTAL CUBIC FOOT VOLUMES IN 1949 AND 1954

(Jameson 1956)

Age	Treatment	Total volume cu. ft. per acre			Per cent trees less than 4 inches d.b.h. in 1954
		1949 BT	1949 AT	1954	
30	Row	521	369	565	72
	Spaced	492	252	389	71
	Control	521	521	671	94
40	Row	1,780	1,077	1,291	36
	Spaced	1,383	844	1,151	26
	Control	1,736	1,736	1,907	43
60	Row	2,884	1,847	2,035	4
	Spaced	2,883	2,238	2,651	1
	Control	2,435	2,435	2,731	2

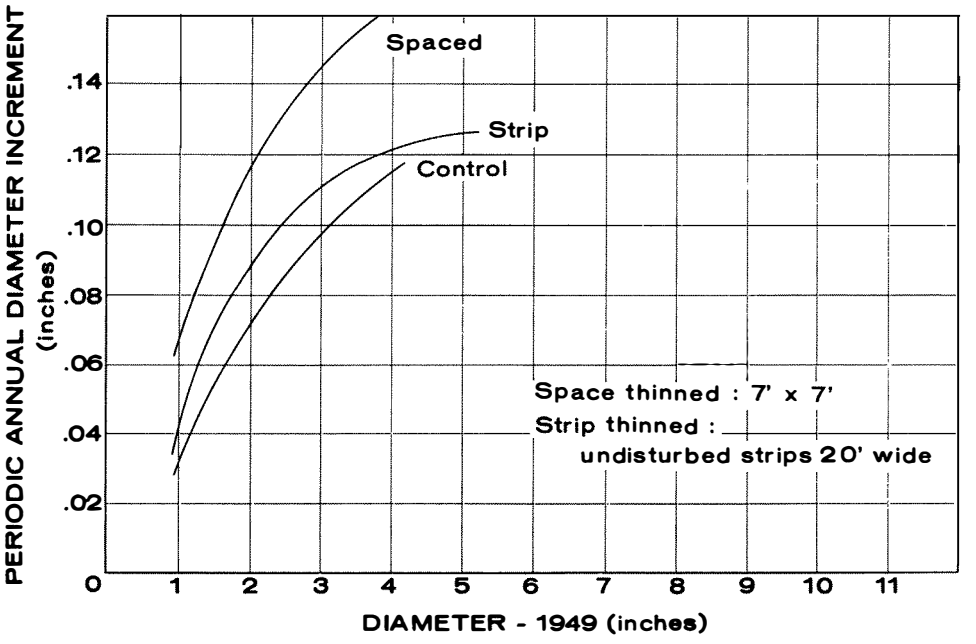

Figure 1. Periodic annual diameter increment for 30-year-old thinned and unthinned jack pine. (Jameson 1956).

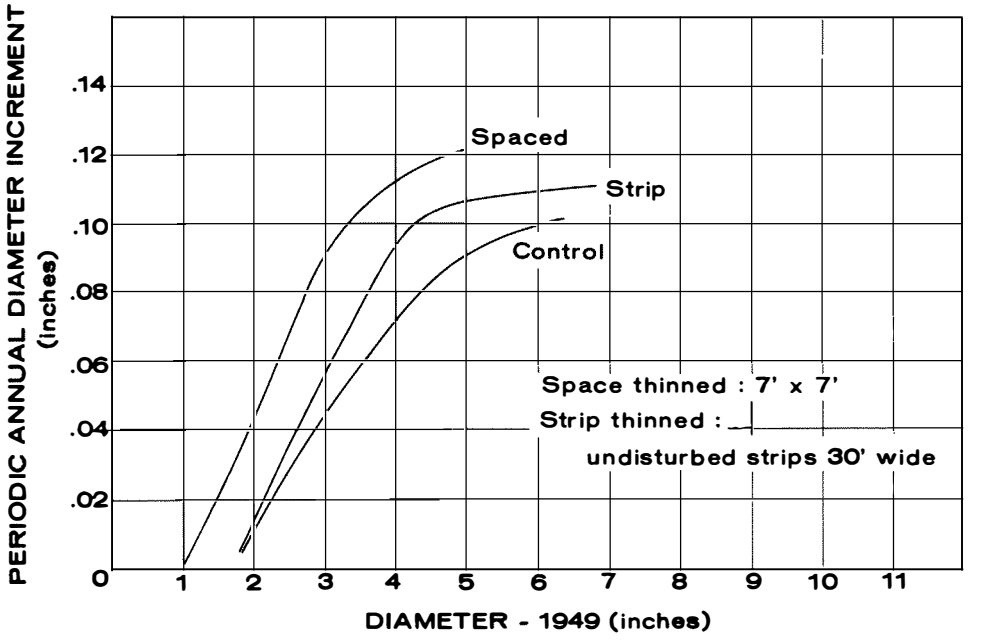

Figure 2. Periodic annual diameter increment for 40-year-old thinned and unthinned jack pine. (Jameson 1956).

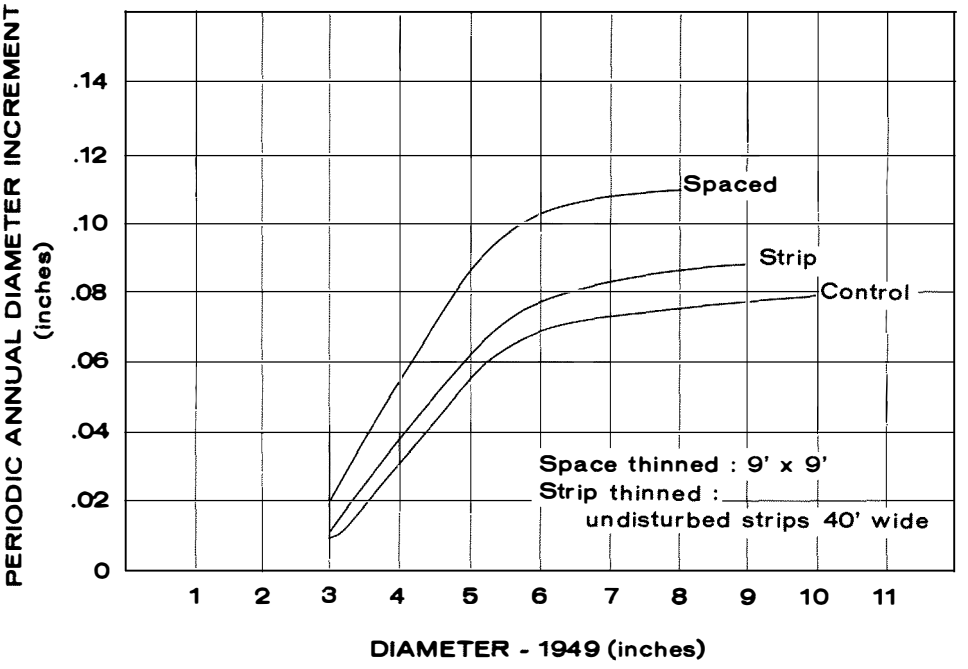

Figure 3. Periodic annual diameter increment for 60-year-old thinned and unthinned jack pine. (Jameson 1956).

Results *(continued)*

(4) Diameter increment in the 30-year-old jack pine row-thinned plot was increased up to 4 feet from the edge of the cut.
(5) Height increment apparently was not increased by thinning.

Comments Costs of mechanical row-thinning were less than for spaced thinning. However, its main economical advantage was in older stands, where row-thinning resulted in a reduction in net cubic-foot volume increment. Further remeasurements are required before valid conclusions can be drawn regarding the relative effects of the two thinning methods on residual stand development.

Status Continuing.

Reports

Unpublished

Kastrukoff, M. 1950. Strip thinning with tractor winch, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Jameson, J.S. 1956. Row thinning, Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Kastrukoff, M. 1950. Strip thinning with tractor winch, Saskatchewan. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 48. 2pp.

Jameson, J.S. 1956. Strip and spaced thinning in overstocked jack pine and black spruce stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., S.&M. 56-6. 8pp.

Project MS-143 Influence of jack pine slash disposal on regeneration, Sandilands.

Classification 231.39

Investigators Past: C.J. Lowe, H.J. Johnson

Location Sandilands Forest Reserve, Manitoba. Latitudes 49°05' to 49°45'N, longitude 96° 00'W.

Objectives To determine, in terms of regeneration, the relative merits of several methods of slash disposal.

Work Done Cut-over areas where six different methods of slash disposal had been practised were examined for regeneration in 1949 and 1950. Disposal methods were as follows:

(1) Left as cut -
After felling, trees were limbed. Branches and tops were left where they fell.

(2) Piled and unburned -
Piles about 6 feet high, circular, with spacing varying according to slash volume.

(3) Piled and burned -
Slash piled as in (2) and thoroughly burned.

(4) Tops only left -
After felling, tops were lopped off and left.

(5) Lopped and scattered -
Slash lopped from the trees and scattered so as to be not more than one and one-half foot deep at any point.

(6) Piled in windrows -
Slash was piled in long parallel rows, approximately one chain apart.

Results Results are tabulated in Tables 1 and 2.

Comments All methods of slash disposal were considered unsatisfactory for regeneration. Seedbeds rather than slash disposal methods were considered to be the cause of failure.

Status Closed.

Reports *Published*

Johnson, H.J. 1955. The effect of various slash disposal methods on the regeneration of cut-over jack pine stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 23. 12pp.

TABLE 1. RESULTS OF 1949 AND 1950 SURVEYS – BY METHOD OF SLASH DISPOSAL

(Johnson 1955)

Method of disposal	Seedlings/acre		Per cent stocking 1949
	1949	1950	
Piled and unburned	972	–	37
Left as cut	574	–	28
Piled in windrows	360	–	16
Lopped and scattered	318	242[1]	9
Tops only left	243	–	11
Piled and burned	170	152[1]	9

[1] Different areas used in 1950.

TABLE 2. RESULTS OF 1949 AND 1950 SURVEYS BY AGE CLASS OF SLASH

(Johnson 1955)

Age of slash (years)	Seedlings/acre		Per cent stocking 1949
	1949	1950	
1–2	191	113	9
3–5	701	638	18
6–9	622	475	17
10–12	370	270	37

Project MS-154 Multiple thinnings in jack pine, Sandilands Forest Reserve, Manitoba.

Classification 242

Investigators Past: H.J. Johnson.
Present: J.H. Cayford

Objectives To determine the density at which optimum growth occurs throughout the development of a jack pine stand.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitude 49°35'N, longitude 96°15'W.

Work Done In 1952 fourteen one-tenth-acre plots were established in a 15-year-old jack pine stand growing on a moist grey-wooded soil of sand to gravel texture. Two plots with stand density indices of 320 units were arbitrarily selected as fully stocked control plots. The other plots have been thinned at 5-year intervals to 120, 100, 80, 70, 60, and 50 per cent of the stand density index of the control plot in 1952 (320). Plots have been thinned in 1952, 1957 and 1962 and remeasured in 1957 and 1962.

Results Two factors, in addition to thinning, have affected the results of the experiment. First, was the fact that extensive rabbit damage occurred in 1952 and many small trees were killed. Second, there was considerable variation in stand density when the project was initiated. At that time, density per acre varied from 4,670 to 11,100 stems per acre. However, by segregating the 14 plots into three groups on the basis of initial stand density and initial average diameter, it has been possible to show the effects of thinning.

(1) Thinning has increased the diameter increment of individual trees, and greatest response has occurred in the 3- and 4-inch trees (Figure 1).

(2) Thinning has resulted in increased average stand diameters and increased the production of trees greater than 4 inches for plots initially averaging 5,130 and 7,740 stems per acre, but not for plots initially averaging 10,650 stems per acre.

(3) Thinning has not increased height increment and may in some instances have reduced height increment.

(4) Basal area increment appears to have been increased by thinning, with the trend more pronounced for the second 5-year period after thinning. Volume increment has not been increased by thinning.

(5) Mortality has been reduced considerably by thinning.

Comments Although the original stand density has affected the results for the first 10-year period, it is anticipated that its influence will diminish in future years and that the influence of thinning will become more pronounced in the future. Thinnings will be continued at five-year intervals.

Status Continuing.

Reports *Unpublished.*

Johnson, H.J. 1953. Multiple thinning in jack pine, Sandilands Forest Reserve. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1959. Multiple thinning in jack pine, Sandilands Forest Reserve, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

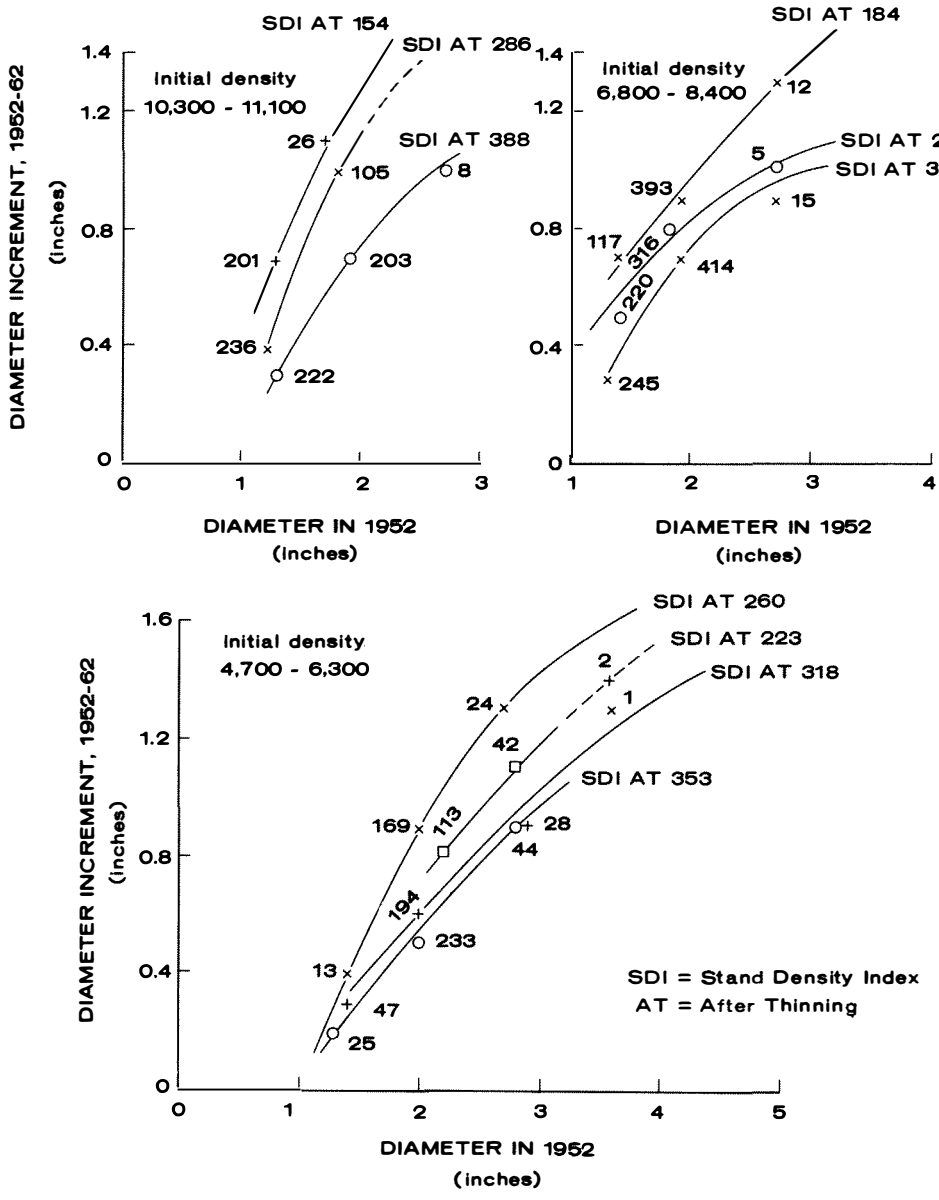

Figure 1. Effect of thinning on diameter increment, 1952-62, (SDI AT are the averages for 1952 and 1957). (Cayford 1964).

Reports *Unpublished (continued)*

Cayford, J.H. 1963. Multiple thinnings in jack pine, Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-14.

Cayford, J.H. 1964. Multiple thinnings in jack pine, Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-9.

Project MS-157 Establishment and survival of jack pine seedlings, cut-over stands, Riding Mountain.

Classification 221.1
231.321

Investigators Past: R.T. Pike. R.A. Haig, J.H. Cayford

Objectives To determine the effect of scarification on the establishment and survival of jack pine seedlings.

Location Riding Mountain National Park, Manitoba. Latitude 50°40'N, longitude 99°45'W.

Work Done In 1951, five blocks varying from 2.0 to 5.3 acres were established in three cut-over areas, and in 1952 a sixth block, 3.0 acres, was established in an uncut stand. Treatments by blocks were as follows:

1 and 2 Clear cut winter of 1950-51, slash lopped and piled. Complete scarification in summer of 1951, followed by hand scattering of slash.

3 and 4 Clear cut winter of 1950-51, slash lopped and scattered. Narrow strips, located about one chain apart, scarified in summer of 1951.

5 Clear cut winter of 1949-50, slash lopped and scattered. Narrow strips, located about one chain apart, scarified in summer of 1951.

6 Complete scarification in 1952 prior to cutting, clear cut in winter of 1952-53, and slash lopped and scattered.

In 1951 a total of 828 circular one-quarter-milacre quadrats were established on Blocks 1 to 5 to observe regeneration, and in 1952 an additional 30 quadrats were established on Block 6. All quadrats were examined annually until 1954, and in 1956 scarified quadrats were again examined. In 1961, the quadrats on Blocks 1 and 2 were re-examined. The soils on the study areas were clay-loam to clay in texture; moisture regimes were rated as fresh to moist.

Results (1) Regeneration results for each treatment for each year of examination are given in Table 1. Only on areas completely scarified after logging, but before slash scattering, was initial stocking satisfactory. In 1956, five years after treatment, stocking averaged 31.2 per cent on the basis of one-quarter-milacre quadrats. However, by 1961 it was reduced to 17.1 per cent with 2,240 stems per acre. Only on about one-fifth of the experimental area did stocking appear to be adequate.

(2) More germination occurred where slash was scattered after complete scarification than where slash was scattered before strip scarification. Also, survival was better where complete scarification preceded slash scattering. Possibly, slash scattered after scarification provided seedlings with protection from direct solar radiation and probably retarded evaporation of moisture from the soil surface.

(3) More germination occurred on areas strip-scarified one year after logging than on areas treated two years after logging. Probably where scarification was delayed, much of the seed had been dispersed before scarification.

(4) Regeneration on the area scarified before logging was a failure. The failure is believed due to poor lopping and scattering of cone-bearing slash.

(5) Seedling mortality was heavy, particularly in the first year after germination. However, appreciable numbers of seedlings germinated one and two years after treatment, and stocking on scarified areas was at a maximum the year following scarification.

(6) Seedling development has been affected by elk browsing. Seventy-six per cent of the seedlings examined in 1961 had been browsed. Mortality resulted when all living buds on a seedling were eaten or when seedlings were trampled.

TABLE 1. REGENERATION OF JACK PINE, RIDING MOUNTAIN NATIONAL PARK (PER CENT STOCKING BY ONE-QUARTER-MILACRE QUADRATS)

(Cayford 1957, 1958; Cayford and Waldron 1963)

Treatment	Year					
	1951	1952	1953	1954	1956	1961
Complete scarification after logging, but before slash scattering	45.0	52.0	51.6	47.6	31.2	17.1
Strip scarification after logging and slash scattering	19.1	26.4	18.8	6.9	6.0	–
Strip scarification two years after logging and slash scattering	0.6	1.2	1.2	0.6	1.2	–
Scarification before logging	–	–	0	0	4.8	–
No scarification	6.5	3.7	4.3	2.6	–	–

Comments

None of the methods used to regenerate jack pine were successful. Failure to obtain satisfactory stocking is largely attributed to browsing and to competition from grasses and other vegetation.

Had measures been taken to reduce vegetative competition by the application of chemicals and to control the elk population through game management or by the use of fencing, repellents, or other techniques, it is believed that some of the treatments undertaken would have been successful.

Status

Closed.

Reports

Unpublished

Haig, R.A. 1954. Establishment and survival of jack pine seedlings, cut-over stands, Riding Mountain. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Haig, R.A. 1955. Establishment and survival of jack pine seedlings in cut-over stands, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1957. Germination and survival of jack pine seedlings in cut-over stands, Riding Mountain National Park. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Cayford, J.H. 1958. Scarifying for jack pine regeneration in Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 66. 14 pp.

Cayford, J.H. and R.M. Waldron. 1963. Regeneration trials with jack pine on clay soils in Manitoba. For. Chron. 39:398-400.

Project MS-160 Planting white spruce in disturbed stands, Riding Mountain.

Classification 232.4

Investigators Past: J.H. Cayford.
Present: R.M. Waldron

Objectives To study the survival of planted coniferous stock under various conditions of site in the Riding Mountain.

Location Riding Mountain National Park, Manitoba. Latitude 50°35'N, longitude 99°50'W.

Work Done *Planting:* – In the spring of 1954 a mixed plantation of jack pine and white spruce was set out in an area that had been clear cut for aspen fuelwood in the autumn of 1952. The site is a fresh to moist clay-loam till.

At the time of planting a dense stand of heavily browsed aspen suckers about 2 to 3 feet high covered much of the planting area. Jack pine 2-1 stock was alternated with white spruce 3-2 stock at 6-foot spacing. The centre-hole method using grub hoes was employed and seedlings were planted in the rough amongst aspen suckers and underbrush. Planting was carried out in early June when both weather and soil moisture conditions were satisfactory. A total of 1,150 jack pine and 1,600 white spruce were planted.

Survival counts of the plantation were made in 1956, 1959, and 1961.

Results Survival and average heights at each survival count are tabulated in Table 1. In 1961 only 18 per cent of the surviving jack pine were above the level of the surrounding underbrush.

TABLE 1. SURVIVAL AND AVERAGE HEIGHTS OF JACK PINE-WHITE SPRUCE PLANTATION

(Waldron 1960, Cayford and Waldron 1962, 1963)

Species	Number planted	Survival (%)			Average height (in.)		
		1956	1959	1961	1956	1959	1961
Jack pine	1,148	20	10	9	8.3	14.1	18.1
White spruce	1,609	69	50	58	9.6	15.4	18.6

Comments Poor planting stock which appeared rather unhealthy due to needle browning, severe competition for soil moisture and light, and browsing by elk were the factors believed responsible for the poor performance of the pine. Better results might be expected if site preparation had been undertaken prior to planting, and if measures had been taken to reduce vegetative competition and to reduce elk browsing.

Status Continuing.

Reports *Unpublished*

Waldron, R.M. 1960. Planting white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. and R.M. Waldron. 1962. Regenerating jack pine on the Riding Mountain National Park in western Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

MS-160

Reports

Published

Cayford, J.H. and R.M. Waldron. 1963. Regeneration trials with jack pine on clay soils in Manitoba. For. Chron. 39:398-400.

Project MS-163 Silvicultural techniques for securing jack pine regeneration, Sandilands Forest Reserve, Manitoba.

Classification 221.1
221.21
221.222
231.31
231.321

Investigators Past: J.A. Fingland, J.S. Jameson, J.H. Cayford

Objectives To compare the effect of different methods of harvesting jack pine on the regeneration of the species.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitude 49°35'N, longitude 96° 10°W, and latitude 49°30'N, longitude 96°00'W.

Work Done The experiment was carried out in two moderately stocked 50- to 60-year-old stands growing on dry, sandy soils. Methods of logging and scarification are presented in Table 1.

Regeneration was examined on both scarified and unscarified areas, using 1/100-acre plots divided into ten milacre quadrats. Annual examinations of plots established on Blocks 2 and 3 were made from 1954 to 1956. On Blocks 4 to 6, unscarified plots were examined in 1954, and in 1955 all plots were examined. A forest fire in September 1955 burned Blocks 4 to 6.

TABLE 1. METHODS OF LOGGING AND SCARIFICATION, SANDILANDS FOREST RESERVE

(Cayford 1958)

Block	Method of cutting	Date of cutting	Method and date of scarification
1	Seed-tree cutting[1]	Summer of 1952 to summer of 1953	Scarified[3] Aug. 1953 after slash was scattered
2	Clear cutting		
3	Clear cutting in strips[2]		
4	Clear cutting in strips	Winter 1953–54	Scarified[3] July 1954. Slash windrowed before scarification and then scattered by hand on mineral soil.
5	Seed-tree cutting		
6	Clear cutting		

[1] Ten and 30 seed trees per acre left uncut.

[2] Clear-cut strips, 44 and 66 feet in width.

[3] Scarification with a tractor-drawn Athens plough.

Results (1) Regeneration stocking for scarified and unscarified areas for each examination in shown in Table 2.

(2) On areas scarified before slash was scattered, jack pine stocking on milacre quadrats increased as area of mineral soil increased. Stocking ranged from 8 per cent where mineral soil was exposed on less than one-quarter of the quadrat, to 65 per cent where it was exposed on more than three-quarters of the quadrat.

(3) At least 15 cones among slash scattered on mineral soil were usually required to produce a single one-year-old jack pine.

(4) On scarified areas most seedlings were growing in furrow bottoms, and in lo-

TABLE 2. REGENERATION OF JACK PINE[1] – PER CENT STOCKING BY MILACRE QUADRATS, SCARIFIED AND UNSCARIFIED AREAS

(Cayford 1958)

Block	Cutting Method	Scarified areas			Unscarified areas		
		1954	1955	1956	1954	1955	1956
		Scarification after slash scattered					
2	Clear cut	8.0[2]	4.7	2.1	7.5	10.0	2.4
3	Strip cut	16.5	19.0	2.5	22.0	32.5	13.5
		Scarification before slash scattered					
4	Strip cut	–	45.5	–	1.0	1.5	–
5	Seed-tree cut	–	59.0	–	0.5	2.5	–
6	Clear cut	–	71.0	–	1.0	1.0	–

[1] All seedlings which germinated after logging are included.

[2] Per cent stocking for each treatment based on between 170 and 200 quadrats.

cales shaded by either branches or furrows. On unscarified areas, seedlings usually occurred amongst bearberry and blueberry litter, while a few also were observed in feather moss and in thin jack pine litter.

(5) A drought during August 1955 caused considerable seedling mortality. Shade provided by slash was important in reducing drought-caused mortality.

Comments The only treatment that showed any degree of success was scarification followed by scattering of slash. Scarification after slash scattering was ineffective as the only areas well scarified were those on which there was little slash. Thus, a large portion of the seed did not reach a seedbed favourable for germination.

Status Closed.

Reports

Unpublished

Fingland, J.A. 1952. Silvicultural techniques for securing jack pine regeneration, Sandilands Forest Reserve. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Jameson, J.S. 1954. Silvicultural techniques for securing jack pine regeneration, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1955. Silvicultural techniques for securing jack pine regeneration, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1957. Silvicultural techniques for securing jack pine regeneration, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Cayford, J.H. 1958. Scarifying for jack pine regeneration in Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 66. 14 pp.

Project MS-173A Forest site classification for Manitoba and Saskatchewan.

Classification 542

Investigators Past: J.S. Rowe

Objectives To examine relationships between landforms, soil types and forest vegetation, and to attempt to establish at least preliminary categories of forest site.

Location Saskatchewan and Manitoba.

Work Done Oldest and least disturbed stands available were chosen for study. Data collected included stand description and measurements, regeneration, vegetation cover and abundance, and soil description.

Results Jack pine is shade intolerant, fast growing, suited for survival on dry porous soils and for regeneration following fire. In Manitoba and Saskatchewan this species is found in pure stands on dry, sandy soils and in mixture with aspen, birch and white spruce on heavier soils. Around swamps it may be mixed with black spruce. On dry sandy soils jack pine reaches maturity in 60 to 80 years; on heavier soils in 100 years. On very dry soils jack pine is associated with ericaceous flora. Its ability to invade prairies is inferior to that of spruce.

Distinctive pine stands are patchy, with numerous openings, situated on soils having no profile except for leaching in the top 2-3 inches; parent material is silicious. Fires are frequent. Jack pine is rarely displaced by other tree species and succession is from pine to pine.

As sites become moist, jack pine becomes less important in forest communities. On upland sites, black spruce-jack pine stands represent the transitional stage in development towards a black spruce type.

Seven jack pine sites were recognized. Some of their characteristics are described in Table 1.

Status Closed.

Reports

Unpublished

Rowe, J.S. 1956. Vegetation of the southern Boreal Forest in Saskatchewan and Manitoba. Univ. Manitoba, Unpublished Ph.D. thesis.

Rowe, J.S. 1957. Forest site classification. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

TABLE 1. CHARACTERISTICS OF JACK PINE SITES, MANITOBA AND SASKATCHEWAN

(Rowe 1957)

Site class	Soil characteristics	Water table	Forest cover
A1	Fresh loam to clay loam tills; grey-wooded profile.	Deep.	Jack pine seldom occurs in pure stands; will be succeeded by spruce or spruce-fir. Most productive jack pine site.
A2	Dry loam to clay loam tills; grey-wooded profile, shallower than in A1 site class.	Deep.	Succession towards mixedwood stands. Good productivity for jack pine.
B	Moist to moderately moist medium and fine sands; moist loams or clay loams.	5 feet on coarse soils or perched on heavier soils.	Pure jack pine or jack pine in mixed stands.
C	Moderately fresh to fresh stony to coarse, medium and fine sands.	6–9 feet.	Pure jack pine or mixed stands; less tendency for invasion by white spruce and balsam fir than A1, A2 and B sites.
D	Dry gravel and sand flats and ridges.	Beyond reach of tree roots.	Pure jack pine stands; often scattered aspen or birch.
E	Very moist soils on coarse sands to clays.	3–8 feet.	Limited importance for jack pine; rapid invasion of black spruce.
F	Arid to very dry coarse sands and gravel.	Deep.	Pure pines in open stands; no tendency for invasion by other species.
G	Dry rock ridges; pattern site of bare rock outcrops, and shallow till soils overlying bedrock.	Deep.	Non-merchantable site; black spruce may invade shallow depressions.

Project MS-173B Soil and minor vegetation of pine forests in southeastern Manitoba.

Classification 181.33
187

Investigators Past: J.C. Ritchie

Objectives To describe the range of soils on which pine stands are found in southeastern Manitoba, to give an account of the minor vegetation, and to provide some preliminary data on the performance of jack pine in relation to site.

Location Southeastern Manitoba. Latitudes 49°05' to 50°00'N, longitudes 95°10' to 96°20'W.

Work Done Oldest and least disturbed stands available were chosen for study. Data collected included stand description and measurements, regeneration, vegetation cover and abundance, and soil description.

Results Soil characteristics under pine stands are as follows:
(1) Drainage varies from excessively drained to poorly drained with a high water table.
(2) Texture ranges from coarse gravelly sands to clay loams and clays.
(3) Parent material may be lacustrine, sorted outwash sands, morainic generally unsorted sands, sand-mantled clays and loams, or deep aeolian sands.
(4) Podzolation ranges from melanized sands to sandy gley podzols.

Six profiles are recognized. These are:

(1) Melanized sands.
(2) Weakly podzolized sands.
(3) Podzolic sands.
(4) Sandy podzols.
(5) Sandy gley podzols.
(6) Grey-wooded.

Best indicator species of the gradient from dry siliceous to very moist grey wooded profiles are as follows: *Arctostaphylos uva-ursi, Antennaria canadensis, Lithospermum canescens, Viola adunca, Potentilla tridentata, Linnaea borealis* var. *americana, Pteridium aquilinum* var. *latiusculum, Aralia nudicaulis, Rubus pubescens, Cornus canadensis, Epigaea repens* var. *glabrifolia, Vaccinium myrtilloides, Equisetum sylvaticum, Ledum groenlandicum,* and *Clintonia borealis.*

A summary of site index data for the six sites is shown in Table 1. Best growth of jack pine occurred on the moister soils.

TABLE 1. SOIL PROFILE TYPE AND JACK PINE SITE INDEX

(Ritchie 1961)

Soil profile type	Number of plots	Site index at 50 years[1]	
		Mean	Range
1. Melanized sands	3	43	37-45
2. Weakly podzolized sands	7	45	39-56
3. Podzolic sands	2	54	53-56
4. Sandy podzols	5	53	48-57
5. Sandy gley podzols	2	55	52-58
6. Grey-wooded	6	50	43-55

[1] Based on heights of dominant trees and derived from a set of site index curves prepared by Gevorkiantz, S.R. 1956. Site index curves for jack pine in the Lake States. United States, Dept. Agriculture, For. Serv., Lake States For. Exp. Sta., Tech. Note 463. 2 pp. Ages based on breast height age plus 10 years.

MS-173B

Status Closed.

Reports *Published*

Ritchie, J.C. 1961. Soil and minor vegetation of pine forests in southeast Manitoba. Canada, Dept. Forestry, For. Res. Div., Tech. Note 96. 21 pp.

Project MS-176 Factors influencing jack pine reproduction on cut-over, burned-over and undisturbed stands.

Classification 181.525
541

Investigators Past: J.S. Jameson

Objectives To study the various environmental factors influencing the establishment and survival of jack pine in undisturbed, cut-over, and burned-over stands, in order to gain a clear understanding of the reasons for success or failure of jack pine reproduction.

Location Saskatchewan portion of the B.18a Mixedwood Forest Section. Field observations made in the Nisbet and Fort à la Corne Provincial Forests, and in the Northern Provincial Forest at Candle Lake, Montreal Lake, Big River and Meadow Lake. Latitudes 53°05' to 54°40'N, longitudes 104°30' to 108°30'W.

Work Done A preliminary reconnaissance was made to determine prevailing conditions and to select sub-areas for study. Partially-cut, clear-cut, and burned-over jack pine and mixedwood stands and, where possible, similar undisturbed stands were examined. Fifty-four plots were examined in 1954 in 13 localities.

Trees and stumps were tallied and aged, heights of several dominants in undisturbed stands measured, habitats described, biotic influences noted, and minor vegetation and soil profile described. Reproduction was tallied.

Five jack pine site groups[1] established on the basis of soil profile development, vegetation, and height/age relationship, were used for classifying the study areas.

Site Group A. Jack pine on Site Group A is a minor component of mixedwood stands. The sites consist of dry to moist, stony to stone-free, sandy-loam or clay-loam till of orthic or bisequa grey-wooded types.

Site Group B soils are moist, coarse to fine sandy soils of the gleyed or orthic podzol type supporting pure stands of jack pine on coarse sands, jack pine-black spruce stands on wetter soils, and mixedwood stands on the finer textured soils.

Site Group C contains moderately fresh to moderately moist soils of coarse to fine sand and sandy loam texture. Profile type is orthic or minimal podzol. Jack pine occurs in pure or mixedwood stands.

Site Group D occurs on dry sands, sandy loams and gravelly sands of the minimal podzol type. This is the most common site supporting pure jack pine stands.

Site Group E is an arid to very dry habitat on coarse gravelly to medium sandy soils. The profile is aeolian regosol with a tendency toward a minimal podzol. Jack pine occurs in pure open to semi-open stands.

Results

Cone Opening

Cone opening occurred when slash was spread evenly not more than 6 inches above the ground. Cone opening decreased with increasing height above 6 inches.

Seedbed

Reproduction on mineral soil seedbeds on C, D and E sites varied from 870 to 3,500 stems per acre, with 55 to 65 per cent stocking. Eighty-five per cent of the

[1] These are similar to the site groups outlined in Project Summary MS-173A, except that Site Group E was originally defined as Site Group F.

TABLE 1. EFFECT OF DEPTH OF SLASH ON SURVIVAL OF JACK PINE SEEDLINGS

(Jameson 1961)

Period since germination (weeks)	Original number of seedlings	Number of seedlings surviving by depth of slash	
		6–12 inches	Less than 6 inches
1	45	8	33
3	45	1	29
10	45	1	29

seedlings were located at the bottom of furrows. Slash burning provided patches of mineral soil seedbed and seedlings were found around their perimeters.

Slash

Depth of slash had more effect on survival than on germination (Table 1).

Aspect

On clear-cut areas where slash had been piled and burned, reproduction was greater on northern and eastern aspects than on southern to western or on level aspects. Reproduction was also greater on the lower portion of northwest aspects than on the upper portion. In partially cut stands the southern aspects were found to be moderately stocked while northern aspects were understocked.

Biotic influences

Biotic influences of mature and immature jack pine included mistletoe broom (*Arceuthobium americanum* Nutt.), stem rusts (*Cronartium* spp.), jack pine budworm (*Choristoneura pinus* Free.), white pine weevil (*Pissodes strobi* (Peck)), pitch nodule maker (*Petrova albicapitana* (Busck)), and the snowshoe hare. Of these only mistletoe and the snowshoe hare were of importance, the former in semi-open stands and the latter in mixedwood stands. Mistletoe was of major importance in reduction of cone production.

Comments

Slash not deeper than 6 inches resulted in cone opening and protection of seedlings from heat and drought. It is recommended that excess slash be disposed of. Under certain conditions a residual canopy provided protection against exposure of seedlings that more than offset any diminution of cone opening it may have caused. Scarification should provide for early season germination and should be done in late autumn or early spring, as soon as possible after cutting. Early season germination minimizes losses due to early autumn frosts.

Site group A should be converted to more favourable species than jack pine. Clear cutting in strips followed by scarifying and slash scattering is recommended for sites B and C. The generally recommended treatment for sites D and E is clear cutting in strips followed by scarification and slash scattering. On southern to western aspects partial cutting is recommended, and for the *Cladonia-Arctostaphylos* vegetation type scarification is not recommended

Status

Closed.

Reports

Published

Jameson, J.S. 1961. Observations on factors influencing jack pine reproduction in Saskatchewan. Canada, Dept. Forestry, For. Res. Div., Tech. Note 97. 24 pp.

Project MS-177 Seeding jack pine, Sandilands Forest Reserve, Manitoba.

Classification 232.216
232.33

Investigators Past: J. H. Cayford

Objectives To study the success of broadcast seeding of jack pine throughout the summer.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitude 49°10'N, longitude 96°00'W.

Work Done Throughout the late spring and summer months of 1954 and 1955 jack pine seed was sown weekly on areas that had been cultivated with a tractor-drawn eight-disk plough. Seeding was done with a hand-operated cyclone seeder, and was sown at an approximate rate of one pound per acre. One, two, and five years after seeding, examinations were made of the seeded areas.

The soil of the experimental areas is a sand with patches of gravel; soil moisture regime was rated as dry.

Results (1) Seeding between the end of May and mid-June generally resulted in moderate to good stocking, whereas seeding from mid-June to mid-September generally resulted in understocking or failure (Figure 1). These effects were more apparent in the 1955 seeding. Strips seeded in late May and early June averaged 1,170 stems per acre. Later seeding usually resulted in 300 or fewer stems per acre (Figure 1). (2) Microtopography on disked areas was characterized by an uneven surface of furrows, ridges, and level areas. Furrows ranged in depth to approximately four inches.

Examinations one year after seeding indicated that 70 per cent of the observed one-year-old seedlings occurred at the bottom of the furrows. At the same time only 47 per cent of the two-year-old seedlings were in this location. Most germination occurred in the furrows, probably because of lower surface temperatures, better soil moisture conditions, and the tendency of seed to collect there. Greatest mortality also occurred in the furrows; this was attributed to burying of seedlings by sand washed into the furrows during rain storms.

Comments Results suggest that direct seeding with jack pine provides a promising technique for restocking dry, open areas in southeastern Manitoba. There is every indication that well-stocked stands can be obtained provided that the ground is well prepared and seeding carried out during the early spring or possibly the late fall, and if temperature and moisture conditions are favourable during the germination and initial establishment periods.

Status Closed.

Reports *Unpublished*

Cayford, J.H. 1955. Seeding jack pine, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1956. Seeding jack pine, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Winget, C.H. 1959. Seeding jack pine, Sandilands Forest Reserve, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

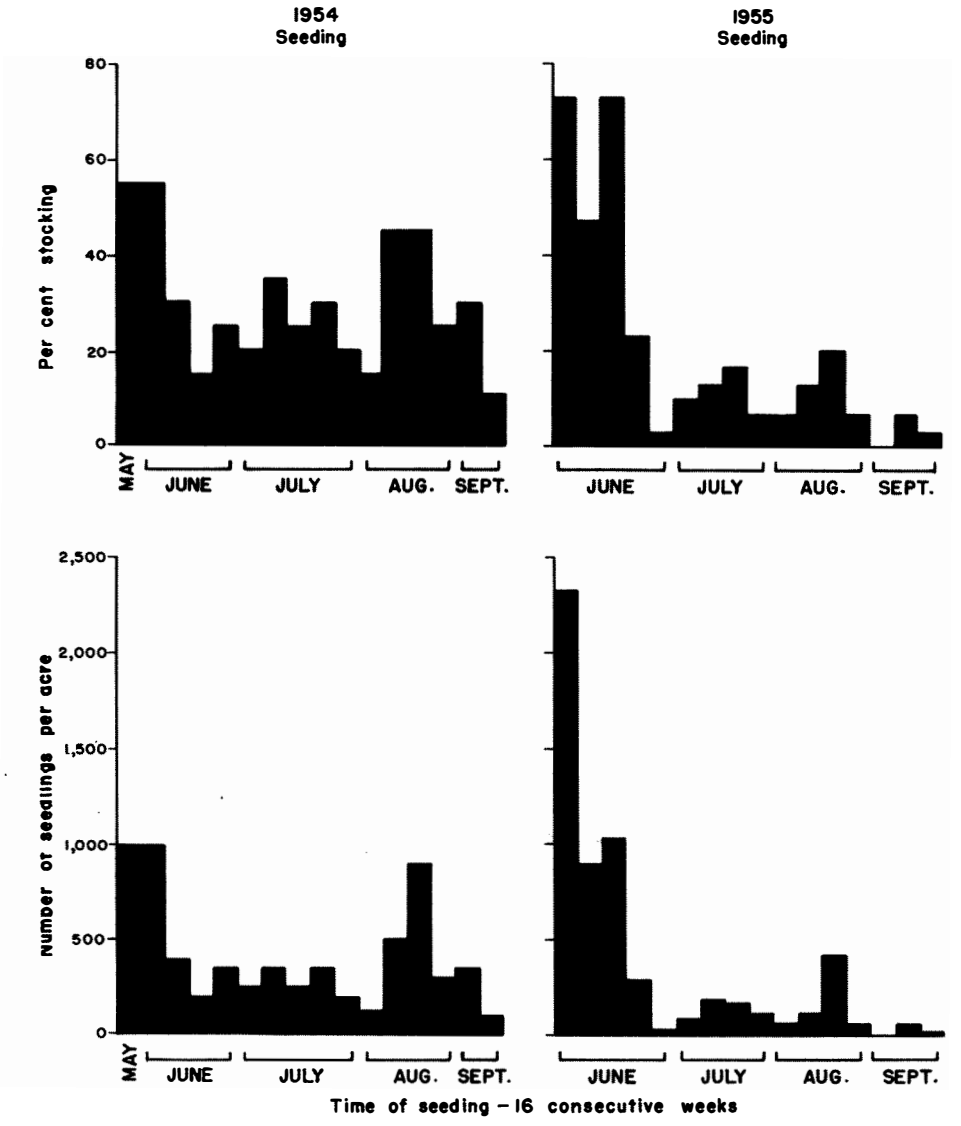

Figure 1. Per cent stocking and number of seedlings per acre for each week of seeding, five years after seeding. (Cayford 1961).

Reports

Published

Cayford, J.H. 1958. Seeding jack pine, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., S. & M. 58-5. 7pp.

Cayford, J.H. 1961. Broadcast seeding jack pine at weekly intervals in Manitoba. Canada, Dept. Forestry, Forest Research Branch, Tech. Note 106. 12 pp.

Project MS-181 Regeneration of jack pine cut-over areas, Sandilands Forest Reserve.

Classification 221.1
221.222
231.321

Investigators Past: H.J. Johnson, J.S. Jameson

Objectives To determine the effects of scarification on the establishment of jack pine seedlings.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitude 49°30'N, longitude 96°05'W.

Work Done In 1952 and 1953 six jack pine areas, cut over during the winter of 1951-52, were examined for regeneration. Five areas were logged in the form of parallel strips. The strips were 5 chains wide and the distances between them varied from 5 to 25 chains. The sixth area was irregular in shape. All areas were clear cut to a merchantable diameter limit of four inches at breast height and the slash was lopped and scattered. In the irregular shaped cut, post-cut scarification in strips was carried out using a tractor-drawn Athens plough.

A total of 1,000 milacre quadrats were established and examined in 1952, and in 1953, 360 of them were re-examined.

Results Results for scarified and unscarified areas are shown in Table 1. Regeneration was unsuccessful on both scarified and unscarified areas.

TABLE 1. JACK PINE REGENERATION ON SCARIFIED AND UNSCARIFIED AREAS

(Jameson 1954)

Treatment	Per cent stocking		Seedlings per acre	
	1952	1953	1952	1953
Scarified	2.7	11.7	38	43
Unscarified	2.0	3.8	40	–

Comments Only on a small percentage of the area was mineral soil exposed, and this was in places where little or no slash was present to hinder the plough. Where slash was present, mineral soil was not exposed. Thus, in general, where the seedbed was favourable for jack pine germination there was no seed source, and where there was a seed source, there was no suitable seedbed.

Status Closed.

Reports *Unpublished*

Johnson, H.J. 1952. Regeneration of jack pine cut-over areas, Sandilands Forest Reserve – 1952. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Jameson, J.S. 1953. Regeneration of jack pine cut-over areas, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Project MS-188 Development of jack pine stands following 1955 fire, Sandilands Forest Reserve, Manitoba.

Classification 181.43
181.525

Investigators Past: J.H. Cayford.

Objectives To determine the amount and distribution of natural jack pine regeneration following fire in various forest conditions. To investigate the factors affecting germination, survival and early growth.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitudes 49°30' to 49°40'N, longitudes 96°05' to 96°15'W.

Work Done The study was initiated in 1956, when 182 permanent regeneration transects were established in a variety of forest conditions that had been burned in September 1955 (Table 1). Each transect was 1/100-acre in size and divided into 10 one-milacre quadrats. Regeneration was examined annually from 1956 to 1961, with the exception of 1959.

TABLE 1. DESCRIPTION OF BURNED-OVER STUDY AREAS

(Cayford 1963)

Study area number	Stand age years	Disturbance before fire		Disturbance after fire	Site
		Cutting	Ground preparation		
1	30–35	None	None	None	Dry
2	60	Uncut[1] strips	None	Cut over	Dry
3	60	Cut[1] strips	None	None	Dry
4	60	Seed-tree cut	None	None	Dry
5	60	Clear-cut	None	None	Dry
6	60	Cut strips	Disked	None	Dry
7	60	Seed-tree cut	Disked	None	Dry
8	60	Clear-cut	Disked	None	Dry
9	25–35	None	None	None	Mod. fresh
10	50–75	None	None	Cut over	Mod. fresh
11	50–75	None	None	Cut over	Mod. fresh
12	70–80	Windfall salvage	None	None	Mod. fresh
13	60–70	None	None	Cut over	Moist

[1]Both uncut and cut strips were one chain or less in width.

Results (1) Stocking and density trends for dry and moderately fresh sites for the period 1956-61, based on pooled data from all 12 areas regularly examined, are shown in Figure 1. Stocking over the period remained constant on the moderately fresh site, whereas on the dry site an initial average stocking of 65 per cent was reduced to 44 per cent by 1957 and to 33 per cent by 1961. Number of seedlings per acre in 1956 did not vary greatly between sites; however, by 1961 there were 5,200 stems per acre on the moderately fresh site as compared with 1,400 on the dry site.
(2) More than 1,100 seedlings were tallied during the study; over 99 per cent of them were 1956 germinants, while the remainder were 1955, 1957 and 1958 germinants.
(3) Most seedling mortality was attributed to drought periods that occurred during the summers of 1957 and 1961.

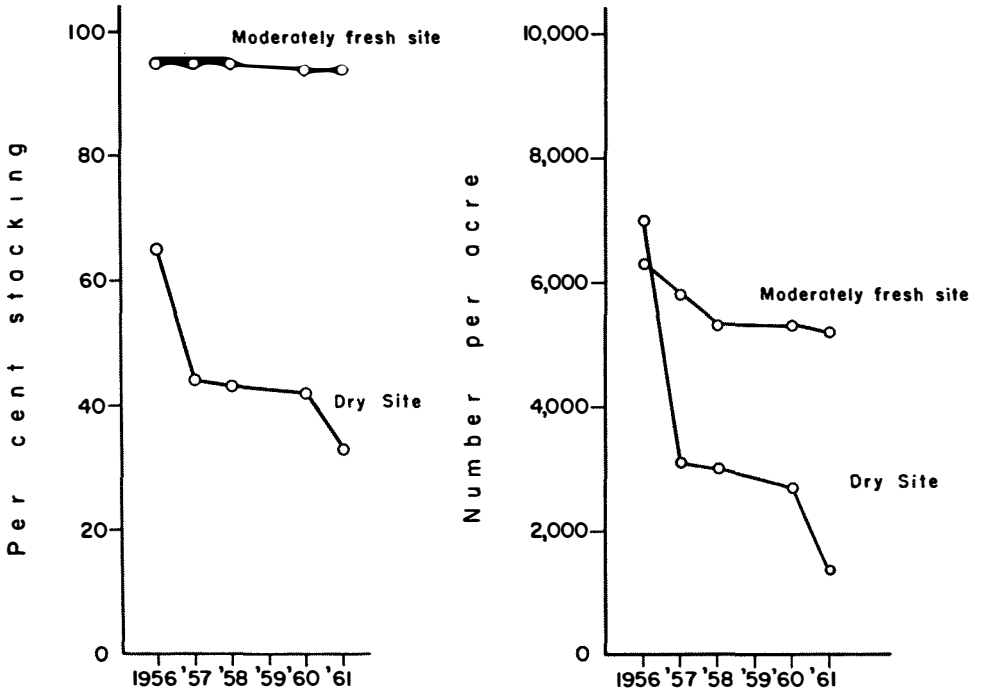

Figure 1. Stocking and density of jack pine regeneration following fire. (Cayford 1963).

(4) Factors that affected reproduction included site, stand density before fire, stand age, topography, and micro-habitat.

Comments

Site was one of the most important of the factors that affected survival and early growth of jack pine. On moderately fresh and moist sites, initial stocking was excellent, mortality was low, and by 1961 well-stocked six-year-old stands of regeneration were present. Initial stocking on dry sites was generally adequate; however, as a result of mortality most areas were under-stocked in 1961. Early height growth was best on moist sites and poorest on dry sites.

Stand density at the time of fire had an effect on initial stocking on dry sites; best stocking occurred under the heaviest canopy. Germination and survival were somewhat related to aspect on the dry site, and in 1961 best stocking generally occurred on northerly and easterly aspects. Disking prior to the fire created favourable conditions for germination.

Status

Closed.

Reports

Unpublished

Cayford, J.H. 1958a. Development of jack pine stands following fire, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS. (April).

Cayford, J.H. 1958b. Development of jack pine stands following fire, Sandilands Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS. (December).

Published

Cayford, J.H. 1963. Some factors influencing jack pine regeneration after fire in southeastern Manitoba. Canada, Dept. Forestry Publn. 1016. 16 pp.

Project MS-189 Two intensities of two types of commercial thinning in dense 35-to-40-year-old jack pine in the Sandilands Forest Reserve, 1957.

Classification 242

Investigators Present: J. H. Cayford

Objectives To study the effects of thinning from below and thinning from above on the volume increment of the residual stand, and to determine the merchantable volumes produced during the rotation from stands subjected to the different thinning techniques.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitude 49°05'N, longitude 95°55'W.

Work Done Five blocks, each approximately 2.5 acres in area, were established in each of two experimental areas in 1957. Pure 40-year-old jack pine stands growing on fresh, sandy soils were selected for the experiment. The following treatments were carried out:

1. Control – no thinning.
2. Light thinning from above.
3. Heavy thinning from above.
4. Light thinning from below.
5. Heavy thinning from below.

In all thinning treatments, only trees greater than 4 inches in diameter were removed. Four circular one-tenth-acre plots were laid out in each block; they were measured before thinning in 1957, and after thinning in 1958 and 1963.

Results (1) In November 1958 one of the experimental areas was destroyed by ice damage. Thus, results are available only for one of the two areas initially included in the project.
(2) Thinning from below increased periodic net increment of total and merchantable volume and basal area, while thinning from above decreased periodic net increment. Light thinning, either from above or from below, resulted in greater periodic net increments than did the corresponding heavy thinning (Table 1).

TABLE 1. PERIODIC NET VOLUME INCREMENT PER ACRE, 1958–1963

(Cayford 1963)

Block	Treatment	Total volume (cu.ft.)	Merch. volume (cu.ft.)	Merch. volume (cords)	Basal area (sq.ft.)
6	Light thinning – above	172	324	2.8	1.2
7	Light thinning – below	287	439	4.6	5.9
8	Heavy thinning – below	243	402	4.4	5.7
9	Heavy thinning – above	152	252	2.0	1.8
10	Control	225	384	3.8	2.0

TABLE 2. PERIODIC DIAMETER INCREMENT 1958–1963

(Cayford 1963)

Treatment	Diameter in 1958 (in.)				
	3.0	4.0	5.0	6.0	7.0
	Periodic diameter increment (in.)				
Light thinning – above	0	0.12	0.34	0.48	0.57
Light thinning – below	0.02	0.26	0.42	0.52	0.56
Heavy thinning – below	0	0.26	0.50	0.61	0.68
Heavy thinning – above	0	0.16	0.34	0.48	0.56
Control	0	0.14	0.26	0.37	0.46

(3) All treatments resulted in increased diameter increment of 4- to 7-inch trees. Generally, heavy thinning from below was most effective in stimulating diameter increment, followed in turn by light thinning from below, heavy thinning from above, and light thinning from above (Table 2).

(4) Height increment was not increased by thinning, and may have been decreased by thinning from above.

(5) In general, mortality decreased with thinning. Least mortality occurred after heavy thinning from below.

Comments

Although it is only five years since the initiation of this study it is evident that the two thinning methods -- from above and from below -- have resulted in considerable differences in behaviour of the residual stand, Thinning from below increased periodic net volume increment, increased diameter increment, did not affect height increment, and reduced mortality. On the other hand, thinning from above decreased periodic net volume increment, slightly increased diameter increment, decreased height increment, and increased mortality. Thus, it is evident that thinning from below was superior to thinning from above.

Intensity of thinning was not as important as method of thinning. A comparison of the effects of the two intensities of thinning from below reveals that maximum periodic net volume increment resulted from light thinning, while heavy thinning resulted in lower mortality and greater diameter increment.

Status

Continuing.

Reports

Unpublished

Cayford, J.H. 1959. Merchantable thinning in jack pine stands on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1963. Two intensities of two types of commercial thinning in dense 35- to 40-year-old jack pine in the Sandilands Forest Reserve, 1957. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-31.

Project MS-190 Planting spruce and pine, Interlake Area, Manitoba.

Classification 232.216
232.4

Investigators Present: J.H. Cayford

Objectives To study the survival and early growth of spruce and pine plantations in the Interlake Area of Manitoba.

Location Hodgson, Manitoba. Latitude 51°15'N, longitude 97°55'W.

Work Done Jack pine has been planted annually since 1957, with the exception of 1958. In 1957 all planting was on unprepared ground, in 1959 planting was done both on unprepared ground and in furrows prepared by a Middlebuster plough, and since 1959 all planting has been in furrows. A total of 9,200 jack pine have been planted to 1964. Survival counts have been made periodically, usually at 1-, 3- and 5-year intervals.

Results Survival of jack pine is shown in Table 1.

TABLE 1. SURVIVAL OF PLANTED JACK PINE, INTERLAKE AREA, MANITOBA

(Cayford 1961, 1962, 1963, 1964, 1965).

Year of planting	Site preparation	Soil		Number of trees planted	Survival – per cent		
		Texture	Moisture		1 year	3 years	5 years
1957	None	Sand and gravel	Very dry to dry	1,200	–	19.3	15.1
1959	None	Sand and gravel	Very dry to dry	800	26.9	19.8	18.3
1959	Furrowing	Sand and gravel	Very dry to dry	720	50.0	45.3	42.1
1960	Furrowing	Sand to clay	Dry to fresh	500	66.5	63.0	–
1961	Furrowing	Sand to clay	Dry to fresh	1,937	66.1	63.1	–
1962	Furrowing	Sand to clay	Dry to wet	1,200	91.5	–	–
1963	Furrowing	Sand to clay	Dry to very moist	1,125	54.9	–	–
1964	Scalping and furrowing	Sand to clay	Dry to wet	1,750	–	–	–

Comments Planting of jack pine in 1957 and 1959 on dry sites with no site preparation was unsuccessful. Moderate initial success has been achieved by planting jack pine in furrows on sites ranging from dry to wet.

Status Continuing.

MS-190

Reports

Unpublished

Cayford, J.H. 1958. Planting spruce and pine, Interlake Area, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1960. Planting spruce and pine, Interlake Area, Manitoba. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1961. Planting spruce and pine, Interlake Area, Manitoba. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1962. Planting spruce and pine, Interlake Area, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Man.-Sask. 62-5.

Cayford, J.H. 1963. Planting spruce and pine, Interlake Area, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-6

Cayford, J.H. 1964. Planting spruce and pine, Interlake Area, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-21.

Cayford, J.H. 1965. Planting spruce and pine, Interlake Area, Manitoba. With a section on site classification by J.S. Jameson. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-20.

Published

Cayford, J.H. 1961. Furrowing improves first-year survival of planted spruce and pine in Manitoba. United States, Dept. Agriculture, For. Serv., Tree Planters' Notes 48:13-14.

Project MS-198 Height growth of mature dominant black spruce and jack pine on ecologically different sites as determined from stem analysis.

Classification 541
542
561.1

Investigators Past: J.S. Jameson
Present: I. E. Bella

Purpose To obtain, by means of stem analysis, information on height growth of mature dominant jack pine (black spruce and white spruce) growing on the common physiographic sites. To compare height/age curves within sites between physiographic regions and between sites within physiographic regions.

Location Jack pine height growth has been studied in two locations as follows:
(1) Carrot River Lowland Physiographic Section[1] of the Manitoba-Saskatchewan Lowlands Region in Saskatchewan. Latitudes 53°15' to 54°05'N, longitudes 103°45' to 104°45'W.
(2) Wapawekka Hills Upland Section of the Saskatchewan Uplands Region in Saskatchewan. Latitude 54°15'N, longitude 105°00'W.

Both locations are within the Mixedwood Section (B.18a) of the Boreal Forest Region.

Work Done Studies were undertaken on the jack pine sites described in Project Summary MS-176, with one exception: Site A was sub-divided into sites A_1 and A_2, with the former occurring on loam to clay-loam till soils and the latter on sandy loam to loam soils of lacustrine or alluvial origin.

Sampling was restricted to 70-year-old, even-aged, undisturbed, pure jack pine stands, judged to be fully stocked. Soil profiles were described to a depth of 4 feet. Soil moisture regime and depth to water table were noted and topography described. Laboratory analysis of soils included pH, texture, organic matter content, cation exchange capacity and determination of calcium, magnesium, potassium, and sodium.

Total heights and ages of ten dominant trees on each plot were measured. Stem analysis was done on two trees per plot.

Results Height growth curves for the six sites are shown in Figure 1. The curves for sites A_2, B, C, D, and E are ranked in this order at all ages and are essentially similar in shape. The curve for the A_1 site differs considerably in shape from the others.

Soil moisture regime, soil nutrient regime and texture all had important effects on height growth of jack pine.

Productivity of the six sites rated as follows: sites A_2 and B, best; site A_1, good; sites C and D, fair; site E, poor.

Status Continuing.

Reports *Published*

Jameson, J.S. 1965. Relation of jack pine height growth to site in the Mixedwood Forest Section of Saskatchewan. Proc. Second North American Forest Soils Conference, Corvallis, Oregon. August 26-30, 1963. pp. 299-316.

[1]Acton, D.F., J.S. Clayton, J.G. Ellis, E.A. Christiansen, and W.O. Kupsch. 1960. Physiographic divisions of Saskatchewan as established by Saskatchewan Soil Survey in Co-operation with Geology Division, Saskatchewan Research Council and Geology Dept., Univ. of Saskatchewan.

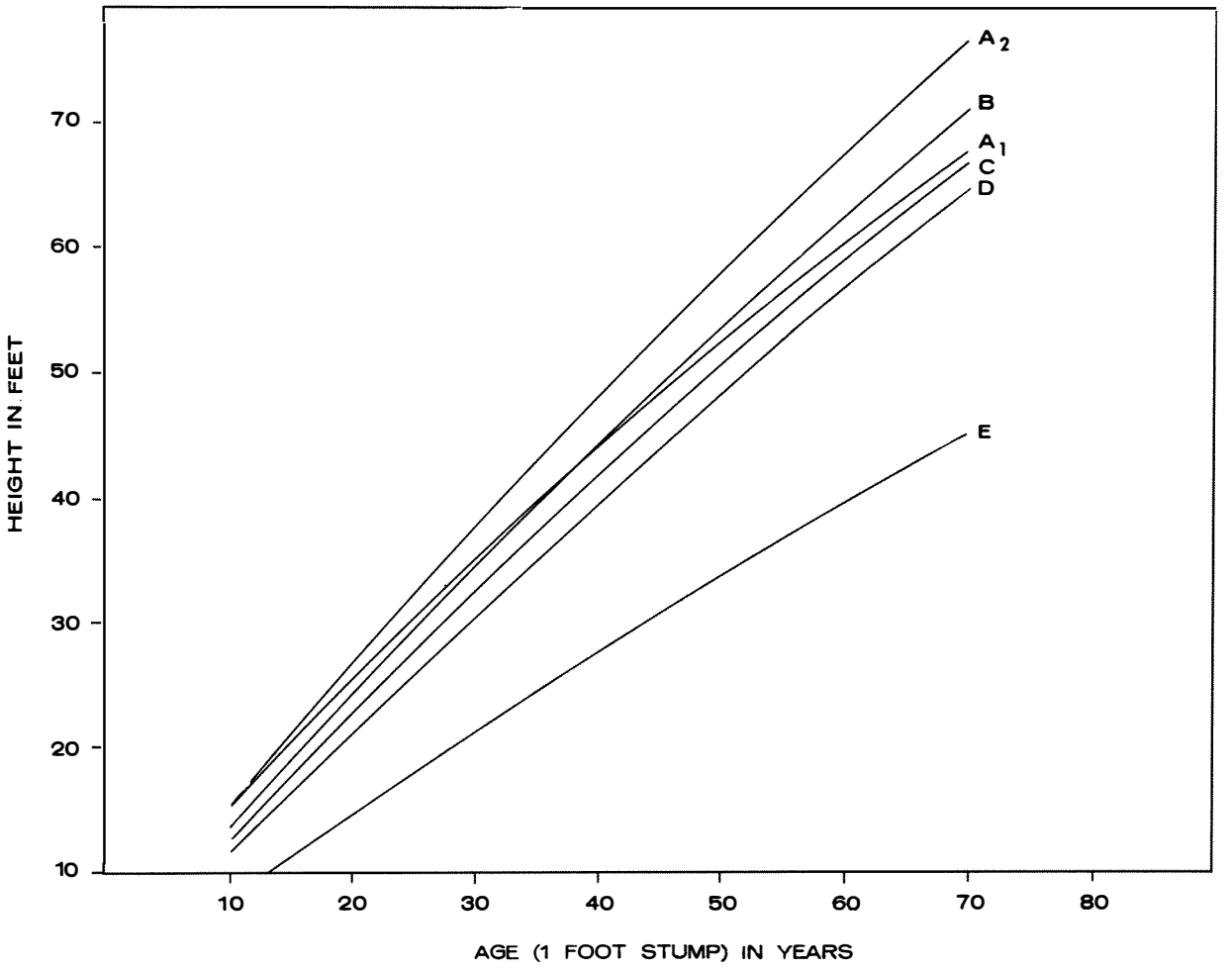

Figure 1. Height/age curves for jack pine in relation to site, Saskatchewan. Jameson (1965).

Project MS-202 An examination of jack pine broadcast seeding undertaken during 1950-56 by the Manitoba Forest Service.

MS-82 Reforestation by artificial seeding, Sandilands Forest Reserve, Manitoba.

Classification 232.216
232.33

Investigators Past: M.B. Morison, J.H. Cayford

Objectives To determine the most suitable methods for direct seeding of jack pine and to assess the results of direct seeding of jack pine on the Sandilands Forest Reserve.

Location Sandilands Forest Reserve, southeastern Manitoba.
Latitudes 49°00' to 49°30'N, longitudes 95°55' to 96°20'W.

Work Done Between 1925 and 1928 jack pine was sown experimentally on 26 one-quarter-acre plots, eight of which were seed spotted and the remainder broadcast seeded. Seed spots were prepared with a hoe and seeds sown by hand. The broadcast-seeded plots were disked four times and thoroughly harrowed before seeding. Seeding was done either by hand or with a hand-operated cyclone seeder. A few plots were again harrowed after seeding. Regular examinations of seeded plots were made from 1926 to 1930 (MS-82).

In 1958 an examination was made of operational seeding trials undertaken by the Province of Manitoba during the period 1943 to 1958. The 1943 seeded plots were sampled by means of one-half-acre sample plots. Other seeded plots were sampled using one-milacre quadrats in continuous strips; the number of quadrats per plot varied from 100 to 225 (MS-202).

Results (1) Experimental seed spotting between 1925 and 1928 was generally unsuccessful, whereas broadcast seeding following scarification was, in general, successful. Fourteen of eighteen plots had more than 2,000 stems per acre in 1930.
(2) Approximately one-half of the area broadcast-seeded between 1950 and 1955 was more than 40 per cent stocked. Thirty-one per cent of the area supported stands exceeding 1,000 stems per acre, while an additional 37 per cent had between 500 and 1,000 stems per acre.
(3) Scattering of jack pine cones and seeding in furrows were not successful.
(4) Factors that affected results included time of seeding, site preparation, lesser vegetation, quantity of seed, and biotic factors.

Comments Direct seeding with jack pine offers promise as a means of restocking dry, open sites in the Sandilands Forest Reserve. Seeding should be done either in the early spring or late autumn to secure spring germination which normally appears to provide maximum opportunity for seedling survival. Seedbed treatment is a necessity and either the entire area, or strips approximately six feet in width and separated by a similar distance, should be scarified. On grassy areas where competition to jack pine seedlings is more intense than on ericaceous areas, there is need for intensive scarification and exposure of mineral soil. Approximately 8 to 12 ounces of viable seed per acre should be sufficient. Greater quantities are neither necessary nor desirable as unfavourable weather conditions may cause seeding failures regardless of amount of seed sown.

Status Closed.

MS-202,82

Reports

Unpublished

Morison, M.B. 1931. Direct seeding on the Sandilands Forest Reserve. Canada, Dept. Interior, Forest Service, Unpubl. MS.

Published

Cayford, J.H. 1959. Seeding jack pine on the Sandilands Forest Reserve, Manitoba, 1925 to 1955. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 79. 16 pp.

Project MS-207 A study of jack pine seedfall in the Sandilands Forest Reserve, Manitoba.

Classification 181.523
181.525
232.31

Investigators Present: J.H. Cayford, H.P. Sims

Objectives To determine annual jack pine seedfall per acre in jack pine stands of different ages and densities occurring on dry sandy sites on the Sandilands Forest Reserve.

Location Sandilands Forest Reserve, Manitoba. Latitude 49°05'N, longitude 95°55'W.

Work Done In 1959 four pure jack pine stands with the following characteristics were selected for study:

(a) 60-year-old stand; well stocked
(b) 60-year-old stand; open
(c) 40-year-old stand; well stocked
(d) 40-year-old stand; open.

In 1960 two additional pure stands were added:

(e) 20-year-old stand; well stocked
(f) 20-year-old stand; open.

Each stand was sampled by thirty 1/20-milacre seed traps. Scalped spots of similar size were prepared beside each trap annually in late summer from 1961 to 1963. Fifteen litter traps per stand were set out in 1962.

Seed collections were made once per month during the snow-free period of the year.

Results Greatest seedfall has occurred in the 20-year-old stands each year; neither of the two stands has been consistently better than the other. Total annual seedfall has ranged from 11,000 to 78,000 per acre and sound seedfall from 7,000 to 56,000 per acre. Seedfall in 40- and 60-year-old stands has varied and has been consistently less than in the 20-year-old stands. Total annual seedfall has ranged from 3,000 to 17,000 and sound seed from 700 to 10,000 per acre. Least seedfall has occurred in the 40-year-old dense stands (Table 1).

Period of peak seedfall has varied, in some cases being in the autumn, in other cases in spring, and sometimes occurring at both times during the year.

Examinations of scalped spots have indicated that large numbers of seedlings germinated in 1962 and 1963 on the scalped spots in the 20-year-old stands. Relatively few seedlings were observed in the 40- and 60-year-old stands. In 1964 few seedlings germinated in any of the stands (Table 2).

Quantity and depth of litter accumulations for 1964 are shown in Table 3. Maximum accumulation – 2,988 pounds per acre – occurred under the 40-year-old open stand.

Status Continuing.

TABLE 1. SEEDFALL BY STAND AGE AND DENSITY, NOVEMBER 1960 – NOVEMBER 1964

(Cayford and Sims 1962, Walker 1963, 1964, 1965)

Stand	Nov. 3, 1960 to Nov. 1, 1961		Nov. 1, 1961 to Oct. 30, 1962		Oct. 30, 1962 to Nov. 5, 1963		Nov. 5, 1963 to Nov. 19, 1964		Totals Nov. 3, 1960 to Nov. 19, 1964	
	Sound	Total	Sound	Total	Sound	Total	Sound	Total	Sound	Total
20-year-open	27,613	33,760	55,682	78,160	17,884	26,300	6,850	10,940	108,029	149,160
20-year-dense	37,442	50,140	20,576	25,320	22,336	34,900	27,895	35,460	108,249	145,820
40-year-open	2,960	4,560	3,291	9,320	5,530	8,640	2,800	7,780	14,581	30,300
40-year-dense	2,090	9,140	665	5,920	700	2,800	2,660	2,660	6,115	20,520
60-year-open	9,860	16,710	3,536	11,300	4,646	14,080	670	4,760	18,712	46,850
60-year-dense	5,685	16,040	2,210	14,700	4,830	5,520	2,800	4,840	15,525	41,100

TABLE 3. QUANTITY AND DEPTH OF LITTER ACCUMULATION – 1964

(Walker 1965)

Date	20-yr-open		20-yr-dense		40-yr-open		40-yr-dense		60-yr-open		60-yr-dense	
	lb/ acre	depth (in.)	lb/ acre	depth (in.)	lb/ acre	depth (in.)	lb/ acre	depth (in.)	lb/ acre	depth (in.)	lb/ acre	depth (in.)
May 12	132	0.014	446	0.046	470	0.048	446	0.046	514	0.053	590	0.061
June 30	142	0.015	163	0.017	337	0.035	286	0.029	314	0.032	241	0.025
Aug. 5	246	0.025	128	0.013	749	0.077	257	0.026	656	0.067	227	0.023
Sept. 2–3	90	0.009	84	0.009	417	0.043	108	0.011	361	0.037	190	0.020
Oct. 6	227	0.023	771	0.079	834	0.086	660	0.068	581	0.060	1,267	0.130
Oct. 28	58	0.006	91	0.009	143	0.015	121	0.012	138	0.014	113	0.012
Nov. 18–19	18	0.002	38	0.004	38	0.004	103	0.010	33	0.003	37	0.004
TOTAL	913	0.094	1,721	0.177	2,988	0.308	1,981	0.204	2,597	0.267	2,665	0.274

TABLE 2. FIRST-YEAR SEEDLINGS PER ACRE AS CALCULATED FROM SCALPED SPOT EXAMINATIONS

(Walker 1963, 1964)

Stand	Seedlings per acre		
	1962	1963	1964
20-year-open	10,000	6,600	0
20-year-dense	10,000	16,000	0
40-year-open	2,000	0	0
40-year-dense	0	0	0
60-year-open	600	0	0
60-year-dense	1,400	1,400	660

Reports

Unpublished

Cayford, J.H. 1960. A study of jack pine seedfall on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Cayford, J.H. 1961. A study of jack pine seedfall on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Cayford, J.H. and H.P. Sims. 1962. A study of jack pine seedfall on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Man.-Sask. 62-2.

Walker, N.R. 1963. A study of jack pine seedfall on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-1.

Walker, N.R. 1964. A study of jack pine seedfall on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-12.

Walker, N.R. 1965. A study of jack pine seedfall on the Sandilands Forest Reserve, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-10.

Project MS-212A Clear cutting and clear cutting in strips, seedbed preparation, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan.

Classification 221.1
221.222
231.321
231.39

Investigators Present: J.H. Cayford

Objectives To determine whether clear cutting or clear cutting in strips, mechanical seedbed preparation, and slash scattering in jack pine stands will result in adequate regeneration.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitudes 49°05' to 49°35'N, longitudes 95°45' to 96°15'W.

Work Done Since 1960 a total of 41 areas, averaging about 16.2 acres in size, have been established. Half of the areas have been clear cut and the other half cut in two-chain-wide strips. In the fall, before logging, mechanical seedbed preparation using a tractor-drawn Middlebuster plough has been carried out on approximately one-half of each area. Areas have been logged during the winter, under timber disposal arrangements with the Manitoba Department of Mines and Natural Resources. About 400 one-milacre quadrats have been established on each area after logging. Limited regeneration examinations were made in 1962 and 1963 on some of the cut-over areas.

Results Regeneration stocking and density are shown in Table 1.

Seedbed preparation has increased regeneration stocking and density over that on control areas. However, there were wide variations in stocking between areas

TABLE 1. JACK PINE REGENERATION STOCKING AND DENSITY, 1962 AND 1963

(Cayford 1963, 1964)

Area number	Year and method of logging	Per cent stocking[1]				Seedlings per acre	
		Control		Prepared		Control 1963	Prepared 1963
		1962	1963	1962	1963		
2	Clear cut, 1960–61	25.0	13.4	60.0	38.3	750	1,250
3	Strip cut, 1960–61	1.7	8.3	33.3	20.0	0	83
4	Clear cut, 1960–61	–	5.0	53.3	50.0	0	1,000
5	Clear cut, 1960–61	43.3	43.3	66.7	48.3	833	1,000
6	Strip cut, 1960–61	–	–	–	26.7	–	83
8	Strip cut, 1960–61	–	–	33.3	15.0	–	167
9	Clear cut, 1960–61	13.3	3.3	45.0	31.7	0	1,500
Avg.	Strip cut	1.7	8.3	33.3	20.8	0	111
	Clear cut	27.2	16.2	56.2	42.1	396	1,190
	Strip and clear cut	20.8	14.5	48.2	32.9	316	726

[1] Based on one-milacre quadrats.

and some prepared areas are understocked. The differences in stocking have resulted from variations in site, intensity of seedbed preparation, and distribution of scattered slash.

Comments

Early indications are that seedbed preparation, followed by slash scattering in conjunction with the logging operation, is not sufficient treatment to ensure satisfactory regeneration.

On several areas supplementary slash scattering was carried out by the Department of Forestry to ensure that cone-bearing branches were scattered over all favourable seedbeds. Stocking, based on three areas sampled, averaged 40.5 per cent with over 2,000 stems per acre.

Status

Continuing

Reports

Unpublished.

Cayford, J.H. 1961. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Cayford, J.H. and H.P. Sims. 1962. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Man.-Sask. 62-12.

Cayford, J.H. 1963. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-5.

Cayford, J.H. 1964. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-18.

Walker, N.R. 1965. Clear cutting and clear cutting in strips, seedbed preparation, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-6.

Project MS-212B Seeding and planting jack pine on prepared and unprepared cut-over areas, southeastern Manitoba.

Classification 232.216
232.33
232.4

Investigators Present: J.H. Cayford, N.R. Walker

Objectives To determine whether seeding and planting on prepared cut-over areas will provide satisfactory jack pine regeneration.

Location Sandilands Forest Reserve, southeastern Manitoba. Latitudes 49°05' to 49°35'N, longitudes 95°45' to 96°15'W.

Work Done These studies are undertaken on the areas established in project MS-212A.

Annually between 1961 and 1964, broadcast seeding was carried out on one-half- to one-acre plots on cut-over prepared areas. Seed was sown with a Cyclone hand seeder at a rate of approximately 12 ounces of seed per acre. Care was taken to ensure that most seed was sown on favourable seedbeds. Regeneration examinations of some of the seeded areas were made in 1962, 1963 and 1964.

In the springs of 1963 and 1964 planting was carried out, both on prepared and unprepared cut-over areas. Seedlings were planted at 6- by 6-foot spacing on 0.08-acre plots. Survival counts of all planted trees were made in the autumns of 1963 and 1964.

Results Results of the examinations on seeded areas are shown in Table 1. Survival of the 1963 and 1964 plantations in the fall of 1964 is shown in Table 2.

Comments Preliminary results indicate that seeding and planting are both suitable for ensuring satisfactory regeneration on cut-over areas, provided weather conditions are favourable.

Status Continuing.

Reports *Unpublished*

Cayford, J.H. and H.P. Sims. 1962. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Man.-Sask. 62-12.

Cayford, J.H. 1963. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-5.

Cayford, J.H. 1964. Clear cutting and clear cutting in strips, scarifying, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-18.

Walker, N.R. 1964. Planting jack pine on scarified and unscarified cut-over areas, southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-6.

TABLE 1. JACK PINE REGENERATION STOCKING AND DENSITY, 1962, 1963 AND 1964

(Cayford 1963, 1964, Walker 1965a)

Area number	Year seeded	Per cent stocking[1]			Seedlings per acre	
		1962	1963	1964	1963	1964
2	1961	66.7	50.0	–	1,667	–
4	1961	50.0	48.3	–	833	–
5	1961	63.3	66.7	–	3,500	–
8	1961	–	23.3	–	833	–
9	1961	80.0	46.7	–	1,333	–
Avg. 2–9	1961	65.0	47.0	–	1,633	–
12	1962	–	61.2	–	1,125	–
13	1962	–	40.8	–	333	–
15	1962	–	41.7	–	1,500	–
17	1962	–	53.3	–	2,833	–
Avg. 12–17	1962	–	49.2	–	1,448	–
21	1963	–	75.0	–	8,000	–
22	1963	–	93.3	–	27,330	–
23	1963	–	87.5	–	23,250	–
25	1963	–	75.0	–	4,500	–
Avg. 21–25	1963	–	82.7	–	15,770	–
26	1964	–	–	36.7	–	1,417
28	1964	–	–	35.0	–	1,250
29	1964	–	–	48.3	–	1,250
31	1964	–	–	94.0	–	19,600
32	1964	–	–	80.0	–	7,250
Avg. 26–32	1964	–	–	58.8	–	6,153

[1] Based on one-milacre quadrats.

Reports

Unpublished (continued)

Walker, N.R. 1965a. Clear cutting and clear cutting in strips, seedbed preparation, and scattering slash in jack pine stands to secure jack pine regeneration, Manitoba and Saskatchewan. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-6.

Walker, N.R. 1965b. Planting jack pine on scarified and unscarified cut-over areas, southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-5.

TABLE 2. SURVIVAL OF 1963 AND 1964 PLANTATIONS–FALL 1964

(Walker 1964, 1965b)

Area number	Year planted	Per cent survival	
		Unprepared	Prepared
20	1963	69.0	69.0
21	1963	62.0	68.0
22	1963	73.0	81.0
23	1963	79.0	90.0
25	1963	79.0	82.0
Avg. 20–25	1963	72.4	78.0
26	1964	91.0	94.0
28	1964	82.0	94.0
29	1964	95.0	87.0
30	1964	92.0	97.0
31	1964	86.0	93.0
32	1964	90.0	89.0
Avg. 26–32	1964	89.3	92.3

Project MS-213 Ecological classification of the Rainy River Forest Section in southeastern Manitoba.

Classification 542

Investigators Past: D. Mueller-Dombois.

Objectives The development of an ecological classification that may serve as a guide to forest management and forest research in the Rainy River Section (L.12) in southeastern Manitoba.

Location Sandilands and Northwest Angle Forest Reserves in the Rainy River Section (L.12) of the Great Lakes-St. Lawrence Forest Region, Manitoba. Latitudes 49°05' to 49°50'N, longitudes 95°10' to 96°30'W.

Work Done One-fifth-acre plots were established over the entire study area in 1960, 1961 and 1962. All vegetation was recorded on each plot and classed within tree, shrub, herb, moss, or lichen strata. Individual species were rated as to dominance and abundance. Soil was described and samples were collected for laboratory analysis.

Results Fourteen forest habitat types and three sub-types were recognized (Table 1). They were divided into three broad groups:

I. Habitats characteristically affected by drought during the growing season.
II. Habitats with favourable soil moisture conditions.
III. Habitats with excessive soil moisture.

Habitats 1, 2, 3, 4, and 7 commonly support jack pine and are briefly described below.

(1) *Very Dry Cladonia nudum Type on Aeolian Regosols (vd)*

Occurs on high dunes or dunes blending into high sandy recessional moraines. Soil is Aeolian Regosol, with a tendency to Minimal Podzol. Dominant undergrowth vegetation is lichens, with *Cladonia mitis* and *C. rangiferina* most common. *Prunus pumila, Arctostaphylos uva-ursi, Melampyrum lineare, Solidago nemoralis, S. hispida* and *Oryzopsis pungens* are consistently present.

Forest productivity is low. The habitat supports only jack pine, which attains a site index (mean height in feet at 50 years of 6 free-growing dominants) of 40 ± 4.

(2) *Dry Arctostaphylos-Cladonia Type on Minimal Podzols (d)*

Occurs on sandy recessional and ground moraines, on glacial outwash and on the knolls and crests of higher beach deposits. It is geographically very dominant. Soil is a typical minimal Podzol. Water table is at 8 feet in spring and drops below 10 feet at the end of the growing season.

Vegetation is characterized by low ericaceous shrubs such as *Arctostaphylos uva-ursi, Gaultheria procumbens,* and *Vaccinium angustifolium.* Taller shrubs such as *Prunus virginiana, Amelanchier alnifolia* and *Rosa acicularis* are typically scattered and of low vigour. Dominant herbs are *Antennaria canadensis, Aster laevis, Maianthemum canadense,* three *Solidago* species and two grasses. The moss *Pleurozium shreberi* is always present and *Cladonia* spp. are also present but less well developed than on the *vd* sites.

A drier sub-type (*d+*) can be recognized which is characterized by greater dominance of *Cladonia.* This type is found on low dunes or on crests of reces-

TABLE 1. FOREST HABITAT TYPES AND MAJOR ECOLOGICAL CHARACTERISTICS

(Mueller-Dombois 1964)

		oligotrophic (nutritionally poor)	mesotrophic (nutritionally intermediate)	eutrophic (nutritionally rich)
I	very dry	(1) Pinus banksiana-Cladonia spp.-nudum/Aeolian Regosol type on high dunes (vd)		
	dry	(2) Pinus-Arctostaphylos uva-ursi-Cladonia spp./Minimal Podzol type on sandy recessional moraines, glacial outwash and crests of beach deposits; (d) and a drier subtype (d+)	(7) Pinus-Betula papyrifera-Populus tremuloides-Corylus cornuta-Linnaea/Bisequa Podzol, Bisequa- and Orthic Grey-Wooded type on gravelly beach deposits, outwash terraces, slopes of recessional moraines and outwash sand over clay loam till; (mf) and a drier subtype (mf-)	
II	fresh	(3) Pinus-Arctostaphylos-Linnaea borealis/low Beta- and Gamma-gley Podzol type on sandy beach deposits, low undulating outwash and sandy ground moraines. (of)		(9) Populus tr.-Fraxinus pennsylvanica Cornus-Corylus-Petasites/Alluvial Grey-Wooded and Chernozemic Dark Grey type on higher flood terraces and plains (evf)
	moist	(4) Pinus-Ledum groenlandicum-Rubus idaeus/Beta-gley Podzol type on margins of beach deposits low lying outwash and sandy ground moraines. (om)	(8) Populus tr.-(Picea glauca)-Cornus stolonifera-Corylus-Petasites palmatus/Pseudo-gley type on water-washed till of sandy loam to clay loam ground moraines (mm)	
	very moist	(5) Picea mariana-Hylocomium splendens-Pleurozium schreberi-Sphagnum spp. /Peaty Gleysol type on lacustrine sand banks and ground moraines (FS) (F for feathermoss-Hylocomium + Pleurozium)	(6) Populus tr.-P. balsamifera-(Picea glauca)-Cornus-Petasites/Alpha-gley type on lacustrine sand banks and ground moraines (mvm)	(10) Fraxinus-Populus b.-Ulmus americana-Matteuccia struthiopteris/Alluvial Regosol type on bottomlands near an active stream (evm)
III	wet+	(14) Picea m.-Sphagnum spp.-Hylocomium-Pleurozium/deep fibrous peat (>20 inches) type on lacustrine pans (S)		
	wet		(13) Picea mariana-Hylocomium-Pleurozium-Sphagnum spp./fibrous peat hummock and mucky sink hole type on lacustrine pans; (sk) and a deep-peat (>20 inches) subtype (skS)	(11) Populus tr.-P. balsamifera-Fraxinus-Larix laricina-Cornus-Carex spp.-Caltha palustris/Alpha-gley and Stagno-gley type on shallow lacustrine flats and depressions on water-washed ground moraines (ew)
	very wet			(12) Larix-(Picea m.)-Betula glandulosa-Carex spp.-Caltha-Potentilla palustris/mucky peat type on lacustrine pans (BC)

I. Habitats characteristically affected by drought during the growing season.
II. Habitats with favourable soil moisture conditions.
III. Habitats with excessive soil moisture.

sional moraines. More commonly it occurs as an historical variant after repeated or severe ground fires.

Forest production is low with a site index of 42 ± 3 for jack pine on the *d+* sub-type and 46 ± 4 on the *d* type.

(3) *Oligotrophic Fresh Arctostaphylos-Linnaea Type on Low Beta- and Gamma-gley Podzols (of)*

Occurs on uniformly sandy beach deposits and on depressional and low undulating outwash. Also on sandy ground moraines and occasionally in depressions between recessional moraines.

Soil is Orthic Podzol or Minimal Podzol. Water table is at 3 to 7 feet.

Colonies of *Pleurozium schreberi* and *Dicranum rugosum* are typical. Low ericaceous shrubs as found in the *d* type are present as well as *Linnaea borealis*. *Alnus crispa* is also typical, while *Equisetum hyemale* is present in seral stands and *Vaccinium vitis-idaea* is found in successionally advanced stands.

Pure stands of jack pine are predominant with a site index of 51 ± 6. Black spruce may form the understorey.

(4) *Oligotrophic Moist Ledum-Rubus Type on Beta-gley Podzols (om)*

Occurs almost invariably on the margins of beach deposits adjoining black spruce bogs. Also found on low lying outwash where it fans into swampy areas, and on shallow ground moraines.

Ledum groenlandicum and *Rubus idaeus* are constant on these sites. *Alnus crispa, A. rugosa,* and/or *Cornus stolonifera* are common. *Vaccinium angustifolium* is very common.

Herbs such as *Cornus canadensis, Rubus pubescens, Petasites palmatus, Equisetum pratense* and others are typical.

Pleurozium schreberi and *Brachythecium rutabulum* are characteristic.

Jack pine, usually with a variably dense black spruce understorey, is typical. On successionally advanced sites black spruce may make up 50 per cent of the mature growing stock. Site index is 54 ± 4, the highest of the study area for jack pine.

(7) *Mesotrophic Fresh Corylus-Linnaea Type on Bisequa Podzols and Bisequa and Orthic Grey-Wooded Soils (mf)*

Occurs on gravelly beach deposits or outwash terraces that are covered with shallow sand caps of 1 to 3 feet in depth. Also found on slopes of recessional moraines, ground moraines of bouldery loamy sands, on outwash sand, and on outwash sand over clay loamy till.

Soil falls into three categories: Bisequa Podzols, Bisequa and Orthic Grey Wooded soils.

Corylus cornuta, Symphoricarpos occidentalis, and *Diervilla lonicera* are typical.

Herb layer is very diversified, containing *Aralia nudicaulis, Pteridium aquilinum, Pyrola secunda* and others.

A drier sub-type, *(mf–)* about midway between *d* and *mf* is recognized.

Forest stands are typically mixedwood of jack pine-white birch, or jack pine-aspen. Pure stands of jack pine or hardwoods are common. Site index of jack pine is 50 ± 4 on *mf* and 44 ± 5 on *mf–*.

Productivity classes

Jack pine productivity classes are as follows:

Site	*Site index at age 50 years*	*Habitat type*
I	54	*om*
II	50	*mf, of*
III	46	*mf–, d*
IV	41	*d+, vd*

Potential productivity classes in terms of planting sites for jack pine are as follows:

Excellent	*om*
Good	*of, mf*
Fair	*mf–*
Poor	*d*

Status

Closed.

Reports

Unpublished

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Mueller-Dombois, D. 1961. Ecological classification of the Rainy River Forest Section in southeastern Manitoba. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Published

Mueller-Dombois, D. 1964. The forest habitat types in southeastern Manitoba and their application to forest management. Can. J. Bot. 42:1417-1444.

Project MS-218 The effect of depth to water table on tree seedling growth in a greenhouse.

Classification 181.31
181.525

Investigators Past: D. Mueller-Dombois
Present: H.P. Sims

Objectives To study the response of tree seedlings to different conditions of soil moisture and grass competition.

Location Greenhouse, Winnipeg, Manitoba.

Work Done

Part I

Seedlings of jack pine, red pine, black spruce and white pine were grown in two soil-filled tanks, each of which were 16 feet long, 5 feet wide, and sloping from 6 feet in height at one end to 1 foot in height at the other. A continuously renewed water table was adjusted to 6 inches at the bottom of each tank. One tank was filled with sand from a dry site which supported a fair growth of jack pine. The other was filled with loamy sand from a fresh site which supported very good growth of jack pine, red pine, trembling aspen, and white birch. Slopes of the tanks were divided into 16 equal sections, each representing a different depth level in relation to the water table.

Greenhouse temperature was maintained at 77°F and tanks were watered to simulate summer showers. At the end of the experiment, all seedlings were removed and height, diameter, and ramification of tops were measured. Root systems were measured and seedlings were oven-dried and weighed. Soil texture, pH, permanent wilting percentage, field capacity, organic matter content, and total exchange capacity were measured.

Part II

Part II of the experiment is identical to Part I except that *Andropogon gerardi, Koeleria cristata* and *Calamagrostis canadensis* were sown on the tanks to provide grass competition.

Results

Part I. Height growth of jack pine seedlings increased with decreasing depth to water table to an optimum depth, beyond which height growth declined sharply (Figure 1). This depth ranged from 80 to 100 cm. (31 to 39 inches) in the loamy sand and from 60 to 75 cm. (24 to 30 inches) in the sand. Optimum depths increased as seedlings became larger.

Jack pine showed gradual height increase with decreasing depth to water table on loamy sand soil and straight line trends indicating no height increase until optimum depth on the sand soils. Jack pine growth was nearly twice as great on the loamy sand soil as on the sand soil.

Part II. Total vegetative production on the loamy sand exceeded that on the sand. However, at optimum depth to water table on the loamy sand a vigorous growth of grasses suppressed tree seedling growth. On the sand, seedling height trends were similar to those observed without competition, although over-all growth of seedlings was much less.

The relationship between seedling heights and grass competition is illustrated in Figure 2. Average maximum height growth in Part II was 80 per cent that reached on the loamy sand and 60 per cent of that reached on the sand in Part I. Seedling heights on the sand in Part II were equivalent or greater than on the loamy sand.

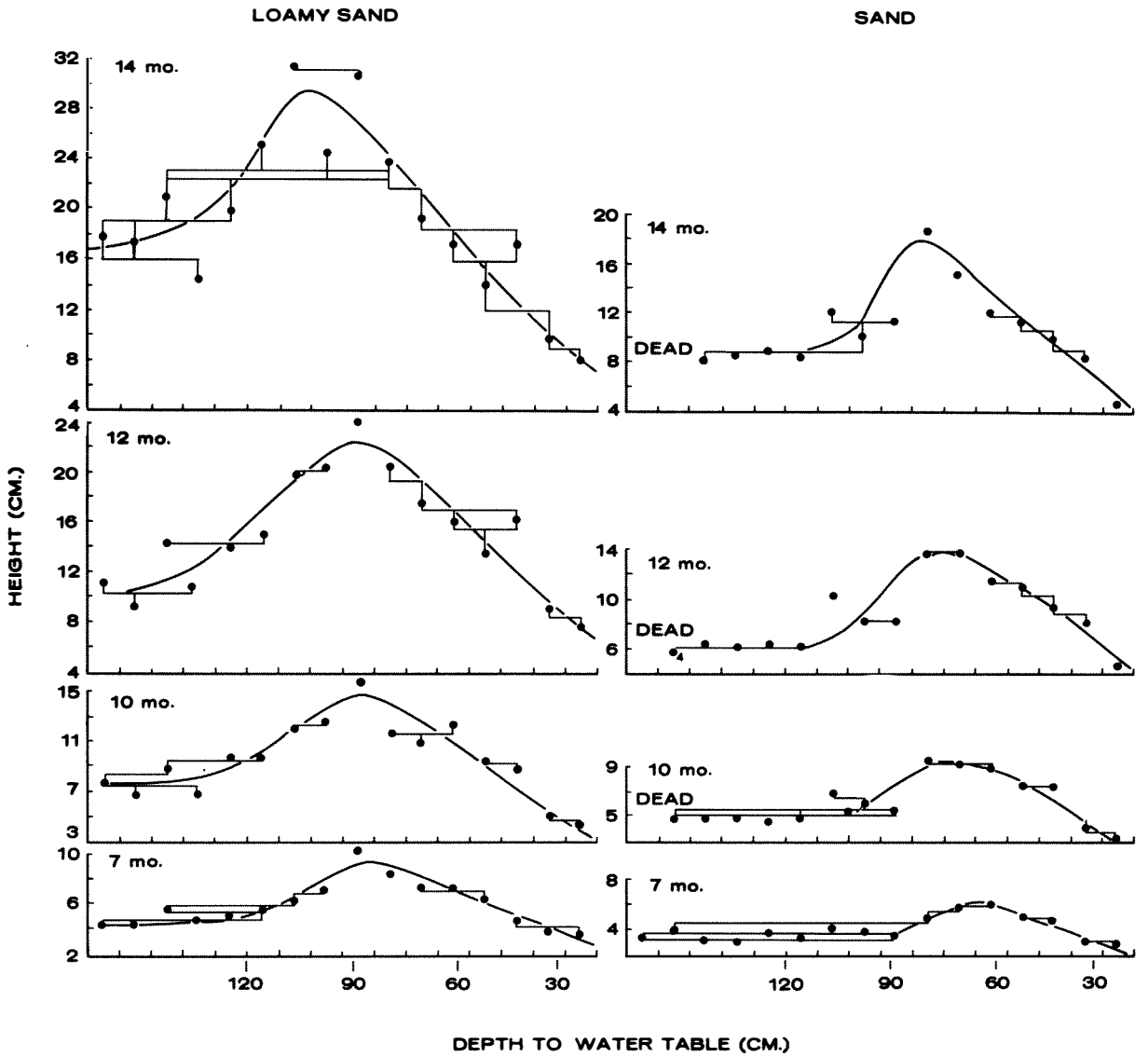

Figure 1. Height growth in cm. of jack pine seedlings on two soils at four successive periods from top to bottom of slopes, level 1 to 16. Points connected to the same horizontal line are not significantly different at the 5 per cent level of probability. (Mueller-Dombois 1964).

Grasses influenced seedling growth through root competition and shading, varying with species and depth to water table.

Comments

The experiment has shown the strong effect of the gradient of depth to water table and grass competition on jack pine height growth. The experiment also indicates that planting stock of jack pine should preferably be established on sands only when the water table stays within 2 to 5 feet from the soil surface.

The tanks represent miniature soil catenas suitable only for seedling studies. The distance to the water table in Level 1 of 160 cm. (63 inches) represents a dry site in the tanks for seedlings but would still be a fresh site in nature. Thus, with advanced growth the upward shift of the optimum depth to water table would continue for jack pine.

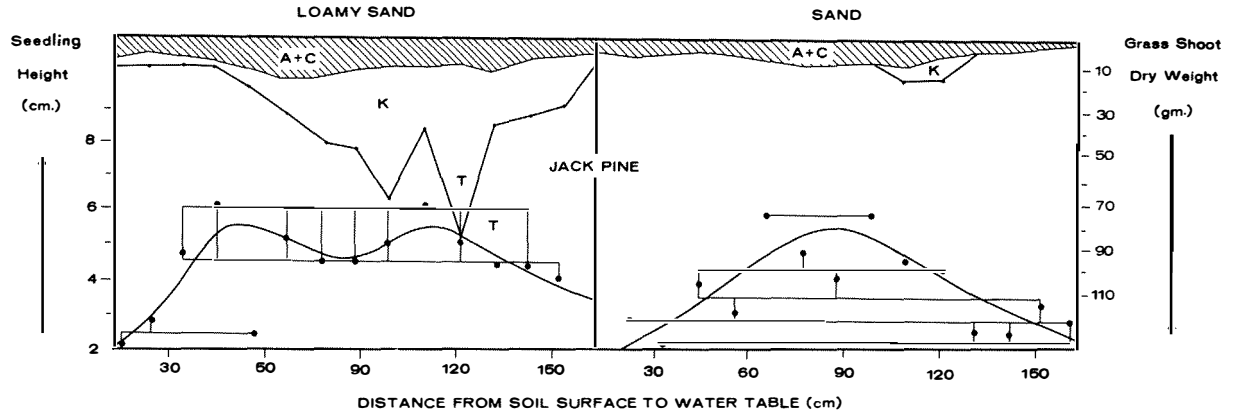

Figure 2. Distribution and dry shoot weight of three grass species (A = *Andropogon;* C = *Calamagrostis;* K = *Koeleria)* and relative seedling heights of jack pine after 13 months of growth on two soil slopes with controlled water tables in a greenhouse. On the tree seedling curves, points connected to the same horizontal line are not significantly different at the 5 per cent level of probability. A "T" indicates shading of seedling by *Koeleria.* (Mueller-Dombois and Sims 1965).

Status Continuing.

Reports

Unpublished

Mueller-Dombois, D. and H.P. Sims. 1965. Effect of depth to water table and grass competition on height growth of tree seedlings in a greenhouse. Canada. Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-3.

Published

Mueller-Dombois, D. 1964. Effect of depth to water table on height growth of tree seedlings in a greenhouse. For. Sci. 10:306-316.

Mueller-Dombois, D. 1965. Techniques for studying soil-water growth relations on an artificial slope. Proc. Second North American Forest Soils Conference, Corvallis, Oregon, August 26-30, 1963. pp. 153-161.

Project MS-222 Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plough in southeastern Manitoba.

Classification 181.22
181.31
181.525

Investigators Present: H.P. Sims

Objectives To assess and compare germination and survival of seeded and planted jack pine on different microhabitats, and to compare the associated soil, vegetative, and microclimatic condition of these microhabitats.

Location Sandilands Forest Reserve, Manitoba. Latitudes 49°05' to 49°15'N, longitudes 95°40' to 96°10'W.

Work Done

Study A

Three cut-over areas, scarified with a Middlebuster plough, were used for the study. Sites investigated were dry *(d)*, mesotrophic fresh (drier subtype) (*mf–*) and oligotrophic fresh (*of*).[1]

The study involved seed spotting and planting on five seedbeds created by the Middlebuster plough (ridge (R), trough (T), undisturbed (U), base of north-facing slope (BNF), and base of south-facing slope (BSF)) on three sites in three years (1962, 1963, and 1964). Seed used in 1962 was treated with Captan fungicide, in 1963 was not treated, and in 1964 was treated with Arasan and Endrin. Planting stock was in the 2-0 age class.

Measurements of germination, mortality, and height growth were made each year. In 1963 air temperature and soil surface temperatures were taken.

Study B

One dry-site area, cut-over in two-chain-wide strips and scarified with a Middlebuster plough, was used for this study. Nine plots were established in 1964; three each on the north (N), middle (M) and south (S) exposures of one of the strips. Seeding and planting methods were as in Study A.

Measurements of germination, mortality, and height growth were made. Air temperature and soil surface temperatures were taken by means of a thermograph and maximum and minimum thermometers, respectively.

Precipitation was measured with three Beal rain gauges and a Cassela recording rain gauge. Soil samples from the surface ½-inch, and from depths of 1½ inches and 3 to 4 inches were taken for gravimetric soil moisture determination, at intervals of 1, 3, and 5 days after rain.

Results

Study A

Seedspots

Germination in 1962 continued into late August and in 1963 and 1964 into mid or late July. However, most germination occurred in the first 2 to 3 weeks of June in 1962 and 1963 while in 1964 most germination occurred in late May on the *of* and *mf–* sites and during the second and third week of June on the *d* site.

[1]Sites are described in Project Summary MS-213.

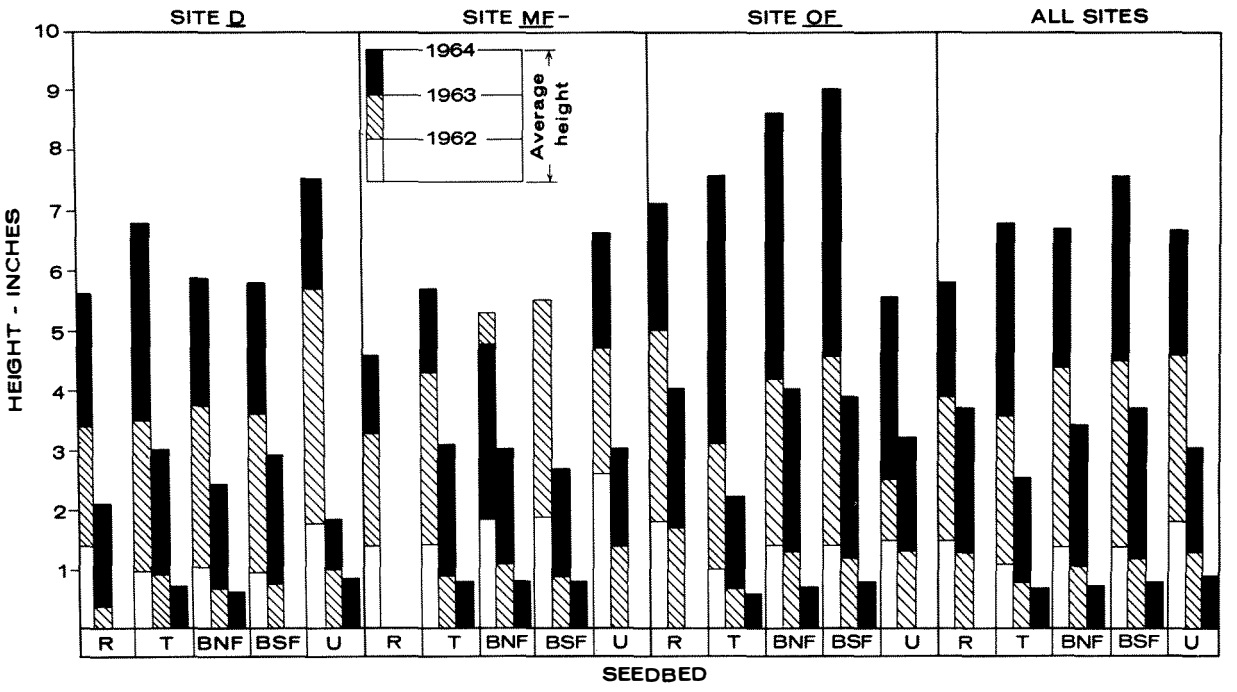

Figure 1. Average heights of 1962, 1963 and 1964 seedspot seedlings for each site and seedbed. (Sims 1965).

Germination was lowest and mortality highest on R and U seedbeds in all years. Germination was highest on BNF seedbeds. Mortality was lowest on the latter seedbed in 1963 and 1964 but intermediate on it in 1962.

The *of* site had the highest germination in 1962 and 1963 and least mortality in all years. Germination on the *mf–* site was higher than on the *d* site in all years but mortality was also higher in 1963 and 1964.

Average germination in 1962>1964>1963 while average mortality in 1962< 1964<1963. In 1964 18 per cent of mortality was attributed to heat and drought combined. Damping-off, and insects and rodents, each accounted for 2.3 per cent of mortality while 26.3 per cent of mortality was attributed to other miscellaneous causes. In 1963 about 50 per cent of mortality was attributed to heat and drought combined. The remaining three categories contributed about 15 per cent each to mortality. In 1962 about 50 per cent of mortality was attributed to damping-off, 10 per cent to insects and rodents, and 40 per cent to other miscellaneous causes. Growth of 1962, 1963,and 1964 seedspots is summarized in Figure 1.

Planted stock

First year survival of 1962 planted stock was almost 100 per cent, but of 1963 planted stock ranged from about 50 per cent on R and U seedbeds to more than 80 per cent on T and BNF seedbeds. First year survival of 1964 stock was intermediate between 1963 and 1962 stock and was good to excellent on all seedbeds. Survival of 1962 stock after 3 years was excellent on all sites and seedbeds. Survival of 1963 stock after 2 years was good on the *of* site but poor on the *d* and *mf–* sites. On the latter two sites survival was poor to fair on all seedbeds except the T seedbed of *d* site.

Growth of 1962, 1963 and 1964 planted stock is summarized in Figure 2.

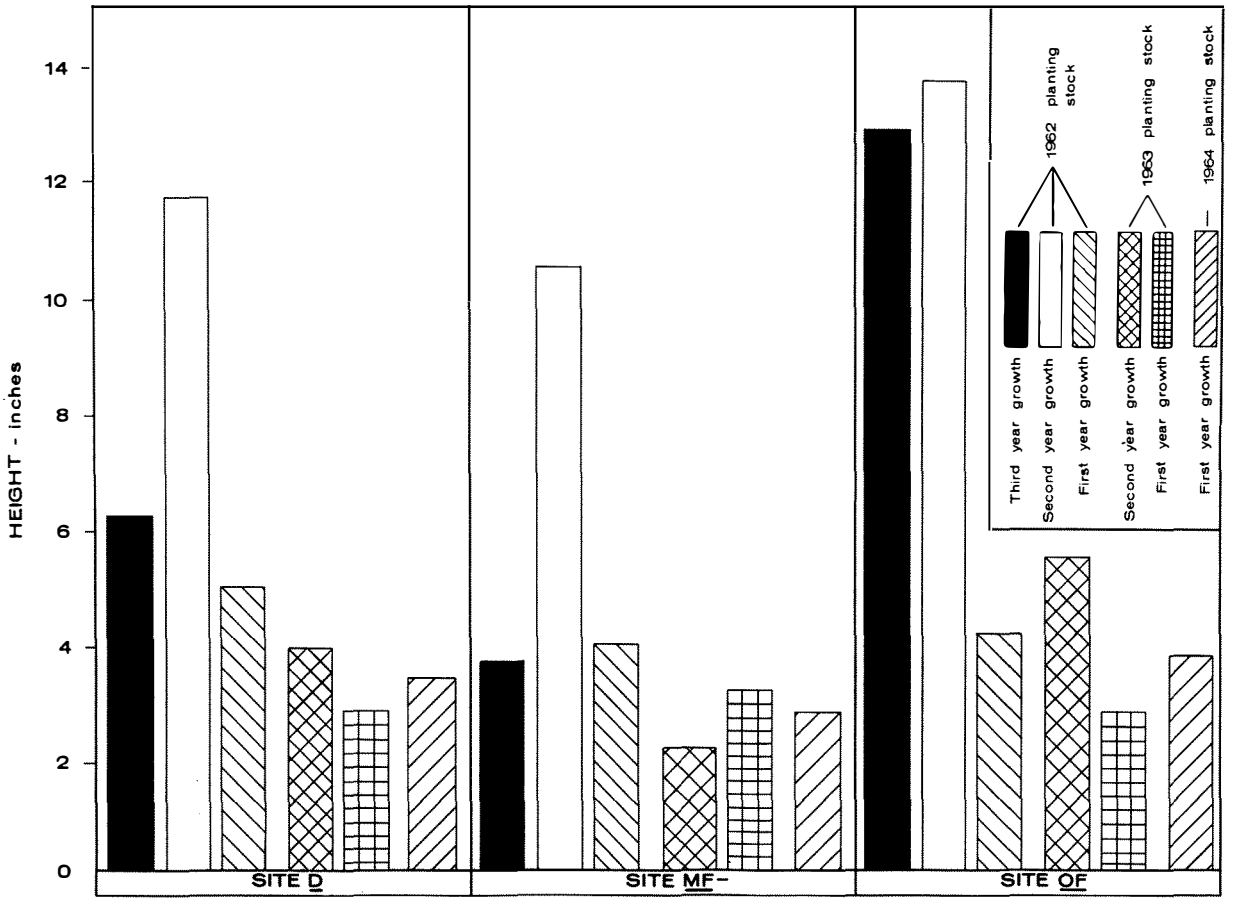

Figure 2. Average height growth (all seedbeds) of 1962, 1963 and 1964 planting stock for each site. (Sims 1965).

Soil Surface Temperature

Results of temperature measurements are summarized in Table 1. The critical level of maximum surface temperature is considered to be 120°F.

Study B

Seedspots

Germination began during the week of May 21-27 and was 98 per cent completed by July 1. It was lowest on the R seedbed and highest on the BNF seedbed. Germination was highest and mortality lowest on the N exposure, but only slightly so. Earlier germinants showed slightly better survival than later seedlings.

Planted stock

Survival of planted stock was generally good to excellent and was slightly better on the N exposure than on the M or S exposures. BNF, T, and BSF seedbeds had better over-all survival than the R and U seedbeds. Height growth of planted stock was generally greatest on the N exposure.

Soil Surface Temperatures

Results of temperature measurements, for a period of 115 days from May 20 to September 11, inclusive, are summarized in Table 2.

Status Continuing

TABLE 1. SUMMARY OF SOIL SURFACE TEMPERATURE MEASUREMENTS – 1963

(Sims 1964)

Seedbed	Seasonal maximum (°F)			Average maximum temperature June 20 – Aug. 1 (°F)			Number of days > 120°F			Total
	Site									
	d	mf–	of	d	mf–	of	d	mf–	of	
R[1]	143	150	148	116	118	119	37	41	44	122
BNF	130	117	114	103[2]	93	94	6	0	1	7
BSF	153	128	123	123	97	101	42	1	4	47
F	134	126	110	106	97	94	12	3	0	15
U	151	143	147	121	119	121	42	40	34	116
					Total		139	85	83	307

[1] R – ridge, BNF – base of north-facing slope, BSF – base of south-facing slope, F – furrow, U – undisturbed.

[2] June 20 to July 19.

TABLE 2. SEASONAL EXTREME SOIL-SURFACE TEMPERATURE AND NUMBER OF CRITICAL TEMPERATURE-DAYS FOR EACH SEEDBED AND EXPOSURE–STUDY B, 1964.

(Sims 1965)

Seedbed	Seasonal maximum (°F)				Seasonal minimum (°F)				Average number days > 120°F			
	Exposure											
	N	M	S	N,M,S	N	M	S	N,M,S	N	M	S	N,M,S
R	159	154	153	159	14	11	14	11	32	43	53	128
U	142	146	149	149	21	17	17	17	20	29	43	92
BSF	139	142	135	142	28	26	28	26	17	29	22	68
T	139	143	144	144	29	30	28	28	10	20	20	50
BNF	136	127	128	136	28	29	25	25	6	6	4	16
								Total	85	127	142	354

Reports

Unpublished

Sims, H.P. 1963. Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plow in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-MS-11.

Sims, H.P. 1964. Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plow in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-17.

Sims, H.P. 1965. Characteristics of soil temperature and moisture, germination of jack pine seed, and seedling establishment on seedbeds created by a Middlebuster plow in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-18.

Project MS-223A Greenhouse studies of spruce and pine germination. Study 1.
Effects of leaf and needle litter on greenhouse germination of white spruce and jack pine seed.

Classification 181.525

Investigators Present: J.H. Cayford, R.M. Waldron

Objectives To determine the effect of depth and position of needles on the germination of jack pine (and white spruce) seed.

Location Greenhouse, Winnipeg, Manitoba.

Work Done The experiment was carried out during the winter of 1961 in small pots containing sand soil. Five treatments involving two depths of jack pine needles, two methods of seeding, and a control were tested using jack pine seed. Fifty seeds were sown per plot.

Details of treatments were as follows:

(1) Control (mineral soil) – no litter added.
(2) ⅛– to ¼–inch layer of pine needles applied after seeding.
(3) ⅛– to ¼–inch layer of pine needles applied before seeding.
(4) ⅜– to ½–inch layer of pine needles applied after seeding.
(5) ⅜– to ½–inch layer of pine needles applied before seeding.
Periodic watering of the plots was carried out during the 8-week germination period.

Results

TABLE 1. EFFECT OF LITTER ON THE GERMINATION OF JACK PINE SEED

(Cayford and Waldron 1962)

Treatment	Depth of litter (in.)	Germination of jack pine seed (%)	
		Litter applied after seeding	Litter applied before seeding
Control (mineral soil)	no litter added	62.7	
Pine needles over mineral soil	1/8 – 1/4	47.0	47.7
	3/8 – 1/2	51.3	18.0

Comments Statistical analysis showed that only seeding on a ⅜– to ½–inch thickness of litter significantly reduced germination. A litter thickness of ⅛– to ¼–inch applied before or after seeding and seeding before application of a ⅜– to ½–inch thickness of litter was neither beneficial nor detrimental to germination.

Status Continuing

Reports *Published*

Cayford, J.H. and R.M. Waldron. 1962. Some effects of leaf and needle litter on greenhouse germination of white spruce and jack pine seed. For. Chron. 38: 229-231.

Project MS-223B Greenhouse studies of spruce and pine germination. Study 2.
Effects of treatment with fungicides and repellents on the germination of white spruce, jack pine, and red pine.

Classification 181.525
232.31

Investigators Present: J.H. Cayford, R.M. Waldron

Objectives To study the effects of seed treatment with Captan-50W, Arasan-75, Dexon, Chemagro 2635, and a mixture of Arasan-75 and Endrin – 75W on the germination of white spruce, jack pine, and red pine.
To study the effects of storage of seed treated with Arasan and Endrin.

Location Greenhouse, Winnipeg, Manitoba.

Work Done Between January 1963 and January 1965 a number of germination experiments were carried out in the greenhouse using seed that had been treated with fungicides or repellents. The fungicides – Captan-50W, Chemagro 2635, Dexon, and Arasan-75 – were added to seed that had been treated with methyl cellulose sticker. Approximately 23 per cent by weight of Captan was added. Rates of application for the Arasan-Endrin treatment were 2.6 pounds of Arasan and 1 pound of Endrin per 100 pounds of seed. One pound of aluminum flakes was also added. Dow 512-R latex was used as the sticker. Except when the effects of storage of treated seed were being investigated, sowing was carried out within one week of seed treatment. Plots were small waxed paper tubs filled with medium-textured sand. Either 50 or 100 seeds were sown per plot. Weekly observations were made for a five- or six-week period following sowing, and all germinants were classified and recorded as normal or abnormal. Each experiment was laid out in the split plot design.

Results

Effects of Captan:
Treatment of jack pine seed with Captan did not affect total germination of surface-sown seed, but greatly increased the percentage of abnormal germinants (from 14 to 76 per cent) and reduced from 73 to 22 the number of normal germinants per 100 seed sown. Density of sowing – from 1 to 64 seeds per 4½-inch diameter tub – had no significant effect on total germination, on per cent of abnormal germinants, or on number of normal germinants per 100 seeds sown.

Treatment of seed with Captan decreased total germination of depth-sown seed (from 88 to 59 per cent), slightly increased the percentage of abnormal germinants (from 2 to 8 per cent), and reduced from 86 to 54 the number of normal germinants per 100 seed sown. Results from sowing treated seed at four depths from 1/8 to ½ inch indicated no significant differences in total germination, in the percentage of abnormal germinants, or in the number of normal germinants per 100 seed sown between any of the depth-sowing treatments.

Effects of Other Fungicides:
Results are shown in Table 1. It is evident that only with depth-sown, Arasan-treated seed was there any appreciable number of normal germinants.

Effects of Arasan and Endrin
Treatment increased total germination of surface-sown jack pine, did not affect the per cent of abnormal germinants, and resulted in an increase from 74 to 83 in the number of normal germinants per 100 seed sown. In a further study of seed surface-sown one year after treatment, total germination and per cent of abnormal

TABLE 1. EFFECTS OF ARASAN, CHEMAGRO AND DEXON ON GERMINATION OF JACK PINE SEED

(Waldron and Cayford 1964)

Chemical	Surface sowing			Depth sowing		
	Total germination (per 100 seed sown)	Percentage of abnormal germinants	Number of abnormal germinants (per 100 seed sown)	Total germination (per 100 seed sown)	Percentage of abnormal germinants	Number of abnormal germinants (per 100 seed sown)
Control	86	13	75	60	0	60
Arasan	64	97	2	86	17	71
Chemagro	88	100	0	41	95	2
Dexon	46	100	0	63	97	2
Chemagro-Dexon	27	100	0	53	100	0

germinants did not differ between treated and untreated seed, and the number of normal germinants per 100 seed sown was 74 for untreated seed and 70 for treated seed. It is thus evident that seed treated with Arasan and Endrin can be stored for at least one year with little loss in germination.

Status Continuing

Reports

Unpublished

Waldron, R.M. and J.H. Cayford, 1964. Effects of seed treatment with fungicides and repellents on the germination of white spruce, jack and red pine. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-4. 30 pp.

Published

Cayford, J.H. and R.M. Waldron. 1965. Multiple jack pine seedlings. Can. J. Bot. 43:481-482.

Cayford, J.H. and R.M. Waldron. 1966. Storage of white spruce, jack pine and red pine seed treated with arasan, endrin, and aluminum flakes. United States, Dept. Agriculture, For. Serv., Tree Planters' Notes. 77:12-16.

Project MS-225 Development of individual jack pine seedlings on burned-over dry sites in southeastern Manitoba.

Classification 181.36
181.525

Investigators Present: H.P. Sims

Objectives To study the root and shoot development of seedling jack pine in southeastern Manitoba.

Location Sandilands Forest Reserve, Manitoba. Latitudes 49°05' to49°45'N, longitudes 95°40' to 96°10'W.

Work Done In 1961 five seedings from each one-year age class from 1 to 8 (excluding 7) years, and growing on a dry sand site, were selected for study. Stem height and diameter, number of laterals at each primary and secondary node, and cone production were recorded.

The root system of one seedling from each of the above age classes was excavated and mapped. Tap roots were measured for all five seedlings in each age class. Tops and roots were oven dried and weighed.

A study of root development of 1-, 2-, and 3-year-old seedlings on burned dry (*d*), mesotrophic fresh (drier subtype) (*mf*–), and oligotrophic fresh (*of*) sites[1] was undertaken in 1964. On the *mf*– and *of* sites five root systems from each age class were excavated and mapped. On the *d* site only sufficient data was taken to supplement results of the 1961 work.

Total height of seedlings was measured and all lateral and vertical roots were measured. Depths of initiation and termination of laterals were measured and noted in relation to soil horizon.

Tops and roots were oven dried and weighed.

Results Results from the 1961 work are summarized in Table 1 and those for 1964 in Table 2.

In the 1961 study a marked increase in stem growth occurred at age 5 years. Average number of secondary nodes, and average number of laterals per primary and per secondary node, increased with age. Cone production was nil on 1- to 5-year-old seedlings, negligible on 6- to 8-year-old seedlings, and showed a marked increase at 9 years.

Root growth showed an over-all increase at age 4 to 5 years. Average length of vertical roots remained relatively constant after 4 years, while average length of lateral roots began a marked increase at the same age. Top: root ratios, by weight, ranged from 0.94:1 to 4.88:1, with highest ratios occurring in the older seedlings.

In the 1964 study the greatest expansion of root systems occurred at age 3 years on all sites.

From the summary of top and root weights, it would appear that the higher nutrient level of the *mf*– site may become noticeable by the third year of growth. The majority of lateral roots on all seedlings began and ended in the H, Aeh or Ae horizons.

[1] Sites are described in Project Summary MS-213.

TABLE 1. SUMMARY OF SEEDLING MEASUREMENTS – 1961

(Sims 1964)

Age (years)	Height (mm.)	Diameter of root collar (mm.)	Weight (grams)		Top:root ratio
			Top	Root	
1	22	0.4	0.01	0.005	2.0 : 1
2	38	0.9	–	0.02	–
3	65	1.2	0.05	0.05	1.0 : 1
4	148	2.7	0.49	0.52	0.94 : 1
5	618	12.8	46.40	12.68	3.66 : 1
6	1,043	17.4	84.72	17.37	4.88 : 1
8	1,290	20.8	174.72	51.98	3.36 : 1

TABLE 2. SUMMARY OF SEEDLING MEASUREMENTS – 1964

(Sims 1965)

Site	Age (years)	Average height (cm.)	Weight (grams)		Top:root ratio
			Top	Root	
of	1	4.3	0.034	0.044	1.29 : 1
	2	8.0	0.342	0.138	2.48 : 1
	3	21.0	2.648	0.806	3.28 : 1
d	1	4.1	0.052	0.045	1.17 : 1
	2	9.0	0.140	0.095	1.47 : 1
	3	28.2	3.060	0.760	4.03 : 1
mf–	1	3.8	0.033	0.022	1.50 : 1
	2	11.7	0.158	0.342	2.16 : 1
	3	31.0	3.438	1.048	3.28 : 1

Mycorrhizae were found on 1-year-old seedlings on the *of* and *d* sites, on 2-year-old seedlings on the *of* site, and on 3-year-old seedlings in the *mf–* and *d* sites.

Status Continuing

Reports

Unpublished

Sims, H.P. 1962. Development of individual jack pine seedlings on burned-over dry sites in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Sims, H.P. 1965. Root development of jack pine on burned-over sites in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-8.

Published

Sims, H.P. 1964. Root development of jack pine seedlings on burned-over dry sites in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Publn. 1061. 15 pp.

Project MS-226 Converting aspen stands to white spruce by planting and seeding on scalped strips, Manitoba.

Classification 226
232.216
232.33
232.4

Investigators Present: R.M. Waldron

Objectives To determine whether aspen stands can be successfully converted to mixed coniferous-deciduous stands by planting or seeding on scalped strips spaced at approximately regular intervals.

Location The project is located in various areas of Manitoba, but only in two locations in the central Interlake district is jack pine included in the study. Secs. 6 and 7, Twp. 26, Rge. 2 E.P.M. and Sec. 20, Twp. 26, Rge. 3 W.P.M. Latitude 51°15'N, longitudes 97°20' and 97°45'W.

Work Done In the fall of 1961 and in the springs of 1963 and 1964, scalped strips were prepared in dense young aspen stands growing on very dry to very moist sites (moisture regimes 0 to 6) on gravel, sandy-loam, loam, and clay-loam soils. The strips were from 7 to 10 feet wide and spaced 9 to 14 feet apart.

In the springs of 1962, 1963, and 1964 jack pine was planted in a single row per strip. Planting was by the slit method at 6-foot spacing. At the same time, jack pine was sown on other strips at a rate of one pound of seed per acre. The 1962 and 1963 plantings and seedings were sprayed with an aqueous solution of 2,4,5-T to reduce vegetative competition; the 1962 areas were sprayed in 1963 or 1964, the 1963 areas in 1964. The plantations and seeded areas have been examined periodically.

Results Results of 1962 and 1963 planting and seeding are presented in Tables 1 and 2. Early survival of planted stock and germination of seed have both been excellent. About 80 per cent of the trees planted in the spring of 1962 were browsed by rabbits, though not severely.

Seedling survival by moisture regime is shown in Table 3. For both years of planting, survival decreased with increase in moisture regime.

Status Continuing.

Reports

Unpublished

Waldron, R.M. 1964. Converting aspen stands to white spruce by planting and seeding on scalped strips, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-16.

Waldron, R.M. 1965. Converting aspen stands to white spruce by planting and seeding on scalped strips, Manitoba. Canada, Dept. Forestry, Forest Research Laboratory, Winnipeg, Manitoba. Unpubl. MS. Internal Report MS-1.

TABLE 1. SURVIVAL OF PLANTED JACK PINE – FALL 1963

(Waldron 1964)

Date of preparation	Date of planting	Average height of planting stock (in.)	Survival per cent fall 1963	Per cent healthy fall 1963
November 1961	May 1962	5.8	83.8	100
March 1963	May 1963	6.2	78.4	97

TABLE 2. STOCKING OF SEEDED JACK PINE – FALL 1963

(Waldron 1964)

Date of preparation	Date of sowing	Pretreatment of seed	Seed viability (%)	Stocking and density – fall 1963	
				Stocking (%)	Seedlings/acre
November 1961	May 1962	Captan 50–W	80	64.0	7,000
March 1963	April 1963	Arasan – Endrin	98	89.0	28,000

TABLE 3. SURVIVAL OF PLANTED JACK PINE BY MOISTURE REGIME – FALL 1963

(Waldron 1964)

Moisture regime	Planted 1962	Planted 1963
	Survival (%)	
2	100.0	–
3	90.4	89.1
4	90.8	79.7
5	36.4	70.4
6	–	42.9
All	83.8	78.4

Project MS-227 Early survival and growth of planted and seeded white spruce as affected by seedbed types on scalped strips in aspen stands, Manitoba.

Classification 181.33
181.525

Investigators Present: R.M. Waldron.

Objectives To study the early survival and growth of planted and seeded white spruce on three seedbed types -- mineral soil, mixed mineral soil and humus, and humus -- on scalped strips prepared in aspen stands.

Location The project is located in the Interlake area and the Whiteshell Provincial Park in Manitoba, but only in the Interlake is jack pine included in the study. Latitude 51°15'N, longitudes 97°20' and 97°45'W.

Work Done In the springs of 1962 and 1963, thirty 1/8,000-acre quadrats located on fresh to moderately moist sites (M.R. 3 to 4) were sown with 50 seeds per quadrat. In the spring of 1964, seventy quadrats on very dry to moderately moist sites (M.R. 0 to 4) were sown with the same number of seeds. In the springs of 1962 and 1963 sixty trees were planted on fresh to moderately moist sites (M.R. 3 to 4) and in 1964 the same number of trees was planted on moderately fresh to fresh sites (M.R. 2 to 3). Seeding and planting plots were distributed on mineral soil, humus and mixed mineral soil-humus seedbeds. Twenty additional seeded plots were located on 1962 broadcast-sown strips. Ten were on a fresh to moderately moist site (M.R. 3 to 4) and 10 on a moist to very moist site (M.R. 5 to 6). Plots were evenly distributed between humus and mineral soil seedbeds.

Results

Seeding

Results of 1962 and 1963 seeding are presented in Tables 1 and 2. Excellent stocking has resulted from seed spotting and broadcast seeding on all seedbeds on fresh to moderately moist sites. Stocking was much lower on the moist to very moist sites.

After two growing seasons survival of seedlings on 1962 seedspots was best on humus seedbeds (92.7 per cent), intermediate on mixed seedbeds (78.1 per cent) and lowest on mineral soil (72.0 per cent). Mortality of 16 per cent of seedlings on mineral soil and 36 per cent of seedlings on the mixed seedbeds was attributed to frost heaving. No mortality was caused by heaving on the humus seedbeds. Heaving was more severe on the wetter sites.

Results of 1964 seeding are presented in Table 3. Most plots were stocked with the exception of those on the very dry site where stocking on mineral soil was 0 per cent and on humus was 50 per cent. There was little difference in stocking between dry to moderately fresh and fresh to moderately moist sites. The largest number of seedlings was found on humus on the fresh to moderately moist sites.

Planting

Results of 1962 and 1963 planting are presented in Table 4. Survival has been excellent on all seedbeds. Height growth on mineral soil and mixed seedbeds has been greater than on humus seedbeds.

Survival of 1964 planting on moderately fresh to fresh sites after one growing season averaged 93 per cent, with little difference in survival on the three seedbeds.

Status Continuing.

TABLE 1. STOCKING AND DENSITY ON JACK PINE SEED SPOTS – FALL 1963 FRESH TO MODERATELY MOIST SITES

(Waldron 1964)

Date of sowing	Pretreatment of seed	Seed viability	Per cent stocking[1]			Seedlings per plot[1]		
			Mineral soil	Humus	Mixed	Mineral soil	Humus	Mixed
May 1962	Captan 50–W	80	100	90	80	3.6	2.5	3.4
April 1963	Arasan – Endrin	98	100	100	100	24.8	29.5	17.0

[1] Based on 10 1/8,000-acre plots per seedbed per year.

TABLE 2. JACK PINE BROADCAST SEEDING 1962, STOCKING AND DENSITY – FALL 1963

(Waldron 1964)

Site	Per cent stocking[1]		Seedlings per plot[1]	
	Mineral soil	Humus	Mineral soil	Humus
Fresh to moderately moist	80	100	2.8	4.0
Moist to very moist	20	60	0.8	1.2

[1] Based on 5 1/8,000-acre plots per seedbed per site.

TABLE 3. JACK PINE SEED SPOTTING 1964, STOCKING AND DENSITY – FALL 1964

(Waldron 1965)

Site	Per cent stocking			Seedlings per plot			Basis: No. of 1/8000-acre plots
	Mineral soil	Humus	Mixed	Mineral soil	Humus	Mixed	
Very dry	0	50	–[1]	0	1.0	–[1]	26
Dry to moderately fresh	81	60	80	2.2	1.0	2.0	31
Fresh to moderately moist	75	75	80	1.5	4.5	2.4	13

[1] No data

TABLE 4. SURVIVAL OF PLANTED JACK PINE – FALL 1963 FRESH TO MODERATELY MOIST SITES

(Waldron 1964)

Date of planting	Survival (%)[1]			Height growth – inches		
	Mineral soil	Humus	Mixed	Mineral soil	Humus	Mixed
May 1962	85	80	100	4.7	2.6	5.0
May 1963	100	95	95	0.9	0.6	0.8

[1] Based on 20 trees per seedbed per year.

Reports

Unpublished

Waldron, R.M. 1964. Early survival and growth of planted and seeded white spruce as affected by seedbed types occurring on scalped strips prepared in aspen stands, Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-MS-19.

Waldron, R.M. 1965. Early survival and growth of planted and seeded white spruce as affected by seedbed types occurring on scalped strips prepared in aspen stands, Manitoba. Canada, Dept. Forestry, Forest Research Laboratory, Winnipeg, Manitoba. Unpubl. MS. Internal Report MS-2.

Project MS-235 Studies on the morphology of jack pine cone opening and the phenology of seed dispersal and germination.

Classification 181.523
181.525
232.31

Investigators Present: J. H. Cayford, H. P. Sims

Objectives (1) To study the morphology of jack pine cone opening.
(2) To study the phenology of seed dispersal from slash lopped and scattered following clear cutting.
(3) To study the germination, survival, and development of seedlings resulting from seed sown at two-week intervals throughout the growing season.

Location Sandilands Forest Reserve, Manitoba. Latitude 49°35'N, longitude 96°10'W and latitude 49°15'N, longitude 96°05'W.

Work Done *Seed Dispersal:* In 1964 fifty transects, each 1.2 chains by 0.1 chain (and divided into 12 one-milacre quadrats) were randomly located on an area where mechanical seedbed preparation (furrowing) had been carried out in the fall of 1963 and which had subsequently been clear-cut during the winter of 1963-64. Slash was lopped and scattered following the logging operation. The experimental area is on a dry, sandy site. In the spring of 1964, a total cone count was made and, during the summer, cone collections were made at 28-day intervals. Open and partially-open cones were collected from three height strata, and the number of seeds dispersed from each cone was determined in the laboratory.

Germination and Survival: Ten blocks, each consisting of twelve 1/20-milacre quadrats, were established in ploughed furrows on the main study area. At two-week intervals from May 6 to October 7 one quadrat per block, selected randomly, was sown with 50 seeds treated with Arasan and Endrin. Weekly examination counts were made from May 14 to October 7, and in the fall the height of each seedling was measured. The study was replicated on a similarly treated area located on a fresh, sandy site.

Results *Seed Dispersal:* The scattered slash contained a total of 76,780 cones per acre, of which 60,380 were located within 7 inches of the ground, 11,540 were between 7 and 12 inches, and 4,860 were more than 12 inches above the ground. The distribution of open, partially-open, and closed cones throughout the summer is shown in Table 1. There was a pronounced increase in the number of open cones in the July 15 collection. Monthly seed dispersal per acre is shown in Table 2. It is evident that most seed was dispersed from cones located within 7 inches of the ground and that dispersal was greatest between mid-June and mid-August.

Germination and Survival: Although little germination occurred on either site, it was found that seed sown in May and early June produced the largest number of germinants. Mortality of seedlings from seed sown on the dry site in May and early June was 57.7 per cent; mortality of seedlings from seed sown after July 1 was 100 per cent. Comparable figures for the fresh site were 23.3 and 38.4 per cent.

Status Continuing.

Reports *Unpublished*

Bruce, N.G. and N. R. Walker. 1965. Studies of the morphology of jack pine cone opening and the phenology of seed dispersal and germination. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-14.

TABLE 1. NUMBER OF OPEN, PARTIALLY-OPEN, AND CLOSED CONES AT MONTHLY INTERVALS

(Bruce and Walker 1965)

Date	Height above ground (inches)											
	0–7				7–12				12+			
	Open	Partially open	Closed	Total	Open	Partially open	Closed	Total	Open	Partially open	Closed	Total
May 20–22	16	4	159	179	0	2	181	183	1	0	123	124
June 17–19	10	47	137	194	2	9	133	144	0	2	90	92
July 15	101	19	75	195	16	18	126	160	1	2	88	91
Aug. 12	96	14	86	196	21	17	118	156	5	4	79	88
Sept. 11	85	33	78	196	23	21	92	136	5	3	60	68
Oct. 7	77	20	91	188	10	18	96	124	1	11	56	68
Total	385	137	626	1,148	72	85	746	903	13	22	496	531
Per Cent	34	12	54		8	9	83		3	4	93	

TABLE 2. PERIODIC SEED DISPERSAL PER ACRE FROM SLASH

(Bruce and Walker 1965)

Date	Height above ground (inches)			Total	Pounds per acre
	0–7	7–12	12+		
May 20–22	104,221	444	1,053	105,718	0.81
June 17–19	170,103	13,251	0	183,354	1.40
July 15	556,244	29,306	1,074	586,624	4.48
Aug. 12	235,008	22,098	8,711	265,817	2.03
Sept. 11	10,963	22,023	2,466	35,452	0.27
Oct. 7	44,739	0	0	44,739	0.34
Total	1,121,278	87,122	13,304	1,221,704	9.33

Project MS-243 The ecological effects of prescribed burning in jack pine – southeastern Manitoba.

Classification 181.43

Investigators Present: H.P. Sims

Objectives To study the ecological effects of prescribed burning in cut-over jack pine stands.

Location Sandilands Forest Reserve, Manitoba. Latitude 49°25'N, longitude 96°15'W.

Work Done Studies are in progress on three one-acre plots that were prescribe-burned in 1964. Effects on lesser vegetation are being studied on 40 one-quarter-milacre quadrats on each plot. Organic matter content of the A horizon and infiltration rates were determined both before and after burning. In addition, samples of the A and B horizons were collected before burning for chemical analysis, determination of pH, and determination of field capacity and wilting coefficient.

Results Organic matter content of the A horizon did not differ significantly before and after burning. Infiltration time (one litre of water over 100 sq. cm.) into mineral soil averaged 8.54 minutes before burning and 9.12 minutes after burning. Percolation time into unburned litter was 5.63 minutes, and into burned humus and ash was 6.63 minutes. Neither difference was significant at the one per cent level.

Comments Ecological studies on future prescribe burns will be distributed to provide a cross-section of site and time of burning. Emphasis will be placed on studies of lesser vegetation, soil chemistry, soil pH, soil-surface temperatures, soil moisture relations, and rodent populations.

Status Continuing

Reports

Unpublished

Sims, H.P. 1965. The ecological effects of prescribed burning in jack pine – southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-17.

Project MS-245 The use of prescribed burning in jack pine management in southeastern Manitoba.

Classification
231.322
232.213
232.33
232.4
436

Investigators Present: J.H. Cayford

Objectives To determine under what conditions fire can be used in cut-over jack pine stands for seedbed preparation for seeding or site preparation for planting.

Location Sandilands Forest Reserve, Manitoba. Latitude 49°25'N, longitude 96°15'N.

Work Done In July 1964 a series of five one-acre plots were burned with the objective of preparing seedbeds for jack pine regeneration. The experimental area had been partially cut over during the winter of 1963-64 and on four plots all remaining trees were felled in June 1964. On the fifth plot ten trees were left to provide a seed source. The experimental area is located on a dry, sandy site.

The plots were burned under drought indices of 10 and 11, and fire danger indices of 8 to 10. After the burning a survey of seedbed conditions was carried out and four seed traps were installed in the plot where the seed trees had been left uncut.

Results Virtually 100 per cent of each plot area was burned; all fine fuel and living vegetation was consumed. The seed trees were all killed. Organic layers were burned and reduced in depth. Depth of organic matter before burning ranged from 1.2 to 1.6 inches; after burning, from 0.3 to 0.6 inch. Reduction in depth ranged from 60 to 79 per cent. Mineral soil exposure varied from 15 to 36 per cent, with the most severe fires occurring on areas that originally supported the densest stands.

Comments Silvicultural studies are planned for the burned-over areas in which natural seeding, planting and artificial seeding will be compared, in which spring and fall planting and seeding will be compared, and in which planting and seeding on burned areas will be compared with similar treatments on mechanically prepared areas. Germination and seedling development will be studied on the various seedbed conditions created by burning. Additional burning will be undertaken under a range of site, fuel, and weather conditions.

Status Continuing

Reports
Unpublished
Cayford, J.H. 1965. The use of prescribed burning in jack pine management in southeastern Manitoba. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65-MS-1.

Project H-65A Experimental cutting to obtain jack pine regeneration.

Classification
221.1
231.321
232.213
232.216
232.33
436

Investigators Past: J.L. Farrar

Objectives To investigate various methods of preparing favourable seedbeds and providing adequate seed supply necessary for jack pine regeneration.

Location Township Fingal, north-northeast of Ramsay, Ontario – accessible by the KVP Company's road system. Latitude 47°30'N, longitude 82°15'W.

Work Done In 1948, six 2.5-acre areas, each divided into two treatment parts, were established in a 58-year-old jack pine stand containing a small admixture of trembling aspen. Various combinations of the following treatments were carried out on these areas in 1948-49.

Conventional logging: Timber clear cut in autumn; 100-inch logs piled by hand along 12-foot-wide strip roads spaced 66 feet from centre to centre; slash piled in windrows between strip roads; wood hauled out on snow.

Logging by skidding in tree lengths: Timber clear cut in autumn; trees close to skidway cut and skidded first and remote ones last; all trees skidded by cable before snowfall.

Logging by skidding logs in bundles: Timber clear cut in autumn; bundles of 100-inch logs skidded by crawler tractor before snowfall.

Scarification with Athens plough: A heavy four-disc Athens plow pulled by a crawler tractor through spaces free of obstructions; scarification done early in May.

Broadcast burning: Slash and litter burned in mid-afternoon on May 10th; estimated slash fire hazard 8-10.

Direct seeding: After mixing with sawdust, local seed broadcast at the rate of 40,000 seeds per acre; seed viability 80 per cent; seeding done shortly after May 10th.

Scattering lopped slash: Lopped slash scattered on exposed mineral soil early in May.

Between 1949 and 1952, annual regeneration tallies were made by means of permanent 0.001-acre quadrats. Arranged in groups of eight, there were 96 of such quadrats per combination of treatments. In addition, pertinent data were collected several times each summer at a number of permanent observation stations.

Results Table 1 shows the 1952 regeneration values by species and treatment combination in terms of per cent 0.001-acre quadrats stocked with one or more seedlings. Table 2 shows the annual stocking values for jack pine averaged over all treatments and covering the entire 1949-52 period. Results obtained were as follows:

(1) Lopping and scattering of cone-bearing slash on mineral soil exposed by skidding logs in bundles produced the best stocking of jack pine seedlings (58 per cent). The use of the Athens plough after conventional logging and accompanied by lopping

TABLE 1. PERCENTAGE OF 0.001-ACRE QUADRATS STOCKED WITH ONE OR MORE SEEDLINGS IN OCTOBER 1952 BY SPECIES AND TREATMENTS

(Farrar, Gray and Avery 1954).

Area	Treatment	Jack pine	Trembling aspen	Any species
1A	Conventional logging, plus broadcast burning.	7	28	32
1B	Like 1A, plus direct seeding.	16	18	29
2A	Conventional logging, plus scattering lopped slash, plus broadcast burning.	6	39	43
2B	Like 2A, plus direct seeding.	23	37	54
3A	Conventional logging.	15	15	25
3B	Like 3A, plus direct seeding	23	16	31
4A	Conventional logging, plus scarification with Athens plow, plus scattering lopped slash.	44	20	45
4B	Like 4A, plus direct seeding.	52	33	54
5A	Logging by skidding in tree lengths	36	27	46
5B	Like 5A, plus scattering lopped slash.	38	42	58
6A	Logging by skidding logs in bundles.	54	66	70
6B	Like 6A, plus scattering lopped slash	58	64	67

TABLE 2. PERCENTAGE OF 0.001-ACRE QUADRATS STOCKED WITH ONE OR MORE JACK PINE SEEDLINGS, 1949-52

(Farrar, Gray and Avery 1954)

Year	Averages (all treatments)
1949	29
1950	41
1951	37
1952	35

and scattering of slash resulted in somewhat poorer stocking (44 per cent), while skidding in tree lengths resulted in still poorer stocking (38 per cent).
(2) Very few seedlings occurred after conventional logging, and broadcast burning early in the spring did not improve the results. After burning, the lower portion of the organic layer remained intact.
(3) Most seeds germinated during the first and the second growing seasons. Some seeds germinated in subsequent years.
(4) Seedling mortality was heavy, especially during their first growing season. Many seeds and seedlings were eaten. Frost was also a cause of damage.
(5) Direct seeding after conventional logging, whether the logging was followed by a burn or not, resulted in a fair crop of seedlings on the few accidentally exposed patches of mineral soil, but not elsewhere.

Comments A usable technique might result if a method for scarifying could be integrated with logging so that the slash need only be handled once (Farrar, Gray and Avery, 1954).

Status Closed.

Reports

Published

Gray, D.W. 1950. Reproduction following the cutting of a pure jack pine stand. Pulp Pap. Mag. Can., Woodlands Review 51 (1): 104–108.

Farrar, J.L., D.W. Gray and D. Avery. 1954. Jack pine reproduction. Pulp Pap. Mag. Can., Woodlands Review 55 (12): 136–146.

Project H-65B Scattering of jack pine slash on exposed mineral soil.

Classification 221.1
231.321
231.39

Investigators Present: Z. Chrosciewicz

Objectives To induce jack pine regeneration by scattering cone-bearing branches on exposed mineral soil.

Location Township L, north-northeast of Espanola, Ontario – accessible by the KVP Company's West Branch Road. Latitude 46°56'N, longitude 82°13'W.

Work Done Early in June of 1956, a slash-scattering operation was carried out on a 26-acre area clear cut in 1955 by a bundle-yarding method. It was estimated that about 10 to 15 per cent of the area was scarified by the yarding operations. Cone-bearing jack pine branches, cut to lengths of 2 to 3 feet, were scattered at about 4-foot intervals on scarified portions of cutting strips, on secondary roads, and wherever the mineral soil was exposed in the course of normal logging operations. In the autumn of 1957, a portion of the treated area was sampled for regeneration by means of transects of 0.001-acre quadrats. Two sets of such transects were established on the same sample area: transects in the first set were located between slash windrows where mineral soil was exposed, and transects in the second set were located 33 feet apart across slash windrows traversing both scarified and unscarified seedbeds. There were 160 quadrats in each of the sets. The purpose of making this survey by two separate sets of strips was first, to determine the effectiveness of the treatment when mineral soil is exposed, and second, to demonstrate that, unless an area is thoroughly scarified, the treatment will not sufficiently improve the overall stocking (Chrosciewicz, 1960).

Results Table 1 shows the percentage of 0.001-acre quadrats stocked with one or more seedlings. The data in this table (Chrosciewicz, 1960) revealed that:

(1) By 0.001-acre quadrats, the over-all stocking of all tree species was only moderate (40 per cent), but half of it was due to jack pine that resulted directly from the treatment. Jack pine stocking on exposed mineral soil was excellent (90 per cent), and many quadrats supported more seedlings than normally required to produce a well-stocked stand.
(2) From a standpoint of acceptable stocking, it is far more important to have scarified patches at say, 4-foot spacings, even if they are relatively small, rather than a few larger patches at much wider spacings. The conditions may be considerably

TABLE 1. PERCENTAGE OF 0.001-ACRE QUADRATS STOCKED WITH ONE OR MORE SEEDLINGS AFTER TWO GROWING SEASONS

(Chrosciewicz 1960)

	Jack pine	Black spruce	Balsam fir	Trembling aspen	All species
Exposed mineral soil (between slash windrows)	90	No other species recorded			
Various seedbeds (across slash windrows)	20	11	4	9	40

improved by the use of some means of mechanical scarification supplementing the normal logging operations.

Comments Provided that sufficient mineral soil is exposed, the scattering of cone-bearing branches can be regarded as a dependable method of regenerating jack pine after cutting (Chrosciewicz, 1960).

Status Continuing.

Reports

Published

Chrosciewicz, Z. 1960. Jack pine regeneration after scattering slash on exposed mineral soil. Pulp Pap. Mag. Can., Woodlands Review 61(3): 164-166.

Project H-69[1] Nipigon growth and yield survey, Forest Section B.9, Ontario.

Classification 542
566

Investigators Past: G.H.D. Bedell,
Present: F. Evert

Objectives To determine the feasibility of assessing growth and yield of the more important forest cover-types and site-types by means of permanent line plots.

Location Forest Section B.9 in the Thunder Bay District of Ontario. Latitudes 48°40' to 49° 40'N, longitudes 87°35' to 90°10'W.

Work Done Between 1948 and 1950, information was obtained about site-types and stand characteristics from 539 plots, of which 93 were pure jack pine. By 1960, all plots had been remeasured once.

The site classification used in the survey is described in Figure 1, and the number of plots by site-types and age classes for the jack pine cover-types are shown in Table 1.

Per acre values of stand density index (SDI), basal area, number of trees, and merchantable and total volume have been compiled from the original measurements but not from the remeasurements.

Results The site indices for jack pine at ages 50 and 100 years, compiled from original measurements, are shown in Figure 2, The site-types are arranged with the driest to the left and the wettest to the right, although site-type E may be considered an exception (see Figure 1). Jack pine site indices increase with increasing moisture regime until an optimum is reached (on site-type C) and then decline. Base yield curves for jack pine show the same trend as the site indices.

Comments None.

Status Continuing.

Reports *Unpublished*

Bedell, G.H.D. 1951. Forest productivity of Forest Section B.9. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Bedell, G.H.D. and D.W. MacLean. 1951. A site classification for Forest Section B.9. Ontario. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Bedell, G.H.D. and D.W. MacLean. 1951. Site classification, Forest Section B.9. The use of ground cover patterns and site indicator plants. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Jarvis, J.M. 1951. Soil profiles for the site-types in Forest Section B.9. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

MacLean, D.W. 1951. Mapping of site-types from air photos. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

[1] Project summary prepared by F. Evert.

Figure 1. Site classification for Forest Section B.9. (Bedell & MacLean 1952).

MOISTURE REGIME

PERMEABILITY	Extremely Dry 0	Very Dry 0	Dry 1	Adequate 2	Somewhat Moist 3	Moist 4	Very Moist 5	Alternately Moist and Wet 6	Wet 7	Very Wet 8	Saturat. 9
Rapid..... 0 Extremely Pervious Gravels And Coarse Sands; 1 Very Pervious Medium And Fine Sands			Site E: Cornus/Aralia/Aster jP, Mwd, bS/jP, some bS and Hwd. Cornus/Aralia/Alnus Crispa Mwd, jP, bS/jP. Hypnum/Hylocomium jP, bS, bS/jP, Mwd.			Site F₂: Hypnum/Hylocomium bS, jP Sphagnum/Ledum/Hylocomium bS, Mwd		Site H: Sphagnum/Ledum/Hylocomium bS, bS/jP Sphagnum/Ledum/Equisetum and Sphagnum/Ledum/Alnus bS			
Moderate..... 2 Pervious Fine Sands And Loamy Sands; 3 Moderately Pervious Loams And Sandy Loams	Site L: Cladonia/ Melampyrum Unmerchantable Stands.	Site I: Cornus/Aralia/ Alnus Crispa (Aralia Stunted) jP, bS/jP Cornus/Aralia/ Aster Hwd, Mwd, jP.	Site C: Cornus/Aralia/ Aster Hwd, Mwd. Cornus/Aralia/ Alnus Crispa Hwd, Mwd, jP, bS/jP Hypnum/ Hylocomium jP, Mwd.	Site A: Cornus/Aralia/Aster Hwd, Mwd. Occasionally Almost Pure wS Aster/Cornus/Hypnum (Temporary Fire Type) bS/jP, jP Hypnum/Hylocomium bS/jP		Site B: Cornus/Aralia/Aster Hwd, Mwd. Hypnum/Hylocomium bS, Mwd		Site D: Hypnum/ Hylocomium bS, Mwd Sphagnum/Ledum/ Hylocomium bS	Site G: (non-telluric) Sphagnum/Ledum/ Hylocomium and Sphagnum/Ledum/ Equisetum bS (telluric) Sphagnum/ Ledum/Alnus bS Sometimes with F and C	Site K: Sphagnum/Ledum/ Chamaedaphne, Sphagnum/Ledum/ Alnus and Sphagnum/Ledum/ Hylocomium bS With Scattered L	Site M: Sphagnum/ Chamaedaphne/ Sarracenia Stunted Scattered bS and L
Slow..... 4 Pervious With Difficulty, Loams And Sandy Loams; 5 Channelled Impervious Clay Loams And Clays											
Very Slow..... 6 Porous Impervious Clays, Silt Loams And Clays; 7 Extremely Impervious Clay											
Essentially Impermeable... 8 Fractured Impermeable Bedrock; 9 Impermeable Bedrock	Site R₂: Umbilicaria/ Potentilla Unmerchantable Stands.	Site R₁: Hypnum/ Hylocomium bS, bS/jP, Mwd. Cornus/Aralia/ Alnus Crispa bS, Mwd	Pattern Sites: Site F₁ = R + E + C + A Hypnum/Hylocomium Mwd, bS Cornus/Aralia/Alnus Crispa Mwd, bS/jP			Site F₃ = R + F₂ + B Hypnum/Hylocomium bS, some jP and Mwd.			Legend: jP Jack Pine; bS Black Spruce; wS White Spruce; F Fir; L Larch; C Cedar; bS/jP Black Spruce/Jack Pine; Mwd Mixedwood; Hwd Hardwood		

TABLE 1. NUMBER OF PLOTS BY SITE TYPES AND AGE CLASSES FOR JACK PINE COVER-TYPES

(Bedell and MacLean 1952)

Cover-type	Age class	A	B	C	D	E	F_1	F_2	F_3	G	H	I	K	R_1	Total
Jack pine	21–40			2		7		1				15			25
	41–60			2		9	3					6			20
	61–80			3		7									10
	81–100	2		19		13									34
	101+					4									4
	Total	2		26		40	3	1				21			93
Black spruce-jack pine	21–40					1						3			4
	41–60											1			1
	61–80			1		3	1							1	6
	81–100	1				1	9							2	13
	101+	9		1		3	1							3	17
	Total	10		2		8	11					4		6	41
Hardwood-jack pine	21–40			6		1						3			10
	41–60			6		1									7
	61–80	3		3		1									7
	81–100	3		4		4	2							1	14
	101–120						1							1	2
	120+						1								1
	Total	6		19		7	4					3		2	41

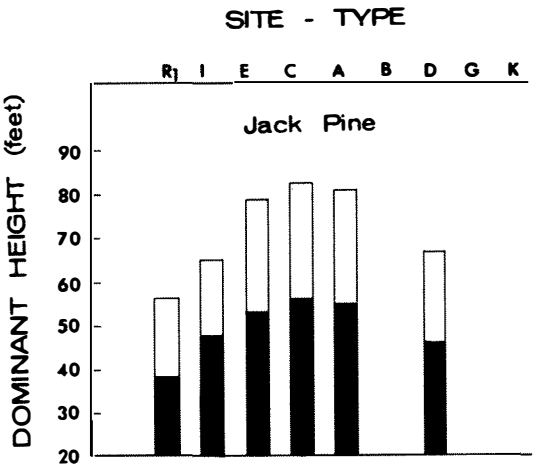

Figure 2. Influence of site on the dominant height/ age relationship. At 50 years, shaded; at 100 years, shaded plus unshaded. (Bedell & MacLean 1952).

Reports

Unpublished (continued)

MacLean, D.W. 1951. Site-type and cover-type estimates, Forest Section B.9. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Bedell, G.H.D. and D.W. MacLean. 1950. Nipigon growth and yield survey. Canada, Dept. Resources and Development, Forestry Branch, S. & M. 50-1. 13 pp.

Hills, G.A. and W.G.E. Brown. 1950. A site classification for the Nipigon area. Canada, Dept. Resources and Development, Forestry Branch, S. & M. 50-2. 15 pp.

Bedell, G.H.D. and D.W. MacLean. 1952. Nipigon growth and yield survey. Canada, Dept. Resources and Development, Forestry Branch, Silv. Res. Note 101. 51 pp.

Project H-72[1] Growth and yield survey, Forest Section B.7, Quebec.

Classification 542
566

Investigators Past: G.H.D. Bedell, D.W. MacLean, J. Krewaz.
Present: F. Evert

Objectives To determine the changes in density and stand composition for the important site and cover-types.

Location Eastern part of Forest Section B.7, Quebec. Latitudes 46°30' to 47°50'N, longitudes 73°30' to 78°30'W.

Work Done Since 1948 information has been obtained about site-types and stand characteristics from 864 plots of which 303 were pure jack pine. Ten-year remeasurement on these plots has been started, but a very limited number of remeasurements have been made as yet.

The features emphasized in site typing were soil moisture regime and permeability. Moisture regimes and permeabilities were grouped as shown in Table 1. The jack pine cover-types were common on site-types C, E, I, L, and A. The number of plots by site-types and age classes for the jack pine cover types are shown in Table 2.

Results The dominant height/age relationships show a strong correlation with the yield site-types, as shown on Figure 1. The base yield curves separated out as well as could be expected with inadequate sampling. These cannot be used for yield prediction until remeasurement data are available. However, to provide rough approximations for immediate use, empirical yield tables were prepared from the sample plot data (Bedell, Brown and MacLean, 1953) and have since been revised (Krewaz, 1962).

Comments None.

Status Continuing.

Reports

Unpublished

MacLean, D.W. 1950. Growth and yield survey – Forest Section B.7. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

McCormack, R.J. 1952. Construction of local volume tables. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Bedell, G.H.D. 1954. Forestry Branch growth and yield investigations in Forest Section B.7. (Quebec). Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Krewaz, J. 1962. Empirical yield tables for selected site-types in Forest Section B.7. (Quebec). Canada, Dept. Forestry, Forest Research Branch. Unpubl. MS. Ont. 62-19.

Published

Bedell, G.H.D., W.G.E. Brown and D.W. MacLean. 1953. Forest site classification and growth of the jack pine cover-types in Forest Section B.7. (Quebec). Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., S. & M. 53-2. 102 pp.

[1] Project summary prepared by F. Evert.

TABLE 1. YIELD SITE TYPES FOR FOREST SECTION B.7, QUEBEC

(Bedell, Brown and MacLean 1953)

Permeability	Moisture Regime										
	Ex. Dry θ	Dry 0	Somewhat dry 1	Optimum 2	Somewhat moist 3	Moist 4	Very moist 5	Somewhat wet 6	Wet 7	Very wet 8	Saturated 9
Instantaneous θ											
Ex. rapid 0				E			F				
V. rapid 1											
Rapid 2											
M. rapid 3	L	I						D	G	K	M
Moderate 4			C		A		B				
M. slow 5											
Slow 6											
V. slow 7					P					S	
Fractured impermeable 8						R					
Impermeable 9											

TABLE 2. PLOT SAMPLE DISTRIBUTION JACK PINE COVER-TYPES, FOREST SECTION B.7

(Krewaz 1962)

Subtype of cover-type	Age class	Site group															
		A	B	C	D	E	F	G	H	I	K	L	M	Ra	Rb	Rc	R (other)
Jack pine	21-40	13		36		23			1	26				2		1	1
	41-60	8		15						20		1					1
	61-80	8		8		3				30							
	81-100	8		22		18				20							1
	101-120	5		7		8			1	1						5	1
	121+	1		3		4			1								
	Total	43*		91*		56*			3	97*		1		2		6	4
Black spruce-jack pine	21-40	6		7	2	3				2				2	3	8	3
	41-60	3		6		10				1							
	61-80	1	1	4	2	6				1							
	81-100	1	2			2										2	
	101-120		6	3		7	3			2						2	
	121+			2		18				2							
	Total	11	9	22*	4	46*	3			8*				2	3	12	3
Mixedwood (Hwd.-jP)	21-40	4	1	4	2	3			1			1		1			
	41-60																
	61-80	10	2	4		1							2	20			
	81-100	3				1						1					
	101-120	3	1			2						2					
	121+																
	Total	20*	4	8*	2	7			1			4	2	21			

* Site types that warrant sampling priority.

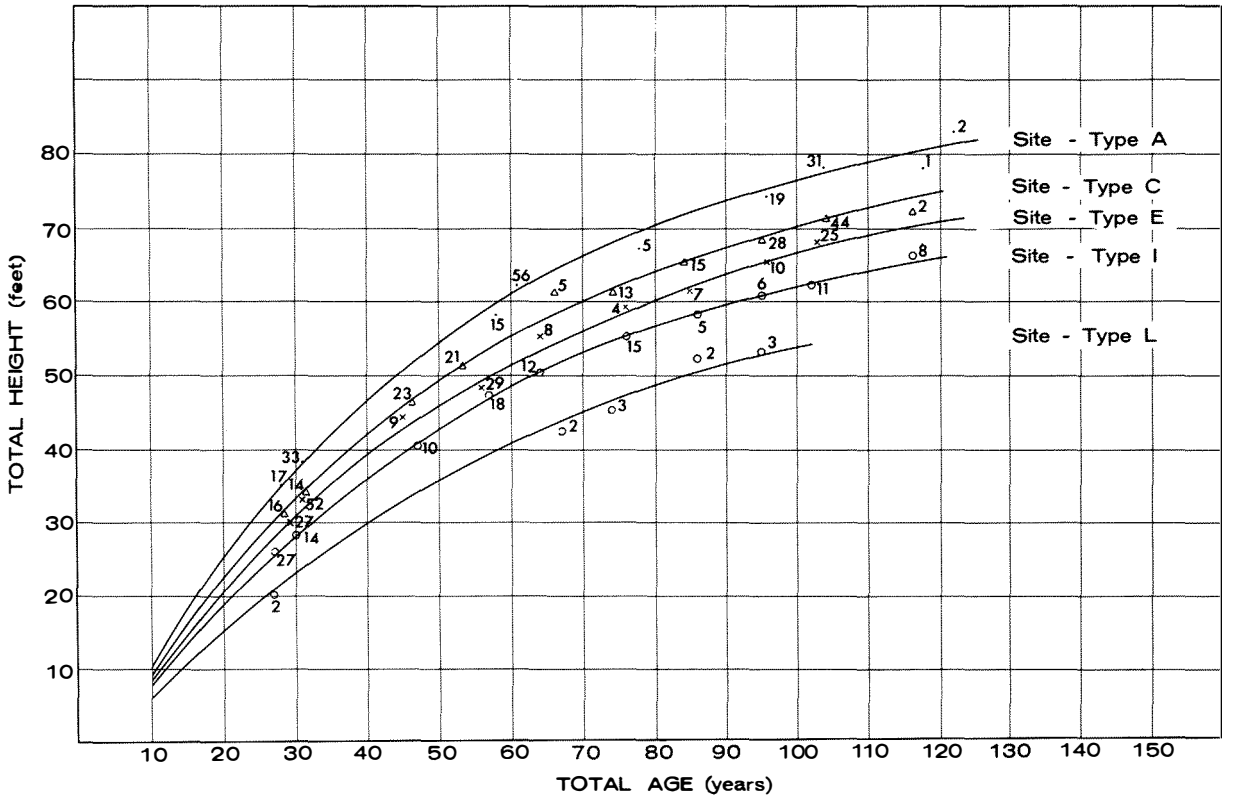

Figure 1. Dominant height/age curves jack pine. (Bedell, Brown & MacLean 1953).

Project H-81 Hand seeding of jack pine.

Classification 232.216
232.33

Investigators Past: J.R.T. Andrews, Z. Chrosciewicz

Objectives To ascertain the extent of jack pine germination, survival and stocking after seeding scarified scalps on five different sites.

Location Townships 120, A and G, north-northwest of Espanola, Ontario – accessible by the KVP Company's West Branch Road. Latitudes 46°33' to 46°49'N, longitudes 81°59' to 82°05'W.

Work Done Five 0.2-acre plots were seeded between July 22 and August 6, 1951. Six-inch-square scalped spots were prepared at 6-foot spacing and sown with about 30 seeds each (germinating capacity 50 to 68 per cent).

Seedlings were tallied in August 1952 and in June 1957. During these two surveys every seeded spot was examined and all seedlings counted.

Results Tables 1 and 2 show site conditions and jack pine regeneration on the spot seeded plots. Both on the basis of these data and from field observations, the following conclusions were derived (Chrosciewicz, 1960):

(1) Best germination resulted from seeding on somewhat moist, uniformly stratified, sorted, and stone-free sandy soil. As the moisture in such soil decreased, the over-all germination was reduced.
(2) Generally, seedling survival was better under less dense ground vegetation. Smothering by fallen litter and excessive overhead shading by competing vegetation were the main factors responsible for the mortality of young seedlings.
(3) After the seedlings were firmly established, they grew best in full sunlight.
(4) In terms of scalps stocked with one or more jack pine seedlings, the over-all stocking six years after seeding was moderate (43.8 per cent) on one plot and poor (below 29 per cent) on the remaining four plots.

Comments Further experimental work is needed to determine the conditions under which spot seeding will produce satisfactory jack pine regeneration (Chrosciewicz, 1960).

Status Closed

Reports

Unpublished

Andrews, J.R.T. 1951. Hand seeding of jack pine, West Branch Spanish River Management Unit, K.V.P. Company limits, Espanola, Ontario. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Chrosciewicz, Z. 1958. Spot seeding of jack pine, K.V.P. Company limits, Espanola, Ont. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Chrosciewicz, Z. 1960. A spot seeding trial with jack pine. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Mimeo 60-1. 8 pp.

TABLE 1. SITE DESCRIPTION ON SPOT SEEDED PLOTS

(Chrosciewicz 1960)

Plot	Parent soil material	Pore pattern	Moisture regime	Eco-climate	History	Overhead cover tree species	Ground cover main species
1	Uniformly stratified, sorted sand	1/0	0 to 1	Normal, moister	Old field, formerly cultivated	None	Dense cover of grass with some bracken.
2	Uniformly stratified, sorted gravelly and stony sand	0	0	Colder, moister	27-year-old burn	Open stand of badly stunted and defective trembling aspen, and widely-scattered jack pine.	Moderately dense cover of sweet-fern, and velvet-leaf-blueberry.
3	Uniformly stratified, sorted sand	2/0	0 to 1	Hotter, drier	27-year-old burn	Extremely open stand of jack pine, and widely-scattered red pine.	Moderately dense cover of sweet-fern, velvet-leaf-blueberry, and bush-honeysuckle.
4	Water-laid till; few boulders	2	1	Normal	3-year-old cut-over	Widely-scattered advance growth of black spruce, white spruce, white pine, and white birch.	Dense cover of beaked hazel, bracken, sweet-fern, velvet-leaf-blueberry, bush-honeysuckle, and large-leaved aster.
5	Uniformly stratified, sorted sand	0	2	Colder, moister	5-year-old cut-over	Widely-scattered advance growth of black spruce, white spruce, and balsam fir.	Dense cover of sheep-laurel, sweet-fern, and velvet-leaf-blueberry.

TABLE 2. JACK PINE REGENERATION ON SPOT SEEDED PLOTS

(Chrosciewicz 1960)

Plot	Number of seeded spots per acre 1951	Stocked spots					Seedlings				
		Number per acre		Per cent		Per cent survival	Number per acre		Per cent survival	Average number per stocked spot	
		1952	1957	1952	1957	1952/57	1952	1957	1952/57	1952	1957
1	1210	650	275	53.7	22.7	42.3	2275	835	36.7	3.5	3.0
2	1210	430	345	35.5	28.5	80.2	850	610	71.8	2.0	1.8
3	1210	750	530	62.0	43.8	70.7	2145	1155	53.8	2.9	2.2
4	1210	425	105	35.1	8.7	24.7	720	160	22.2	1.7	1.5
5	1210	785	260	64.9	21.5	33.1	2740	880	32.1	3.5	3.4

Project H-82 Thinning in overstocked jack pine.

Classification 242

Investigators Past: J.R.T. Andrews.
Present: Z. Chrosciewicz

Objectives To determine which of the intensities of thinning used will produce the most satisfactory results in terms of diameter, height, basal area, and volume increment.

Location Township 120, north-northwest of Espanola, Ontario – accessible by the KVP Company's West Branch Road. Latitude 46°37'N, longitude 81°59'W.

Work Done In 1951, four adjoining one-acre experimental areas were established in an overstocked, 26-year-old jack pine stand on a flat sandy site. Three of these areas were thinned and the remaining area was left intact as a control. The resultant average spacings between trees on the individual areas were 5.5, 7.2, 8.4, and 11 feet. All stand measurements before and after thinning were made by means of 0.2-acre plots centrally located, one on each of the four areas. The plots were remeasured in 1956 and 1961, and further remeasurements are scheduled every ten years.

Results The first five-year results revealed that (Chrosciewicz, 1957):

(1) Thinning very positively affected the rate of diameter growth. Growth increased considerably with wider spacing.
(2) Generally, thinning failed to stimulate height growth. In fact, growth at wider spacings tended to be less than growth on the control plot.
(3) Net increment in basal area per acre and in volume per acre decreased with wider spacing. It appears that these increments were in a direct relationship with the number of trees per acre.

Comments Results covering the first full ten-year period of growth following thinning will be published in the near future.

Status Continuing.

Reports *Unpublished*

Chrosciewicz, Z. 1957. Thinning of overstocked jack pine, KVP Company limits, West Branch Spanish River. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Project H-91 Survival and development of plantations established by pulpwood companies in Ontario and Quebec.

Classification 232.4

Investigators Present: W.M. Stiell

Objectives To study various plantations established by pulpwood companies in Ontario and Quebec and to determine reasons for their success or failure.

Locations Forest Section B.4 – Northern Clay, Ontario. Latitude 49°30'N, longitude 82°30'W.
Forest Section B.9 – Superior, Ontario. Latitude 48°44'N, longitude 86°23'W.
Forest Section L.11 – Quetico, Ontario. Latitude 48°30'N, longitude 89°30'W.

Work Done *Forest Section B.4.* Between 1924 and 1927, jack pine was planted on flat or gentle slopes of well-drained to wet clays on areas burned over in 1916 and 1921. The plantations were examined in 1927 and in 1948.

Forest Section B.9. Planting has been carried out near Marathon since 1946. By 1955, about 290 acres had been planted, mostly with jack pine and white spruce, but including a few acres each of red and Scots pine. All stock was obtained from Ontario Government nurseries and most jack pine stock was 2-1, although some was 2-0 and 2-2; provenances were Seed Collection Zones 4 and 5. All planting was carried out in the spring, chiefly by hand methods in ploughed furrows, although some plantations were established with a Lowther machine. Spacings were 6 by 6 feet for hand planting and 6 by 4 feet with the machine. The predominant site was an outwash plain, with soils described as somewhat dry loamy sand with gravel. Two old beach formations were described respectively as somewhat dry loamy to medium sands, and dry medium to coarse sands. The areas, which were believed to have supported mixedwoods formerly, had been subjected to repeated burning. At planting, a dense heath cover and scattered clumps of brush and defective hardwoods occupied the site. Occasional survival counts were made and in 1956 height measurements were taken in a number of plantations (Stiell, 1958).

Forest Section L.11. Jack pine was planted in the vicinity of Kakabeka Falls between 1952 and 1955, using 2-1 stock of local origin obtained from an Ontario Government nursery. Both spring and fall planting were practised, with spacings of 6 by 6 to 8 by 8 feet. Most planting was carried out with a Lowther machine. The jack pine was planted on moist silt and clay loams supporting a meadow-type of vegetation with a sod base, and on somewhat moist fine sands with a 50 per cent cover of willow brush. The plantations were examined in 1955.

Results *Forest Section B.4.* In 1948 survival of jack pine was less than 2 per cent. Causes of failure include the unsuitability of the site and competition from natural vegetation.

Forest Section B.9. With regard to the Lowther, machine planting in open areas was found to be practicable from the standpoints of costs and production, as well as the manner in which the individual trees were set out. Some modifications to the machine were considered desirable in the interests of increased safety and ruggedness. A five-man crew was found to be the most efficient, capable of planting 10,000 to 12,000 trees per 8-hour day. However, production was curtailed by heavy brush, windfall, stumps, logging debris, and broken terrain. Since these conditions are more typical of logged-over areas, the usefulness of the machine in its present form was felt to be limited.

TABLE 1. WHITE SPRUCE, JACK PINE, AND RED PINE – MARATHON – 1956

(Stiell 1958)

Years planted	Species	Height (feet)		Seed zone
		Average	Mean of tallest 10 per cent	
10	rP	5.6	6.5	–
7	jP	6.5	7.9	4
	wS	1.9	2.6	4
6	jP	4.5	5.2	4
5	jP	4.3	5.7	4
4	wS	1.5	2.4	4
		1.2	1.8	4
3	jP	2.8	3.6	5
	wS	1.1	1.7	4
2	jP	1.6	2.2	5
1	jP	0.5	0.7	4
		0.8	1.1	5
		0.4	0.7	5

Of the few causes of mortality recorded, too-deep planting of spruce was suspected in one plantation, and frost and exposure in two others. Survival was more than 89 per cent, one to four years after planting, for the five plantations tallied at those ages. Development of the 12 plantations measured in 1956 is shown in Table 1. Jack pine shows much the best performance, achieving height growth of more than a foot in the first growing season after planting. There were three species in the 10-year-old plantation, but growth figures are available only for red pine; however, jack pine was reported to be the tallest, followed by Scots pine which generally showed poor form. White spruce has made very slow initial growth, although current leader growth of the larger trees in the 4- and 6-year-old plantations is about one foot. No prediction can be made on the basis of such early performance. So far there has been no growth differential of the jack pine according to provenance, but these records may eventually prove valuable if differences in future growth or quality are correlated with seed source.

Forest Section L.11. Jack pine averaged 0.4 feet at planting, and made an average growth of 0.4 feet and 0.5 feet, respectively, the first and second seasons after planting. Growth was somewhat better on the sandy site, possibly due to less competition from ground cover vegetation. Survival exceeded 70 per cent.

Comments None.

Status Continuing.

Reports

Unpublished

Stiell, W.M. 1954. Co-operative plantation survey. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Stiell, W.M. 1958. Pulpwood plantations in Ontario and Quebec. Can. Pulp Pap. Assoc., Woodlands Section Index 1770(F-2). 42 pp.

Project H-108 The use of controlled burning to secure jack pine regeneration.

Classification 231.322
232.213
232.33
436

Investigators Past: J.R.T. Andrews, Z. Chrosciewicz.

Objectives To develop methods of regenerating jack pine by fire.

Location Townships 120, B and L, north-northwest of Espanola, Ontario – accessible by the KVP Company's West Branch Road. Latitudes 46°35' to 46°58'N, longitudes 81°58' to 82°14'W.

Work Done Between 1949 and 1956, several trials of controlled burning were carried out. The experiments included burning an open jack pine stand, burning slash plus subsequent broadcast seeding of jack pine, and burning slash with jack pine seed trees. Results were evaluated in per cent of 0.001-acre quadrats stocked with one or more jack pine seedlings per quadrat approximately two years after the application of treatments.

Results Data describing the burns are summarized in Table 1. These data and direct field observations revealed that (Chrosciewicz, 1959):

(1) Jack pine can be successfully regenerated by the use of fire, providing (a) the depth of humus is substantially reduced in the course of burning, and (b) the seedbeds thus created are adequately seeded.
(2) In general, the quality of burns improves with increasing dryness of humus. If prolonged droughty weather precedes a burn, the fire may destroy the humus thus creating a favourable seedbed for germination.
(3) Burning cannot be regarded as a dependable means of releasing seed from cones in slash, because the fire either destroys the seed or drastically reduces its viability. In the absence of seed trees, either broadcast seeding or spot seeding must follow burning.
(4) The success of opening cones on seed trees by slash fires depends largely upon the intensity of the fire. A good head-fire may open all the cones on seed trees, or twice as many cones as an average back-fire.
(5) If properly planned, controlled burning may be carried out efficiently and without complications. Suitable weather and adequate fire protection are the main requirements for safe burning.
(6) The cost of burning tends to vary with both the size of burned area and the type of fire.

Comments Some of the experiments were not successful, mainly because the relatively thick humus encountered was too moist for adequate burning. Thus, further study of the use of fire under various conditions, and particularly when the humus is dry, was recommended (Chrosciewicz, 1959). This is being done in Project H-130.

Status Closed.

Reports *Unpublished*

Andrews, J.R.T. 1955. The use of controlled burning to secure jack pine regeneration, West Branch Spanish River Management Unit. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

TABLE 1. SUMMARY OF DATA ON 1949–56 BURNING

(Chrosciewicz 1959)

Burning		Approx. area (acres)	Original jack pine stand	Av. depth of humus[1]		Seeding					Jack pine[2] stocking (%)
Date	Slash fire hazard index			Before burn (in.)	After burn (in.)	Date	Seed trees		Seeds		
							Number per acre	Height (ft.)	Ounces per acre	Viability (%)	
						Burning open stand					
May 30 1949	Unspecified	4	Undisturbed very open	<1.0	<0.5	Shortly after burn	Unspecified	25	Unspecified	Unspecified	60
						Burning slash and broadcast seeding					
Oct. 15 1953	15	4	Clear cut in 1946	1.5	0.5	May 17 1954	–	–	6	87	25
Oct. 15 1953	15	4	Clear cut in 1946	1.5	0.5	May 17 1954	–	–	10	87	50
Oct. 15 1953	15	4	Clear cut in 1946	1.5	0.5	May 17 1954	–	–	12	87	55
Oct. 15 1953	15	4	Clear cut in 1946	1.5	0.5	May 17 1954	–	–	32	50	20
						Burning slash with seed trees					
June 3 1955	16	1	Partial cut in 1954	2.0	1.0	Shortly after burn	10	60	Unspecified	Unspecified	10
June 7 1956	15	13	Partial cut in 1954	2.0	1.0	Shortly after burn	6	60	Unspecified	Unspecified	17
June 11 1956	11	25	Partial cut in 1954	2.0	1.5	Shortly after burn	6	60	Unspecified	Unspecified	13
June 11 1956	11	10	Partial cut in 1954	2.0	1.5	Shortly after burn	12	60	Unspecified	Unspecified	10

[1] Raw humus, or duff

[2] Stocking by 0.001-acre quadrats approx. two years after seeding.

Reports

Unpublished (continued)

Andrews, J.R.T. 1957. The use of controlled burning to secure jack pine regeneration. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Chrosciewicz, Z. 1957. Controlled burning and seeding on jack pine cut-over, K.V.P. Company Limits, West Branch Spanish River. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Chrosciewicz, Z. 1957. Controlled burning with seed trees, K.V.P. Company Limits, West Branch Spanish River. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Chrosciewicz, Z. 1959. Controlled burning experiments on jack pine sites. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 72. 19 pp.

Project H-116 A study of jack pine site indices in Forest Site Regions 4E, 4S and 3W.

Classification 114.4
181.33
181.65
541

Investigators Present: Z. Chrosciewicz

Objectives To determine the effects of soil moisture regime, soil texture, soil petrography, and regional macroclimate on height growth and diameter growth of dominant jack pine trees.

Location Various areas in Ontario. Latitudes 46°58' to 50°12'N, longitudes 80°24' to 92°44'W.

Work Done Field work was done in 1958-59. Sampling was restricted to pure or almost pure, fully stocked, 43- to 97-year-old jack pine stands growing on deep, uniformly sorted, acid, podzolized, sandy soils. Included were five soil moisture regime classes (0 to 4), three soil texture classes (very fine sand, fine sand, and medium sand), and two soil petrography classes (siliceous soil material with less than 10 per cent basic intrusive and effusive rock particles, and siliceous soil material with 30 to 40 per cent basic intrusive and effusive rock particles). Within one of the petrography classes, the entire sampling was replicated in three site regions, 4E, 4S and 3W (Hills), each with a different macroclimate (mid-humid warm-boreal, moist-subhumid warm-boreal, and dry-humid mid-boreal). Three to six dominant jack pine trees per combination of the above site factors were felled and analysed for height and diameter growth. The analysis of data included plotting average growth curves by the various combinations of site factors, and comparing site indices read from these curves at points corresponding to the total tree age of 50 years (Chrosciewicz, 1963).

Results Figures 1 and 2 show the comparisons of site indices, based on average total heights and average breast-height diameters of dominant jack pine trees respectively, by various combinations of soil moisture regime, soil texture, and soil petrography in Site Regions 4E, 4S and 3W. The index values are listed in Tables 1 and 2.

From Figure 1 it is evident that, in terms of tree heights, the effects of site were (Chrosciewicz, 1963):

(1) *Effects of Soil Moisture Regime*

By soil textures and soil petrography classes studied, the highest site indices in each of the three regions were associated with soil moisture regime 3. As the moisture regime in each region decreased from 3 to 0, the site indices gradually diminished. A similar reduction of the site indices in each region occurred when the moisture regime increased beyond the optimum from 3 to 4.

This variation in site indices was generally greater on soils with a lower content of basic rock particles.

(2) *Effects of Soil Texture*

By soil moisture regimes and soil petrography classes studied, the highest site indices in each of the three regions were associated with very fine sand in which the upper soil horizons were silty or loamy. As the texture in each region changed from very fine sand to fine sand, and then to medium sand, the site indices gradually diminished. This variation in site indices was generally greater on drier soils than on moister soils.

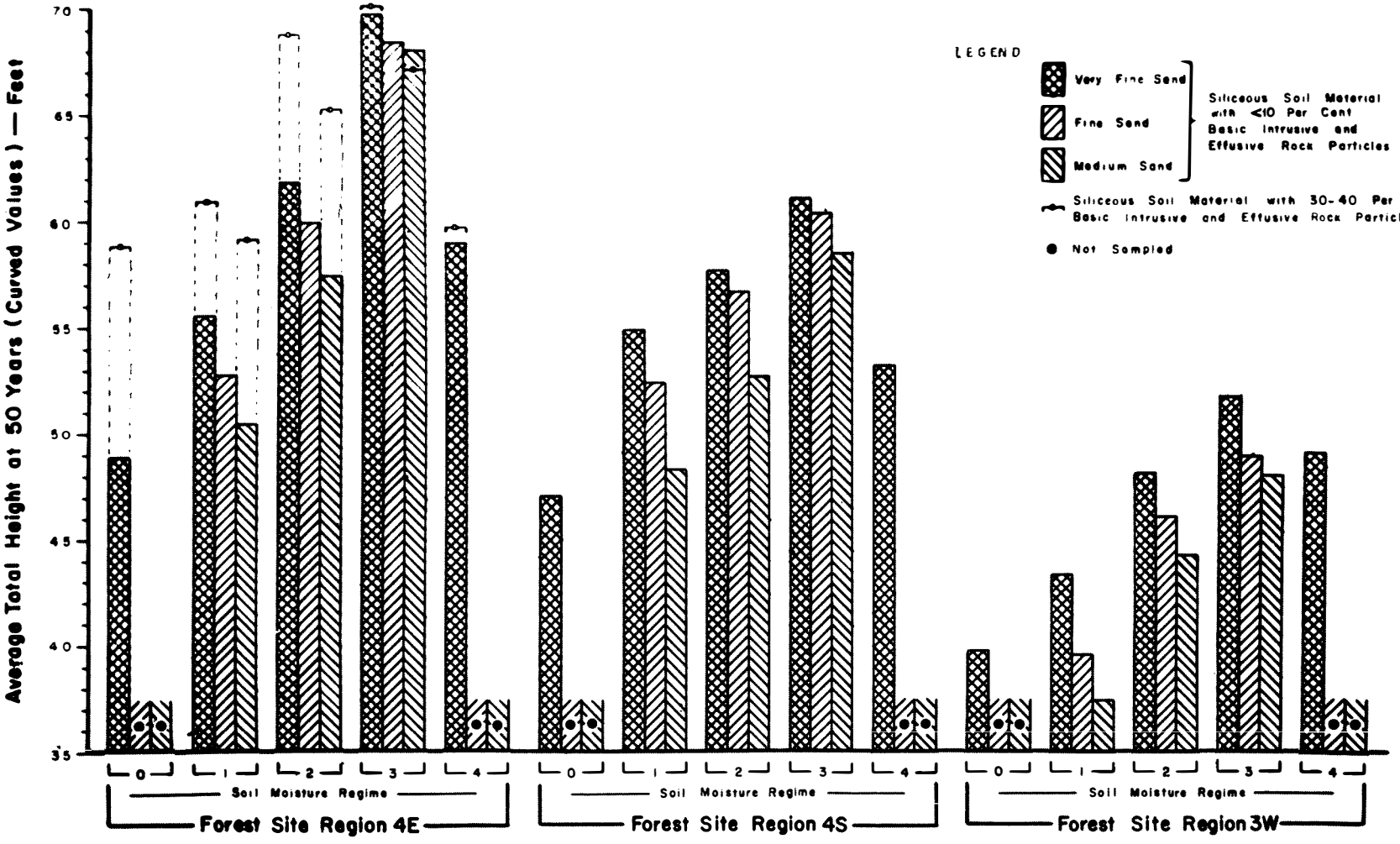

Figure 1. Site indices based on average total heights of dominant jack pine trees. (Chrosciewicz 1963).

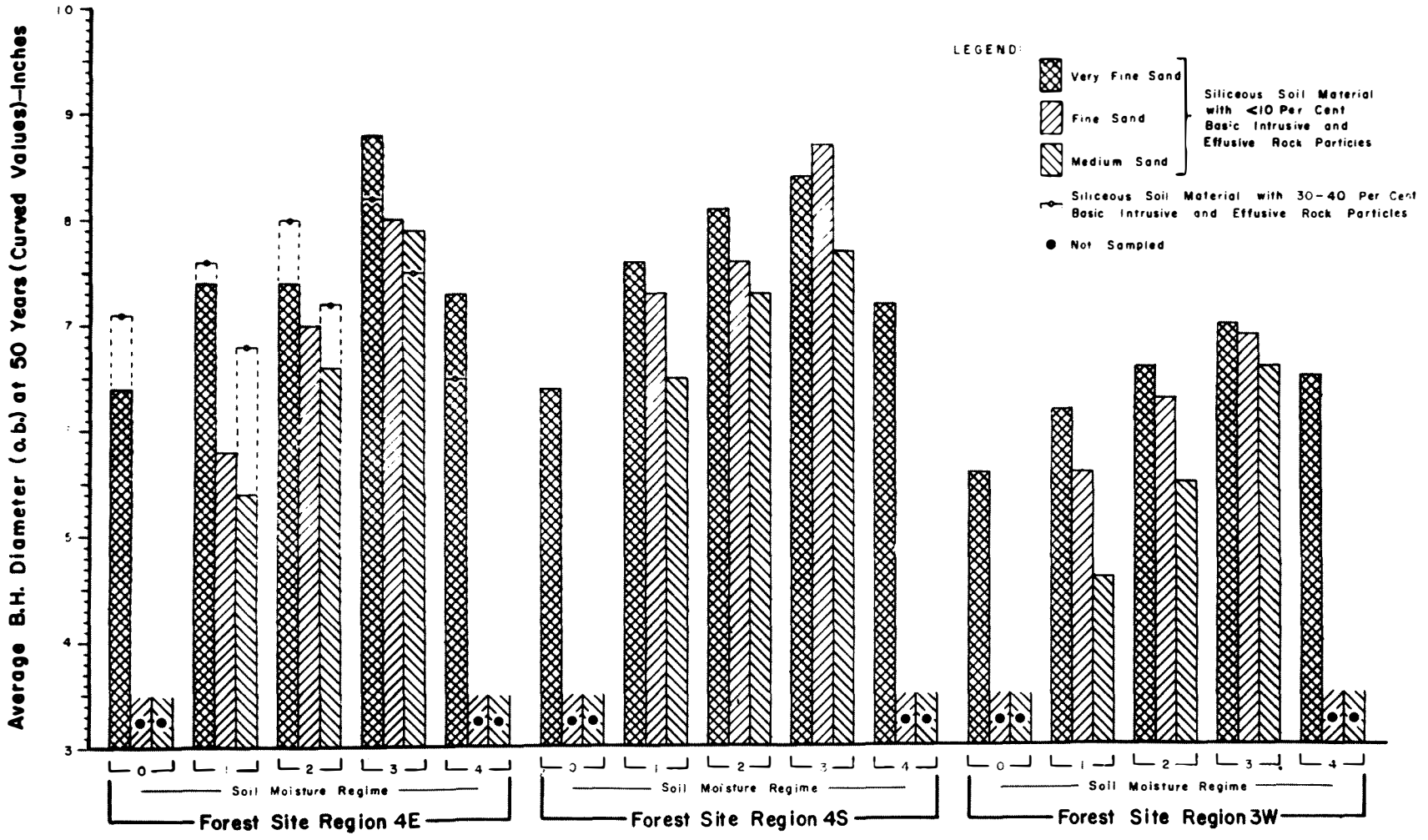

Figure 2. Site indices based on average B.H. diameters of dominant jack pine trees. (Chrosciewicz 1963).

TABLE 1. SITE INDICES BASED ON AVERAGE TOTAL HEIGHTS OF DOMINANT JACK PINE TREES

(Chrosciewicz 1963)

Texture of parent mineral soil material horizons C_1 and C_2	Average total height at 50 years (curved values) feet														
	S.M.R.O.*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	Siliceous soil material with <10 % basic intrusive and effusive rock particles														
Very fine sand**	48.9	47.1	39.8	55.6	55.0	43.4	61.9	57.8	48.2	69.8	61.2	51.8	59.1	53.3	49.2
Fine sand	–	–	–	52.8	52.5	39.6	60.0	56.8	46.1	68.5	60.5	49.0	–	–	–
Medium sand	–	–	–	50.5	48.4	37.4	57.5	52.8	44.3	68.1	58.6	48.1	–	–	–
	Siliceous soil material with 30–40 % basic intrusive and effusive rock particles														
Very fine sand**	58.8	–	–	61.0	–	–	68.9	–	–	70.2	–	–	59.8	–	–
Medium sand	–	–	–	59.2	–	–	65.3	–	–	67.2	–	–	–	–	–

* S.M.R. – Soil moisture regime. 4E, 4S and 3W – Forest site regions.

** Silty sand in the A_2 horizon, and loamy sand in the B_2 and B_3 horizons.

TABLE 2. SITE INDICES BASED ON AVERAGE B.H. DIAMETERS OF DOMINANT JACK PINE TREES

(Chrosciewicz 1963)

Texture of parent mineral soil material horizons C_1 and C_2	Average b.h. diameter (o.b.) at 50 years (curved values) inches														
	S.M.R.O.*			S.M.R.1*			S.M.R.2*			S.M.R.3*			S.M.R.4*		
	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W	4E	4S	3W
	Siliceous soil material with <10 % basic intrusive and effusive rock particles														
Very fine sand* *	6.4	6.4	5.6	7.4	7.6	6.2	7.4	8.1	6.6	8.8	8.4	7.0	7.3	7.2	6.5
Fine sand	–	–	–	5.8	7.3	5.6	7.0	7.6	6.3	8.0	8.7	6.9	–	–	–
Medium sand	–	–	–	5.4	6.5	4.6	6.6	7.3	5.5	7.9	7.7	6.6	–	–	–
	Siliceous soil material with 30–40 % basic intrusive and effusive rock particles														
Very fine sand**	7.1	–	–	7.6	–	–	8.0	–	–	8.2	–	–	6.5	–	–
Medium sand	–	–	–	6.8	–	–	7.2	–	–	7.5	–	–	–	–	–

* S.M.R. – Soil moisture regime. 4E, 4S and 3W – Forest site regions.

** Silty sand in the A_2 horizon, and loamy sand in the B_2 and B_3 horizons.

(3) *Effects of Soil Petrography*
By soil moisture regimes and soil texture classes studied, the highest site indices (except for one value) in Site Region 4E were associated with siliceous soil materials containing 30 to 40 per cent basic intrusive and effusive rock particles. As the content of such particles decreased to less than 10 per cent, the site indices diminished. This variation in site indices was generally greater on drier soils than on moister soils.

(4) *Effects of Regional Macroclimate*
By soil moisture regimes and soil textures within the same soil petrography class studied, the highest site indices were associated with mid-humid warm-boreal climate in Site Region 4E. As the climate changed from mid-humid warm-boreal in this region to moist-subhumid warm-boreal in Site Region 4S, and then to dry-humid mid-boreal in Site Region 3W, the site indices gradually diminished. This variation in site indices was generally greater between Site Regions 4S and 3W than between Site Regions 4E and 4S.

A comparison of Figure 2 with Figure 1 shows that, except for a few irregularities, the site indices based on breast height diameters varied in a similar way to those based on total heights of the same trees (Chrosciewicz, 1963).

Comments

This project represents an initial venture into the complex relationships between jack pine growth and site. There is a definite need for extending the growth study over a much wider range of site conditions. Both the effects of site and the effects of stand density on jack pine growth should be incorporated in such a study. In addition, the existing variations in the basal area per acre, and also in the volume per acre, should be studied on comparable sites and between different sites to determine the actual ranges in their productive capacity (Chrosciewicz, 1963).

Status

Continuing.

Reports

Unpublished

Chrosciewicz, Z. 1962. Original growth curves and data for: The effects of site on jack pine growth in northern Ontario. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Ont. 62-15.

Published

Chrosciewicz, Z. 1963. The effects of site on jack pine growth in northern Ontario. Canada, Dept. Forestry, Publn. 1015. 28 pp.

Project H-119 The effect of black spruce on the development of soil profiles on sandy jack pine sites in Forest Section B.7, Quebec.

Classification 114.3
181.33
181.36
181.65

Investigators Present: Z. Chrosciewicz.

Objectives To determine the relationships between the occurrence of ironpan and the distribution, rooting and growth of black spruce and jack pine.

Location Various areas about halfway between Mont St. Michel and Parent, Quebec – accessible by the James Maclaren Company's road system. Latitudes 47°11' to 47°30'N, longitudes 74°46' to 74°55'W.

Work Done Field work was carried out in 1959. It was restricted to deep, uniformly sorted, acid, podzolized, siliceous fine sand, medium sand and coarse sand, all on flat terraces supporting 6-, 36-, and 102-year-old jack pine–black spruce stands. The species composition ranged from almost pure pine to almost pure spruce. Five different stages of ironpan formation were recognized, and sampling within the individual stages included detailed description of soil profiles, determination of soil moisture regimes, classification of ground vegetation, stand and regeneration tallies, root studies, stem analyses of dominant trees, and growth measurements of dominant seedlings. The stages of formation ranged from the first stage, in which the ironpan was totally absent, to the fifth stage, in which the ironpan attained a thickness of 24+ inches (Chrosciewicz, 1962).

Results The study indicated that (Chrosciewicz, 1962) :

(1) In most cases, the occurrence of a well-consolidated ironpan was associated with the presence of shallow-rooted black spruce. If jack pine was intermixed with the spruce, its deep root system tended to break up the existing ironpan.
(2) With very few exceptions, the average height and diameter growth of dominant jack pine and black spruce trees, and the average diameter and basal area per acre for all trees over one-half inch, gradually decreased with each higher stage of ironpan formation.

Comments Results will be published in the near future.

Status Continuing

Reports *Unpublished*

Chrosciewicz, Z. 1962. The significance of ironpan formation on sandy sites in Forest Section B.7, Quebec. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Ont. 62–23.

Project H–124A[1] Experimental seeding of conifers on scarified strips.

Classification 232.216
232.33

Investigator Present: K.W. Horton

Objectives To find an efficient method of restocking cut-over, burned valley sites by direct seeding. Jack pine was one of the four species tested.

Location Goulais River Research Area, 15 miles northeast of Searchmont, Ontario. Latitude 46°55'N, longitude 83°58'W.

Work Done Two experiments are being carried out, one comparing three sowing techniques with four species on freshly-scarified ground, and one comparing sowing on freshly-scarified, year-old scarified, and unscarified ground.

The sowing technique experiment was established in October 1960 and replicated in 1961 and 1962. Annual stocking and survival tallies were made in 1961, 1962 and 1963. The earliest treated plots were sprayed in July 1963 with "Brushkill" for release. The scarification-timing experiment was done in the fall of 1961, and tallied in 1962 and 1963 (Horton, 1960–1963).

Results The effects of three sowing techniques and of three classes of seedbeds on jack pine regeneration are shown in Tables 1 and 2, respectively. In jack pine, all techniques produced acceptable stocking after two years, with surface broadcasting being slightly superior. Mortality between the first and second year was negligible. Unscarified seedbeds were unsatisfactory; freshly-scarified seedbeds were more productive of first-year regeneration than year-old seedbeds (Horton, 1963).

[1]Project summary prepared by K.W. Horton.

TABLE 1. SECOND-YEAR REGENERATION FROM THREE TECHNIQUES OF SEEDING JACK PINE

(Horton 1963)

Sowing technique	Quadrats stocked (%)*		
	Sown fall 1960		Sown fall 1961
	Tallied fall 1961	Tallied fall 1962	Tallied fall 1962
Surface broadcast	87	91	92
Spot-seeded and covered	87	82	98
Broadcast and raked in	81	77	93

TABLE 2. JACK PINE REGENERATION (FIRST YEAR) ON DIFFERENT SEEDBEDS – BROADCAST SEEDING 1961

(Horton 1963)

Seedbed	Quadrats stocked* (%)	Production from viable seeds sown (%)
Year-old scarified	64	15
Freshly scarified	83	24
Unscarified	24	2

* 1/4,000-acre quadrats.

H-124A

Comments Preliminary results suggest the feasibility of simultaneous (one pass) strip scarification and direct seeding. A mechanized operation has been devised and tested (Project H–124C).

Status Continuing

Reports

Unpublished

Horton, K.W. 1960. Experimental seeding of conifers on scarified strips. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Horton, K.W. 1962. Seeding of conifers on scarified strips. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Horton, K.W. 1963. Experimental seeding of conifers in scarified strips. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63–0–4.

Project H-124B Experimental seeding of conifers on scarified strips.

Classification 232.216
232.33

Investigators Present: K.W. Horton

Objectives To explore the suitability of hardy farm cereals as nurse crops in direct seeding of conifers in forest conditions.
To compare germination and survival of jack pine and white spruce sown on scarified seedbeds in conjunction with three farm cereals - rye, oats, and alfalfa.

Location Range II, Township 23, about 45 miles northeast of Sault Ste. Marie, Ontario. Latitude 46°55' N, longitude 83°58' W.

Work Done The study is being carried out on a flat valley terrace of coarse sand capped with loamy fine sand. The moisture regime is somewhat dry.

An area was selected and scarified with a D-6 equipped with "dozer" blade. Sixty milacre quadrats were established and sown with rye, oats, or alfalfa. Half of each quadrat was sown with 50 viable jack pine and the other half with 50 viable white spruce seeds. Thirty of the quadrats were raked by hand to simulate harrowing Sowing was carried out in mid-June 1962. Periodic counts of conifers and estimates of per cent cover of cereals have been made.

Results In October 1964, the mean number of jack pine seedlings averaged 22.3 on raked plots and 11.0 on unraked plots. On raked plots, jack pine combined with alfalfa resulted in highest germination and survival. On unraked plots, jack pine combined with oats gave the best first-year results, but in the second and third years, the rye treatment gave significantly better results. Mice caused considerable damage to the pine seedlings, especially when jack pine was sown in combination with oats.

Status Continuing.

Reports *Unpublished*

Boekhoven, L.W.D. 1964. Direct seeding of conifers with cereals as nurse crop. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-0-18.

Project H-124C Mechanized forest seeding method.

Classification 232.216
232.33

Investigators Present: K.W. Horton

Objectives To develop a mechanical seeder that will provide for simultaneous scarification and seeding.

Location Hanmer and Lumsden Townships, Sudbury District, Ontario. Latitude 46°40' N, longitudes 81°00' to 81°10' W.

Work done A mechanical method of furrow seeding was devised. It involved a modified corn-seeding unit attached behind a bulldozer equipped with a front-mounted V-blade. It was designed as a one-pass operation in which the scarification and seeding operations were carried out simultaneously.

Pilot-scale trials began in June 1964 on a 130-acre tract of scrub aspen and jack pine growing on dry and fresh sand flats. Seeding was in rows spaced eight feet apart and at a rate of 2.5 seeds per foot. Jack pine was one of four species tested.

Additional trials covering 103 acres were carried out in November 1964. This area was characterized by an erratic cover of aspen and jack pine, having low hill topography and sandy soils locally strewn with boulders. Jack pine was seeded on the dry portions of the area. Examinations of the June seeding were made in July, August and November 1964 using a sample unit of 10 links (6.6 feet) of furrow.

Results First-year results for jack pine were very good in terms of distribution, number of seedlings and their vigour (Table 1).

TABLE 1. FIRST-SEASON RESULTS OF MECHANICAL SEEDING OF JACK PINE, JUNE 1964

(Horton and Flowers 1965).

Site	Stocking (%)*			Seedlings per acre		
	July	August	November	July	August	November
Moisture regime 1	81	88	78	2,000	3,200	2,400
Moisture regime 3	75	80	86	2,000	3,600	3,100

* Based on one or more seedlings per 6.6 feet of furrow.

Status Continuing.

Reports *Published*

Horton, K.W. and J.F. Flowers. 1965. Mechanized forest seeding method promises lower costs. Can. For. Industries 85(3):66-69.

Project H-127A The effects of various sizes of scarified scalps on jack pine regeneration following spot seeding.

Classification 181.21
181.525
232.216
232.33

Investigators Present: Z. Chrosciewicz

Objectives To determine the effects of various sizes of scarified scalps on jack pine stocking (percentage of stocked scalps) and growth (average height of dominant seedlings) in relation to the soil and vegetation conditions associated with individual sites, and also in relation to climatic conditions associated with individual years of seeding.

Location Townships L and Durban, north-northwest of Espanola, Ontario -- accessible by the KVP Company's West Branch Road. Latitudes 46°56' to 46°59' N, longitudes 82°13' to 82°15' W.

Work Done This spot seeding experiment was established in 1960 on eight different jack pine sites. All sites were clear cut in 1954-55, and two of them burned over in 1956. The treatments were early spring seeding, in three consecutive years, on scarified scalps of three different sizes (diameters 0.5, 1.0, and 2.0 feet), using 5 viable jack pine seeds per scalp. On each site, the experiment was laid out in a factorial randomized split-plot arrangement, with six replications of the three years of seeding, and with six replications of the three sizes of scalps per year. On each site there are 18 plots and 54 sub-plots. Each plot is 54 by 54 feet and provides for one year of sowing; each sub-plot is 18 by 54 feet and provides for one size of scalp. A uniform spacing of 6 feet between the scalps provided 27 scalps per sub-plot. In other words, there were 144 plots, 432 sub-plots, and 11,664 scalps for the entire experiment. Apart from the application of treatments, the experimental design made provisions for: classification of vegetation on 1-foot margin around each scalp six weeks after seeding; light measurements on each scalp four years after seeding; regeneration tallies six weeks and four years after seeding; height measurements of dominant seedlings four years after seeding; study of climatic fluctuation during three successive growing seasons after seeding; and analysis of data by statistical methods. The three-year scarification and seeding treatments commenced by groups of four sites in 1960 and 1961. By 1963, they were completed on all eight sites. So far, other work has consisted of regeneration tallies and classification of vegetation six weeks after each treatment (Chrosciewicz, 1961-64).

Results Covering of seeds with a thin layer of soil was beneficial to the establishment of jack pine, and the number of scalps stocked varied with the weather conditions following each year's seeding. Table 1 summarizes the preliminary results. The overall initial stocking six weeks after seeding ranged from poor (19 per cent) in a very few cases to excellent (98 per cent) in many cases, and the three-year treatment averages in such stocking varied by sites and scalp sizes between moderate (44 per cent) and good (79 per cent). Indications are that the final stocking and seedling growth four years after seeding will vary with the different scalp sizes and the different site factors under investigation. Being generally successful, this project will yield the much needed ecological information on the uses of spot seeding in jack pine regeneration silviculture.

TABLE 1. INITIAL JACK PINE STOCKING FOLLOWING SPOT SCARIFICATION AND SEEDING TREATMENTS

(Chrosciewicz 1961, 1962, 1963 and 1964).

Scalp diameter in feet	Type of data	Area							
		A	B	C	D	E	F	G	H
		Per cent stocked scalps six weeks after seeding							
0.5	3-year range	60-94	57-91	56-85	56-75	62-80	43-82	33-90	27-86
	3-year avg.	71	70	66	63	70	60	60	55
1.0	3-year range	67-96	67-96	59-93	54-80	46-82	46-80	28-91	19-91
	3-year avg.	79	79	71	64	62	62	50	48
2.0	3-year range	54-98	72-88	61-95	40-78	49-84	42-83	20-89	21-83
	3-year avg.	73	78	74	58	62	61	44	44

Comments Results will be published shortly after 1967.

Status Continuing.

Reports

Unpublished

Chrosciewicz, Z. 1961. The effects of various sizes of scarified scalps on jack pine regeneration following spot seeding. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Chrosciewicz, Z. 1962. The effects of various sizes of scarified scalps on jack pine regeneration following spot seeding. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Ont. 62-4.

Chrosciewicz, Z. 1963. The effects of various sizes of scarified scalps on jack pine regeneration following spot seeding. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-0-2.

Chrosciewicz, Z. 1964. The effects of various sizes of scarified scalps on jack pine regeneration following spot seeding. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-0-10.

Project H-127B Depth seeding of jack pine.

Classification 181.525

Investigators Present: Z. Chrosciewicz.

Objectives To study the effects of various depths of seeding on jack pine regeneration, survival and growth in relation to soil and ecoclimate associated with eight different sites.

Location Townships L. and Durban, north-northwest of Espanola, Ontario -- accessible by the KVP Company's West Branch Road. Latitudes 46°56' to 46°59' N, longitudes 82°13' to 82°15' W.

Work Done In 1961-62, a depth-sowing experiment was carried out on eight different jack pine sites. The sites were the same as those used for the spot seeding operations in Project H-127A. In this experiment, each year's treatments consisted of sowing 12 jack pine seeds (viability 70+ per cent) at each of six different depths ranging from 0 to 1 inch, all assigned at random, and all replicated ten times. The treatment units were 6 by 6-inch plots arranged in adjoining blocks. Site preparation included removal of humus, tilling, packing and levelling the mineral soil underneath. All sowing was done during the last week of May by making appropriate holes in the soil with the aid of wire, dropping single seeds in the holes, and closing the openings. To keep away rodents, birds, and insects, all plots were screened. Apart from the application of treatments, the experiment made a provision for regeneration tallies in mid-July and late September during the first growing season, and in late May, mid-July and late September during the second and the third growing seasons. Three years after seeding, dominant seedlings, one per plot, were excavated and their various parts measured. On termination of this work the data will be analysed by statistical methods.

Results Not yet available for publication.

Comments Results will be published in the near future.

Status Continuing.

Reports None.

Project H-127C Blueberry litter and jack pine survival.

Classification 181.525

Investigators Present: F. Curtis, Z. Chrosciewicz

Objectives To assess the effect of six different depths of blueberry litter on the survival of jack pine seedlings during two growing seasons after surface sowing.

Location Township L, north-northwest of Espanola, Ontario -- accessible by the KVP Company's West Branch Road. Latitude 46°58' N, longitude 82°15' W.

Work Done The study was carried out on a very fine sand site (moisture regime 2) which had been clear-cut in 1954 and burned in 1956. Tilled soil, free of humus and roots, was surface sown with jack pine in early spring of 1962. There were 60 adjoining 6 by 6-inch plots, each sown with 12 seeds (viability 90 per cent). Eight weeks after seeding, a blueberry litter of six different depths ranging from 0 to 1 inch, and each replicated ten times at random, was uniformly spread over the surface of individual plots. Seeding tallies were made in the fall of 1962, and in the spring and fall of 1963.

Results Litter coverings up to 0.25 inch in depth had no apparent effect on seedling survival, while those of 0.50, 0.75, and 1.00 inch in depth had increasingly detrimental effects. Survival after two growing seasons was as follows:

Depth of litter cover (inches)	Jack pine survival 1963 (per cent)
Surface	87
1/8	89
1/4	92
1/2	77
3/4	74
1	60

Comments There is a need for extending this study to other types of litter with replications in both space and time.

Status Continuing.

Reports *Unpublished*

Curtis, F. 1963. Effect of various depths of blueberry litter on survival of jack pine seedlings. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-0-3.

Curtis, F. 1964. Effect of various depths of blueberry leaf litter on survival of jack pine seedlings. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 1-0-64.

Project H-129[1] Influence of hygroscopic materials, stone chips, and seedpads on germination and survival in seedspots: field trial.

Classification 181.525
232.33

Investigators Past: R.F. Sutton.

Objectives To test the hypothesis that germination and survival in seedspots may be increased by applications of hygroscopic materials and organic fertilizer.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00' N, longitude 77°30' W.

Work Done In July 1960, 144 scalped seedspots were prepared on a flat, sandy site to accommodate eight replications of 18 treatments, including seedspot coverings with anhydrous calcium sulphate (four rates), silica gel (four rates), stone chips (four rates), and polyethylene seedpads. The seedpads were prepared from 1-foot square sheets of aluminum-painted polyethylene. It was hoped that seedpads would reflect much of the incident radiation, be sufficiently limp and heavy to conform to the configuration of the ground, and prevent germination until the whole soil body became thoroughly moist, the seeds having been protected from light rains which might otherwise initiate foredoomed germination. Half the seedspots were protected by conical wire shelters. The progress of germination and fate of germinants was followed by inspection at frequent intervals during 1960 and 1961.

Results Results will be published in the near future.

Status Closed.

Reports

Unpublished

Sutton, R.F. 1964. Tests of spot-seeding techniques with hygroscopic and other materials. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

[1]Project summary prepared by R.F. Sutton.

Project H-130 Experimental burning of slash and humus for seedbed improvement on various jack pine sites.

Classification 232.213
232.33
436

Investigators Present: Z. Chrosciewicz.

Objectives To determine the moisture relationships and the associated weather conditions under which burning of slash and humus can be successful in the preparation of seedbeds favourable for jack pine regeneration.

Location Township Durban, north-northwest of Espanola, Ontario -- accessible by the KVP Company's West Branch Road. Latitude 47°03' N, longitude 82°15' W.

Work Done In 1960, eleven 0.26-acre plots, each with windrowed and scattered slash, were established on two 1957 clear-cut jack pine sites. The plots were burned in summer under different drought conditions. Four plots were burned in 1960, one in 1961, and six in 1962. Other work included daily observations of local weather and determination of fire indices, classification of fuels and mapping fuel distribution before burning, measurements of humus depths before and after burning, determination of humus moisture immediately before burning, broadcast seeding of jack pine in early spring following burning (one pound of seed per acre, viability 70+ per cent), and regeneration surveys on permanent strips of 0.001-acre quadrats six weeks after seeding and at the end of the first, second and third growing seasons (sampling approximately 30 per cent) (Chrosciewicz, 1961-65).

Results So far, this project has produced much useful information on the uses of fire in jack pine regeneration silviculture. Both the humus moisture and the reduction of humus depth by burning correlated with weather conditions as represented by the corresponding combinations of drought and fire danger indices (Tables 1 and 2). On this basis, the specific requirements for each of several intensities of burning in relation to the original types and depths of humus were ascertained (Chrosciewicz, 1965).

TABLE 1. RATED FIRE INDICES AND HUMUS MOISTURE ON DAYS OF BURN

(Chrosciewicz 1965)

Fire indices			Avg. moisture of 2.5-inch humus		Date of burn
Drought Index	Danger		Coarse-textured mor[1]	Fine-textured mor[2]	
	Index	Rating			
3	9	High	75	–	July 13, 1961
6	9	High	70	57	Aug. 20, 1960
7	12	High	65	55	July 19, 1962
9	10	High	53	46	Aug. 23, 1960
10	12	High	57	–	Aug. 3, 1962
12	12	High	42	45	Aug. 6, 1962
14	8	Moderate	60	–	Aug. 8, 1962

[1] Jack pine raw humus.

[2] Jack pine – black spruce raw humus.

TABLE 2. HUMUS CONDITIONS BEFORE AND AFTER BURNING BY DROUGHT INDEX-FIRE DANGER COMBINATIONS

(Crosciewicz 1965)

Drought index	Fire danger	Coarse-textured mor[1]					Fine-textured mor[2]				
		Plot	Avg. humus depth		Total humus cover		Plot	Avg. humus depth		Total humus cover	
			Before burn	After burn	Before burn	After burn		Before burn	After burn	Before burn	After burn
			Inches		Per cent			Inches		Per cent	
3	High	C	2.0	1.4	93	87	–	–	–	–	–
6	High	A	2.6	1.4	83	76	K	2.4	1.1	78	71
7	High	D	2.7	1.2	97	86	I	2.0	0.7	98	87
9	High	B	2.7	1.2	88	78	J	2.5	0.8	86	76
10	High	E	2.6	1.0	83	54	–	–	–	–	–
12	High	F	2.3	0.3	78	40	H	2.2	0.5	80	63
14	Moderate	G	2.3	1.3	89	74	–	–	–	–	–

[1] Jack pine raw humus.

[2] Jack pine – black spruce raw humus.

TABLE 3. JACK PINE STOCKING ONE GROWING SEASON AFTER THE BURNING AND SEEDING TREATMENTS

(Crosciewicz 1962–64)

Scarified plot portions[1]		Unscarified plot portions[2]	
Number of plots	Jack pine stocking by 0.001-acre quadrats (%)	Number of plots	Jack pine stocking by 0.001-acre quadrats (%)
2	45–46	2	47–48
3	52–63	3	60–71
6	87–100	6	78–100

[1] Patches of mineral soil exposed by logging.

[2] All other seedbeds prepared exclusively by burning.

Table 3 shows jack pine regeneration in terms of per cent 0.001-acre quadrats stocked with one or more seedlings one growing season after seeding. It is evident from this table that, in most cases, the burning-seeding treatments were fully successful. Subsequent regeneration surveys, completed on about half of the plots, indicated no major changes in jack pine stocking between the first, second and third growing seasons (Crosciewicz, 1961-64).

Comments

The relationships obtained can be used as guides for future burning operations. The minimum requirements for humus disposal differ greatly from those for slash disposal. The thick raw humus materials predominant in Ontario will require at least a high fire danger, and moderately high drought indices within that danger, before they can be adequately reduced in depth by fire (Crosciewicz, 1965).

Status Continuing.

Reports

Unpublished

Chrosciewicz, Z. 1961. Experimental burning of slash and humus for seedbed improvement on various jack pine sites. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Chrosciewicz, Z. 1962. Experimental burning of slash and humus for seedbed improvement on various jack pine sites. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. Ont. 62-2.

Chrosciewicz, Z. 1963. Experimental burning of slash and humus for seedbed improvement on various jack pine sites. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63-0-1.

Chrosciewicz, Z. 1964. Experimental burning of slash and humus for seedbed improvement on various jack pine sites. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-0-9.

Chrosciewicz, Z. 1965. Experimental burning for humus disposal on clear-cut jack pine sites in Central Ontario. Canada, Dept. Forestry, Ontario Region, Unpubl. MS. 65-0-11.

Project P-20 Thinning in jack pine.

Classification 242

Investigators Past: A.L. Best

Objectives To study the effects of different degrees of thinning in a pure stand of 35-year-old jack pine.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done In 1922, three permanent 0.5-acre plots were established in a pure, 35-year-old jack pine stand. The plots were thinned as follows:

Plot	Type of Thinning
70	"A" – Dead and dying trees removed.
71	"C" – Dead, dying and all intermediate trees removed.
72	"D" – Dead, dying, intermediate and some codominant trees removed.

All trees over 0.5 inch d.b.h. were tagged, mapped and measured for diameter and height in 1922; remeasurement of the plots took place in 1927 and 1932. During the last remeasurement the 200 largest and best-developed trees per acre were selected on each plot for the purpose of comparing their growth between plots.

Results The analysis of data showed that (Best, 1933):

(1) Although the before-thinning tree heights on Plot 70 were slightly less than those on the other two plots, this plot had the best heights, and Plot 72 the poorest, of the three plots. Generally, diameter growth in relation to height growth increased with the intensity of thinning.

(2) While the individual trees gained in diameter as a result of thinning, the stand as a whole showed less volume increment over the ten-year period on the more heavily thinned plots than on the lightly thinned plots. This was partly due to the heavy windfall that occurred on Plots 71 and 72 during the first five years after thinning (Tables 1 and 2).

TABLE 1. EFFECT OF THINNING ON STAND DENSITY AND VOLUME

(Best 1933)

Treatment and plot	Stems per acre				Volume per acre – cubic feet			
	1922 B.T.	1922 A.T.	1927	1932	1922 B.T.	1922 A.T.	1927	1932
70 – "A"	1,159	1,063	836	661	2,032	1,922	1,941	2,012
71 – "C"	1,274	602	510	474	2,395	1,827	1,886	2,180
72 – "D"	1,204	406	258	238	2,356	1,339	1,179	1,410

TABLE 2. NET ANNUAL VOLUME INCREMENT PER ACRE – CUBIC FEET

(Best 1933)

Treatment and plot	1922–1927	1927–1932	1922–1932
70 – "A"	3.8	14.2	9.0
71 – "C"	11.8	58.8	35.3
72 – "D"	-32.0	46.2	7.1

TABLE 3. COMPARISON OF 200 LARGEST TREES PER ACRE ON EACH PLOT

(Best 1933)

Treatment and plot	Average diameter (in.)			Total volume (cu. ft./acre)		
	1922	1927	1932	1922	1927	1932
Plot 70–A	5.21	5.68	6.18	646	792	1027
Plot 71–C	5.53	6.07	6.70	762	968	1221
Plot 72–D	5.53	6.23	6.89	742	969	1267

(3) The largest trees, representative of the final crop, benefited most by the thinning. Both their average diameter and their total volume increased with the intensity of thinning (Table 3).

Comments Indications are that a series of light thinnings should give the best results in total yield of young jack pine stands (Best, 1933).

Status Closed

Reports

Unpublished

Best, A.L. 1933. Jack pine thinning experiment, Petawawa Forest Experiment Station. Canada, Dept. Interior, Forest Service, Unpubl. MS.

Project P-33[1] Development of red, white, Scots and jack pine seed spots in Vaccinium-Comptonia[2] site-type.

Classification 221.1
232.33

Investigators Past: A. Bickerstaff, J.W.B. Sisam.
Present: K.T. Logan

Objectives To determine the possibility of obtaining jack pine reproduction in a cut-over stand by seed-spotting, or of converting the area to a more valuable species by the same method.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done A mature jack pine stand, with an understory of red and white pine, was clear-cut during the winter of 1938-39 and the area seed-spotted in 1939 to four species of pine: white, red, jack, and Scots. Each species was seeded in mineral soil at a spacing of 6 by 6 feet. Four plots per species, each plot containing 33 seed-spots, were established in a Latin Square design. Using survival and growth as criteria, the 1950 remeasurement data indicate the degree of success obtained (Logan, 1951).

Results For this site-type, the success of regeneration by seed-spotting varies greatly according to the species; survival of Scots and jack pine was good, while that of red and white pine was poor (Figure 1). All white pine were dead after seven years. Since red and white pine formed an understory in the previous stand, and as red and white pine seedlings are present in small openings in the surrounding stand, it is apparent that these species require some shelter in their early years. Jack pine has shown the best growth; it has grown a foot a year for the past four years, compared with half a foot for Scots pine and only a tenth of a foot for red pine. Most of the jack and Scots pine are now well established and reaching sapling size, but the red pine are stunted and probably will die. Scots pine has the best form now, but it remains to be seen whether it will deteriorate as it matures (Logan, 1951).

Comments This experiment demonstrates that seed-spotting may be successfully employed either to regenerate jack pine on a clear-cut dry site, or to convert the area to Scots pine. Red and white pine could not be successfully seed-spotted, as these species apparently require some shelter to survive on a dry site (Logan, 1951).

Status Continuing.

Reports

Unpublished

Sisam, J.W.B. 1939. Seed spot experiment – Racehorse – White, red, Scotch and jack pine. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS.

Bickerstaff, A. 1941a. Relative development of white, red, jack and Scotch pine on the Vaccinium-Myrica site-type. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS. (May).

Bickerstaff, A. 1941b. Relative development of white, red, jack and Scotch pine on the Vaccinium-Myrica site-type. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS (November).

[1] Project Summary prepared by K.T. Logan.
[2] Originally referred to as Vaccinium-Myrica Site-type.

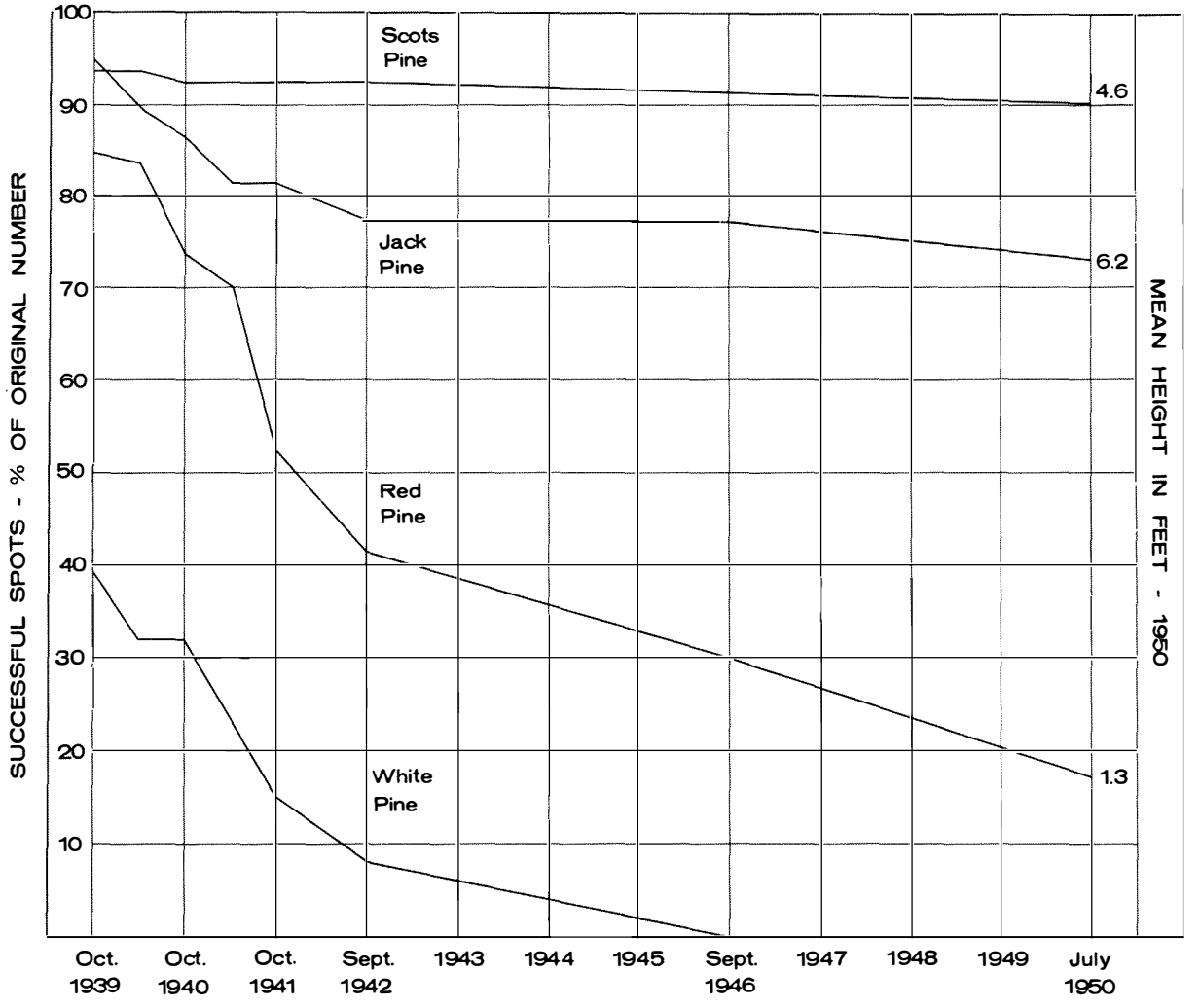

Figure 1. Survival of seedspots of Scots, jack, red, and white pine, 1939–1950 (Logan 1951).

Reports

Unpublished (continued)

Logan, K.T. 1951. Relative development of white, red, jack, and Scotch pine on a Vaccinium-Myrica site-type. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Logan, K.T. 1951. Seed spotting in a cut-over jack pine stand. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 57. 2 pp.

Project P-126 Effect of different methods of slash disposal on jack pine reproduction after clear cutting on Vaccinium-Comptonia[1] site.

Classification 221.1
231.39

Investigators Past: J.W. Noakes, E.S. Atkins, J.L. Farrar.

Objectives To determine the effects of three methods of slash disposal on jack pine reproduction.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46° 00'N, longitude 77° 30'W.

Work Done In the fall and winter of 1943-44, a predominantly jack pine stand on a deep, coarse sand extending over lower flat, south slope, and upper flat was cut for sawlogs to a 7.5-inch diameter limit. Within each of the three topographic situations, or sites, slash disposal was carried out concurrently with logging by three methods; slash piled and burned, slash lopped and scattered, and slash left in its undisturbed state. In 1944 and 1949, regeneration was tallied on nine permanent sample plots, each consisting of a strip of 20 contiguous 0.001-acre quadrats.

Results Tables 1 and 2 show the stocking values based on sampling by 0.001-acre quadrats at the end of the first and sixth growing seasons. It is evident from these tables that neither site nor slash disposal had much effect on reproduction. In general, reproduction was unsatisfactory. Most of the seedlings were jack pine, either five or six years old, and one to five feet in height (Atkins and Farrar 1950).

Comments None

Status Closed.

Reports *Published*

Noakes, J.W. 1946. Effect of different methods of slash disposal on jack pine reproduction. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Silv. Res. Note 78.8 pp.

Atkins, E.S. and J.L. Farrar. 1950. Slash disposal in relation to jack pine reproduction. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 45. 2 pp.

[1]Originally referred to as Vaccinium-Myrica site-type.

TABLE 1. STOCKING BY SITE

(Atkins and Farrar 1950)

Site	Year	Quadrats stocked (%)		Seedlings per acre	
		Jack pine	All softwoods[1]	Jack pine	All softwoods
Lower flat	1944	0	31.7	0	450
	1949	25	28.5	1083[2]	1167[2]
Upper flat	1944	3.3	8.3	50	150
	1949	18.3	20	467	483
South slope	1944	0	1.7	0	167
	1949	15	15	283	283

TABLE 2. STOCKING BY SLASH DISPOSAL

(Atkins and Farrar 1950)

Slash disposal method	Year	Quadrats stocked (%)		Seedlings per acre	
		Jack pine	All softwoods	Jack pine	All softwoods
Slash burned	1944	3.3	20	50	317
	1949	28	28	1200[3]	1217[3]
Slash lopped	1944	0	8.3	0	100
	1949	13	15	183	217
Slash undisturbed	1944	0	13.3	0	200
	1949	17	20	450	517

[1] Jack pine, white pine, red pine, balsam fir.
[2] Two abnormal quadrats contained 30 and 15 seedlings out of a total of 59 seedlings on one plot. If average figures were substituted, the above would become 400 and 500 respectively.
[3] Would become 517 and 533 respectively if averages were substituted for the two abnormal quadrats.

Project P-154[1] Research in tree breeding techniques. Flower induction.

Exp. No. 156 Transplants of Scots, jack and red pine given salt shocks at various intensities at different times during the growing season.

Exp. No. 160 Comparison of time of root pruning of fertilized and non-fertilized young jack pine on Macky Plains.

Exp. No. 232 Girdling of jack pine branches to determine the period when the flower primordia are formed.

Exp. No. 316 Scots pine, red pine, jack pine, and Mugho pine in the Pine Graft Arboretum given NH_4NO_3, $(NH_4)_2SO_4$ and KNO_3 to study the flower-inducing effect of ammonia and nitrate. Doses adjusted to equal amounts of N.

Classification 232.31

Investigators Present: M. J. Holst

Objectives To find techniques that will control male and female flower production in jack pine.

Location Petawawa Forest Experiment Station.

Work Done Between 1956 and 1960 a number of treatments were given to young plants (5 years old when the experiment began). Some of the details are given under "Results". An experiment with 4-foot-high saplings planted in the field was initiated in 1955. Treatments included combinations of root pruning and applications of ammonium nitrate to the soil. Flowers were counted in 1955 and 1956. An experiment with branch girdling performed every two weeks from May 1 to August 4 was carried out in 1959 and the flowers counted in 1960. Finally an experiment was laid out in 1965 to see whether it is the ammonium ion (NH_4+) on the nitrate ion (NO_3-) that promotes flowering.

Results There was no effect of root pruning in 5-year-old jack pine seedlings and only a slight increase in female flowers from the treatments in 1957. Treatments in 1958 showed that spraying with 10, 20, 40 and 80 p.p.m. of 2, 3, 5 triiodobenzoic acid during the period June 29 – July 23 had no effect on female flowering but increased male flowering 50 per cent. Spraying with 20, 40, 80 and 160 p.p.m. of guanine during the same period had no effect on female flowering but increased male flowering 80 per cent. Again in 1959 100 p.p.m. of 2, 3, 5 triiodobenzoic acid tripled both male and female flowering when started June 1, but had no effect when started June 29. Ethylene chlorhydrin had no effect on the male flowering but increased the female flowers. Of the fertilizers given in 1959, an application of 100 gram ammonium nitrate per tree given April 27 doubled male flowers and tripled female flowers. Double the amount given on the same date doubled female flowers and slightly increased male flowering. The 100 gram application given on June 8 had no effect on male flowers, but doubled female flowers. A 200 gram application had a negative effect on male flowering and no effect on female flowers.

A timing experiment with root-pruning and ammonium nitrate given separately and in combination to four-foot-high jack pines on May 4, June 8, June 28 and August 4 during the 1955 growing season had the following results. Root pruning at all dates and in all combinations with ammonium nitrate reduced the female flowers to one-fourth of the controls and prevented male flowering. An application of 100 gram per tree ammonium nitrate on May 4 and June 8 increased female

[1]Project Summary prepared by M.J. Holst.

flowering roughly 50 per cent, on June 28 there was a slight increase, and on August 4 a slight decrease in the female flowers. Of the different amounts of ammonium nitrate given May 4, the 50 gram application reduced female flowering, while 100 gram increased female flowers by 50 per cent, and the 200 gram increased female flowering by 100 per cent. All ammonium nitrate levels reduced or stopped male flowering in comparison with the control trees.

In 1959 a timing experiment with branch girdling of jack pine was performed The girdling was done May 1, May 15, June 5, June 18, July 2, July 16 and August 4. High breakage occurred so results are only indicative. Female flowers were reduced by the May 1 girdling, but were stimulated by the May 15, June 5, June 8 and July 2 girdling. Male flowering was only stimulated by the May 15 girdling.

It appears then that flower inducing techniques must be applied early in the growing season. Those techniques that promote female flowers should be applied in May or early June. A heavy application of ammonium nitrate given early May was particularly effective.

Those techniques that promote male flowers could be applied a little later. Spraying with 2, 3, 5 triiodobenzoic acid and guanine should begin June 1 – perhaps earlier. Spraying delayed to the end of June had no flower promoting effect.

In 1965 jack pines were given NH_4NO_3, $(NH_4)_2SO_4$, and KNO_3 to study the flower inducing effects of the ammonium and nitrate ions. Flowers will be counted 1966.

Comments The techniques that stimulate female flowering may inhibit male flowering, – and vice versa. Techniques that will stimulate both are still required.

Status Continuing

Reports

Unpublished

Holst, M.J. 1960. Comparison of time of root pruning of fertilized and non-fertilized young jack pine. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS. (Exp. 160).

Holst, M.J. 1960. Flowering of jack pine treated with fertilizer and anti auxins. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS. (Exp. 156).

Holst, M.J. 1960. Girdling of jack pine branches to determine the period when the flower primordia are formed. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS. (Exp. 232).

Published

Holst, M.J. 1961. Experiments with flower promotion in *Picea glauca* (Moench) Voss. and *Pinus resinosa* Ait. Recent Advances in Botany. pp. 1654-1658. The University of Toronto Press.

Project P-156A[1] Research on provenance, population genetics, heritability, and breeding in pine. A. Jack pine provenance experiments of limited scope.

Exp. No. 40 Provenance experiment with 12 Ontario jack pine provenances (sown 1951 and planted on the Petawawa Forest Experiment Station).

Exp. No. 41 Observation plots of 12 Ontario jack pine provenances planted on the Mozhabong Lake Road by the K.V.P. Company, Espanola, Ontario (sown 1951).

Exp. No. 42 Observation plots of 12 Ontario jack pine provenances planted on the Valcartier Forest Experiment Station, Quebec (sown 1951).

Exp. No. 49 Provenance experiment planted in New Zealand including seven provenances of red pine, six provenances of jack pine, four provenances of white spruce, and four provenances of red spruce. (Jack pine sown in 1953 and established on two sites in New Zealand).

Exp. No. 70 Nursery provenance experiment with 14 provenances of Ontario jack pine (sown 1951 in the Petawawa Forest Experiment Station nursery).

Exp. No. 82 Jack pine provenance experiment including five Ontario and four Quebec provenances. (Sown 1953 and field planted on the Petawawa Forest Experiment Station in 1957).

Classification 165.5
232.12

Investigators Present: M.J. Holst

Objectives To study the effect of the seed collection zones set up for Ontario by the Ontario Department of Lands and Forests.

Location Most of the experiments that are followed with repeated measurements are established at the Petawawa Forest Experiment Station. The observation plots have been established on jack pine sites in the Timagami Section (L.9) and on the border of the Laurentian Section (L.4a) on the Valcartier Forest Experiment Station. The two tests in New Zealand are near Waimihia on the North Island and near Naseby on the South Island.

Work Done The nursery provenance experiment (Exp. No. 70) was established with 1-0 seedling in the spring of 1952. Tree heights were measured at the conclusion of the growing seasons in the years 1953-55. Phenological measurements of leader growth were made during the 1955 growing season. The comparable field planting (Exp. No. 40) was established with 3-year-old transplants in the spring of 1954. Twelve provenances were planted with four replications. Survival count was made in 1956 and tree heights were measured in the falls of 1957, 1958, 1960, and 1961. Sample roots were excavated during the summer of 1964. One of the observation plantings (Exp. No. 41) was established in 1954 and heights were measured in 1961. The other observation planting (Exp. No. 42) was abandoned because of poorly aerated soil. The provenance experiment with the Ontario and Quebec provenances (Exp. No. 82) was sown 1953 and field planted 1957 with three replications. Heights were measured in 1960 and 1961.

Results Most of the variation in height and phenology is clinal, and is highly correlated with both length of growing season and May-September mean monthly temperature. Hills' Site Regions for Ontario are presently being used to delineate seed collec-

[1]Project Summary prepared by M.J. Holst.

tion zones. Although the test sites are located towards the southern part of jack pine range in Ontario and will only indicate relative performance of the provenances, it is still possible to investigate the relationship between growth rate and site regions. Comparisons within and between western Ontario regions are rather inconclusive because of insufficient sampling, but the eastern regions differ significantly in height and phenology (period of shoot growth). Provenances from continental western Ontario and cold northern Ontario start growth early in the spring, finish early in the fall, and have short growth-periods. Provenances from the milder parts of middle and southern Ontario start growth late in the spring but finish much later in the fall and therefore have longer growth-periods. Hills' Site Regions are important indicators of potential yield and may be adequate first approximations for the delineation of seed collection zones. In an eleven-year-old provenance experiment, (Exp. No. 40) mean height differed significantly between regions, e.g., when comparing three provenances from the Georgian Bay Site Region with four provenances from the Lake Abitibi Site Region it was found that 7 of 12 possible differences were significant. On the other hand it could be shown that significant height differences occurred which demonstrated the influence of local climate within a site region. The Lake Abitibi Site Region is a case in point. The Stevens provenance (short growing season) is 11 per cent shorter than the other three provenances (Timmins, Swastika and Connaught) from this site region.

Five-year results from nursery tests and eight-year results from field tests give good indications of potential yield. However, some of the fastest growing provenances are susceptible to windthrow when heavily laden with snow. These provenances do not regenerate good anchor roots after transplanting. These, and perhaps other defects, show up relatively late and confirm the need to maintain provenance experiments well beyond crown closure, and preferably to rotation age.

Comments These experiments are considered to be preliminary to the larger range-wide provenance tests.

Status Continuing

Reports

Unpublished

Holst, M.J. 1964. Field and nursery tests with Ontario jack pine provenances. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 40 and 70).

Holst, M.J. 1964. Observation plots of Ontario jack pine provenances planted on the Mozhabong Road by K.V.P. Company (West Branch Unit). Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 41).

Holst, M.J. 1964. Provenance experiment with nine races of jack pine. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 82).

Published

Holst, M.J., and C.W. Yeatman. 1961. A provenance study in *Pinus banksiana* Lamb. Recent Advances in Botany, pp. 1612-1616. The University of Toronto Press.

Sweet, G.B. and I.J. Thulin. 1963. The performance of six provenances of *Pinus banksiana* in a 7-year-old trial in New Zealand. New Zealand For. Serv. For. Res. Inst., Res. Leafl. 2. 3 pp.

Holst, M.J. 1964. Forest tree breeding and genetics at the Petawawa Forest Experiment Station. Biennial Report: 1 April, 1962 to 31 March, 1964. Proc. 9th. Meet. Comm. For. Tree Breed. in Canada. Part II, pp. 63-107.

Project P-156B[1] Research on provenance, population genetics, heritability, and breeding in pine. B. Lake States jack pine seed source study.

Exp. No. 125 Provenance experiment including 16 provenances of Lake States jack pine (sown 1952 and planted on the Petawawa Forest Experiment Station in 1955).

Exp. No. 132 Observation plots including 16 provenances of Lake States jack pine planted at Valcartier Forest Experiment Station, Quebec (sown 1952).

Exp. No. 133 Observation plots including 16 provenances of Lake States jack pine planted in Chatham Twp., Quebec, by Canadian International Paper Company (sown 1952).

Classification 165.5
232.12

Investigators Present: M.J. Holst.

Objectives To study the growth of Lake States jack pine in Canada in co-operation with the Lake States Forest Experiment Station and the University of Minnesota.

Location As indicated above.

Work Done The provenance material was obtained in 1955 as 3-0 stock from the Lake States Forest Experiment nursery in Rhinelander, Wisconsin. One replicated experiment (Exp. No. 125) with 49-tree-plots and five replications was planted at the Petawawa Forest Experiment Station in 1955. Heights of this experiment were measured in 1958, 1960, 1961 and 1962 and insect damage was rated in 1961. The second experiment (Exp. No. 132) in this series was established as observation plots on the border of the Laurentian Section (L.9) at the Valcartier Forest Experiment Station. Due to poorly aerated soil this experiment was abandoned. The third experiment in this series was established as observation plots on the northern border of the Upper St. Lawrence Section (L.2). These observation plots were measured in 1960 and 1962.

Results This is an extension of a 29-provenance test sown in 1952 by the Lake States Forest Experiment Station and established in 17 permanent outplantings in the Lake States. The ranking of provenance height is similar to that found in the Michigan experiments. The exceptions to this rule are Manistee from the Lower Peninsula that gained 10 ranks, Otonagon Co. that fell 8 ranks, Cass Co. that fell 6 ranks, and Becker Co. that fell 5 ranks. Significant differences in susceptibility to the white pine weevil were not found in the Petawawa experiment. The lattice-square design resulted in a gain in precision of 34 per cent. Keul's Studentized Range Test at the 5 per cent level showed only the highest and the lowest mean heights to be significantly different. When calculated as a randomized block design, Duncan's Multiple Range Test at the 5 per cent level indicated the existence of three distinct groups. This lack of a clear separation between provenances may be typical of southern provenances grown on somewhat colder test sites.

Comments These experiments are preliminary to the all-range jack pine experiment (Project P-156D, Exp. No. 255).

Status Continuing.

[1]Project Summary prepared by M.J. Holst.

Reports

Unpublished.

Holst, M.J. 1955. Provenance experiments including 16 provenances of Lake States jack pine established in three locations in Canada. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS. (Exp. 125, 132, 133).

Holst, M.J. 1959. The 1958 height measurement of 16 provenances of Lake States jack pine. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS. (Exp. 125).

Putnam, M.M. and J.C. Anspach. 1963. The 1960 and 1962 height measurements of observation plots of 16 provenances of Lake States jack pine. Canadian International Paper Company, Grenville, Que., Unpubl. MS. (Exp. 133).

Morgenstern, E.K. 1964. The 1960 and 1961 height measurement of 16 provenances of Lake States jack pine. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 125).

Holst, M.J. 1965. The 1962 height measurement of 16 provenances of Lake States jack pine. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 125).

Project P-156C[1] Research on provenance, population genetics, heritability, and breeding in pine. C. Jack pine compared with other pines.

Exp. No. 169 Provenance experiment with Scots pine (IUFRO), jack pine and lodgepole pine.

Exp. No. 192 Trial of jack pine and lodgepole pine provenances, and of "Riga Pine", Hungarian Austrian pine and Korean *Pinus sinensis*.

Classification 165.5
232.11
232.12

Investigators Present: M.J. Holst.

Objectives To compare a number of jack pine and lodgepole pine provenances with various exotic pines and to test these for resistance to the sweet-fern blister rust.

Location Plantation Area No. 43 and Plantation Area No. 60 at the Petawawa Forest Experiment Station.

Work Done Three provenances of jack pine, four of lodgepole pine, and 30 of Scots pine were sown during the period 1937-40 and were planted during the period 1942-46 (Exp. No. 169). Heights were measured in 1943 and 1950. The other experiment (Exp. No. 192) was sown in 1941 and planted in 1945. It contains four jack pine provenances, five lodgepole provenances and three exotic pine species. This plantation was assessed in 1956 and 1962.

Results Coastal lodgepole pine was killed by frost, while the interior lodgepole pine was hardy but heavily attacked by sweet-fern blister rust. Both were much slower growing than jack pine. Differences in stem straightness, branch angle and open coned types were found in jack pine provenances.

Comments Some of this jack pine material was used in a study of stem form.

Status Continuing.

Reports

Unpublished

Holst, M.J. 1956. Assessment of Plantation Area No. 60. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS. (Exp. 169).

Published

Holst, M.J. 1953. A provenance study in Scots pine *(Pinus sylvestris)*. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Silv. Leafl. 96. 4pp.

[1]Project Summary prepared by M.J. Holst.

Project P-156D[1] Research on provenance, population genetics, heritability, and breeding in pine.

Exp. No. 255 Range-wide jack pine provenance experiment.

Classification 165.5
232.12

Investigators Present: M.J. Holst.

Objectives To study the genetic and environmental components of phenotypic variation associated with geographic source for the whole range of jack pine.

Location The experiment is being carried out in a large number of locations. In Canada, experiments have been established in New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and Northwest Territories. Other experiments have been established in the United States, Holland, Scotland, Finland, Denmark, Czechoslovakia and New Zealand.

Work Done Cone collections of jack pine were made over a five-year period from 100 locations scattered throughout the range of jack pine. A particular attempt was made to sample all known isolated occurrences in the southern part of the range of jack pine. Each location is identified by latitude, longitude, and elevation. Climatic summaries, including temperature, precipitation and growing season data have been assembled from published records.

Seed lots have been distributed to a variety of co-operators, who will carry out either nursery or field provenance experiments. First sowings were made in 1959; some experiments were still being established in 1966.

Results Preliminary results from the nurseries in Scotland show a very high correlation between growth rate and length of growing season of place of origin for the provenances coming from western Ontario and further west (west of longitude 90°W), while the provenances from eastern Ontario and Quebec (between longitude 70°W and 90°W) are more variable and the slope of the regression line is not as steep. The same trend is found in T. Schantz-Hansen's provenance experiment that was planted on the Cloquet Experimental Forest which contained 10 Canadian provenances and 12 American provenances. The growth rate in the western part of the range is closely related to climate (clinal variation), but there is more genetic variability towards the middle of the range (or a poorer matching of climatic station and collection site). In the extreme eastern part of the range there seems to be a wider scatter associated with a disjunct distribution. This may be a simplified version of the actual variation, and better estimates will be forthcoming in the future (see also project summary P-156E).

Comments This range-wide provenance experiment will illustrate the broad range of variability in jack pine. More detailed experiments must be designed to investigate the patterns of variation within specific climatic or geographic regions of particular interest.

Status Continuing.

[1]Project Summary prepared by M.J. Holst.

Reports

Unpublished

Holst, M.J. 1963. All-range jack pine provenance experiment. Notes on the origin and climates of one hundred jack pine provenances. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 255).

Published

Holst, M.J. 1964. Forest tree breeding and genetics at the Petawąwa Forest Experiment Station. Biennial Report: 1 April, 1962 to 31 March, 1964. Proc. 9th Meet. Comm. For. Tree Breed. in Canada, Part II, pp. 63-107.

Project P-156E[1] Research on provenance, population genetics, heritability, and breeding in pine.

Exp. No. 255-A-10 Geographic variation of *Pinus banksiana* seedlings.

Classification
161.34
161.4
165.5
181.21
181.22
232.12

Investigators Present: C.W. Yeatman.

Objectives
(1) To test the validity of intensive studies of seedlings for the determination of patterns of genetic variation in populations collected from the geographic range of jack pine.
(2) To determine the nature and extent of genotype-environment interaction in seedlings of jack pine provenances grown in a series of controlled environments and in field nurseries.
(3) To investigate variation in cold hardiness and associated physiological characteristics in seedlings of selected jack pine provenances.

Location Greeley Memorial Laboratory, Yale School of Forestry, New Haven, Connecticut; Longlac, Ontario; Petawawa F.E.S., Ontario; Acadia F.E.S., New Brunswick.

Work Done
(1) Seedlings of 50 jack pine provenances were grown in 9 controlled environments (3 photoperiods x 3 temperature regimes) and in a greenhouse (3 photoperiods) for 3 months. Fresh and dry weights of shoots and roots were determined, together with observations of shoot, bud and needle development.
(2) Seedlings of 87 jack pine provenances were grown for 4 months in the winter and 4 months in the summer. Similar records of growth and development were made as in (1) above.
(3) One-year-old seedlings of 87 jack pine provenances were collected from three nurseries: Longlac, Ont.; Petawawa F.E.S., Ont.; and Acadia F.E.S., N.B. Dry weights of tops were recorded.
(4) Seedlings of 15 jack pine provenances (5 each from 3 latitudinal transects) were grown from summer through autumn and winter to early spring in a nursery and in a greenhouse. Progressive tests of cold hardiness were made on sample seedlings, and coincident analyses were made of sugars and of colour development in the foliage. Genotype-environment interactions of spring flushing were investigated by exposing dormant seedlings to a series of 9 controlled environments (3 photoperiods x 3 temperature regimes) for two weeks in early spring. Shoot and needle development were recorded.
(5) Most of the data were entered on data processing cards, summaries were prepared and statistical analyses carried out at the Yale Computer Center and by the Statistical Research Service of the Department of Forestry.

[1]Project Summary by C.W. Yeatman.

P-156E

Results

A compound analysis of the shoot and root weights of seedlings grown in the 9 controlled environments demonstrated the existence of highly significant differences between the 50 provenances and the spatial relationships between them along three independent compound coordinates (variates). The mean response over all environments provided the main basis for discrimination among provenances. Over the ranges employed, photoperiod affected growth more than did temperature, and the interaction of provenance with photoperiod was the second important source of discrimination among provenances. A climatic parameter, growing degree-days, accounted for from 65 to 80 per cent of the variation in the first variate; seed weight accounted for from 47 to 50 per cent of the variation in the second compound variate. These relationships were significantly different for populations east and west of longitude 91°W (Head of the Lakes) respectively.

Simple regression analyses were made for all environments separately, including greenhouse and nurseries, between shoot dry-weight and growing degree-days and root dry-weight and growing degree-days, again taking the eastern and western areas separately. The dry-weight data were all adjusted for seed weight by co-variance. Most of the relationships were very highly significant, all regressions were in the same direction; the slope and/or position varied significantly between environments and between shoots and roots, and between east and west of longitude 92°W. The median controlled environment of 15 hour photoperiod and 70°F day: 65°F night temperature provided the best condition for genetic differentiation among populations, and for demonstrating the relationships between the dependent and independent variables.

These analyses demonstrate an over-all clinal pattern of genetic variation due to environmental adaptation. A number of climatic parameters were tested singly and in combination, of which growing degree-days was the best single index of variation of the macro-environment. The difference in relative response between the eastern and western populations is associated with the different relationship between latitude (day length) and growing degree-days in the eastern and western sections of the continent. These results are consistent with other nursery and field jack pine provenance experiments dealing with older seedlings and saplings.

The hardiness and spring-flushing experiments demonstrated latitudinal patterns of variation in cold resistance and growth in the spring. Northern populations were hardier than southern populations. Degree of hardiness was associated with foliar sugar-content and colouration. All these characteristics were related to phenology of bud formation in late summer and autumn.

Status

Closed.

NOTE:

This work was supported by the Department of Forestry of Canada, the School of Forestry and Graduate School of Yale University, and by U.S. National Science Foundation Grants G-8891 and G-19973 awarded to Prof. François Mergen.

Reports

Unpublished

Yeatman, C.W. 1966. Geographic variation of *Pinus banksiana* Lamb. seedlings. Ph.D. Thesis, Yale University. 231 pp.

Published

Yeatman, C.W. 1964. Genetic variation in seedlings of jack pine provenances grown in controlled environments. Progress Report. Proc. 9th Meet. Comm. For. Tree Breed. in Canada. Part II, pp. 135-140.

Yeatman, C.W. 1965. Provenance discrimination of jack pine seedlings grown in controlled environments. Abstract, Can. J. Gen. and Cytol. 7:359.

Yeatman, C.W. 1966. Germinant size of jack pine in relation to seed size and geographic origin. *In* Joint Proc. 2nd Genetics Workshop, Soc. Amer. For. and 7th Lake States For. Tree Improvement Conf., Oct. 21-23, 1965. United States, Dept. Agriculture, For. Serv., North Central For. Exp. Sta., Res. Pap. NC-6, pp. 28-36.

Project P-156F[1] *Exp. No. 318*	Research on provenance, population genetics, heritability, and breeding in pine. Biochemical investigation of seed of 14 jack pine provenances; study of proteins, carbohydrates and amino acids.
Classification	160.24 161.34 165.5
Investigators	Present: V. Chalupa (NRC Post-doctorate Fellow), D.J. Durzan, M.J. Holst.
Objectives	Biochemical investigation of the embryo and female gametophyte of jack pine provenances. A study of the free sugars, amino acids and soluble protein.
Location	Petawawa Forest Experiment Station.
Work Done	Quantitative chromatographic analyses for the free sugars, automated instrumental analyses (Spackman, Stein and Moore) for the free amino acids, and disc electrophoresis on acrylamide gels for the soluble protein have now been completed.
Results	Correlations have been made with the chemical composition of two genetically and functionally different tissues of the seed to climatic factors at the seed source. The chemical analyses now provide a new insight into the metabolism of the major soluble nitrogenous compounds of the seed such as arginine, glutamine and protein.
Status	Near completion.
Reports	Publications in preparation.

[1]Project Summary prepared by D.J. Durzan.

Project P-156G[1] Research on provenance, population genetics, heritability, and breeding in pine. G. Provenance hybrids.

Exp. No. 130 Grafted jack pine population samples intended for provenance hybridization.

Exp. No. 255-B All-range jack pine provenance experiment (planted in Breeding Arboretum 1965).

Exp. No. 268 Provenance hybridization in jack pine.

Exp. No. 300 Testing of jack pine provenances, provenance hybrids, and lodgepole x jack pine hybrids on dry and wet sites.

Classification 165.5
165.7
232.12

Investigators Present: M.J. Holst.

Objectives To study the genotype-environment interaction of growth rate, hardiness and quality traits; to produce fast growing heterotic F_1 hybrids for specific environments; and to combine several desirable quality traits into the heterotic provenance hybrids.

Locations Most of the experimental material is planted at the Petawawa Forest Experiment Station. Additional tests are located in Alberta, Manitoba and northern Ontario.

Work Done Various grafted population samples and older provenance experiments have provided material for provenance crosses. In 1965 3–0 seedlings of 93 provenances of the all-range jack pine provenance experiment were field planted on wide spacing in the Pine Graft Arboretum to establish a breeding garden for provenance hybridization (Exp. No. 255-B). The first provenance hybrid was made in 1952 when a Petawawa and a Minnesota provenance was crossed. In 1960 14 jack pine provenance hybrids were made by removing the male flowers in our jack pine provenance collection (Exp. No. 130) and pollinating the open flowers with Petawawa pollen. Thus provenances from Northwest Territories, Alberta, Manitoba, Ontario, Wisconsin, Michigan, Quebec, New Brunswick, Nova Scotia and Maine were crossed with Petawawa. This seed was sown in 1962. In 1965 2–1 plants of 12 provenance hybrids and 17 control lots were field planted at the Petawawa Forest Experiment Station (Exp. No. 268-D-1). Ten of these provenance hybrids with control provenances, were established as observation plots in the Pine Graft Arboretum (Exp. No. 255-D-2). Five of the provenance hybrids were tested on dry and wet soil at Petawawa Forest Experiment Station (Exp. No. 300-A) and in the Central Plateau Section (Exp. No. 300-B).

In 1961, 50 jack pine provenance hybrids were made by controlled pollination. These, together with control provenances, are presently in the Petawawa Forest Experiment nursery (Exp. No. 268-E).

Results The provenance hybrids and control provenances will be measured in the fall of 1966.

Comments The provenance hybrids made to date have been between average populations. Considerable gain in quality traits could be expected if highly selected plus trees of the various provenances were used.

[1]Project Summary prepared by M.J. Holst.

P-156G

Status Continuing.

Reports

Unpublished

Holst, M.J. 1965. Provenance hybridization in jack pine. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 268-D).

Published

Holst, M.J. 1964. Forest tree breeding and genetics at the Petawawa Forest Experiment Station. Biennial Report: 1 April, 1962 to 31 March, 1964. Proc. 9th Meet. Comm. For. Tree Breed. in Canada. Part II. pp. 63-107.

Project P-156H[1] Research on provenance, population genetics, heritability, and breeding in pine. H. Heritability study.

Exp. No. 273 Single tree progeny test of 300 jack pines to study inheritance of cone characteristics, stem form and branch angle.

Classification 165.3

Investigators Present: M.J. Holst.

Objectives To assess the heritability of cone characteristics, stem form and branch angle by parent-progeny correlation.

Location Petawawa Forest Experiment Station.

Work Done In the fall of 1961 cones were collected from each of 300 jack pine trees. The collections were made just before the trees started to open the cones. The trees were scored for cone characteristics, stem form and branch angle. None of the trees were permanently marked in the field. The 2-0 plants of 255 of these progenies were field planted in the spring of 1964 at the Petawawa Forest Experiment Station. The design includes ten replications of ten-plant plots. A further study of heritability of stem form was initiated in 1964 when crosses were made between trees with straight, average and crooked stems.

Results This experiment will be rated for cone characteristics, stem form and branch angle when ten years old. The experiment will also be used for rating of insect and disease resistance, as well as for wood quality.

Comments Jack pine typically has a poor stem form, heavy branches with a small branch angle, and poor self-pruning. An improved type is needed, but little is known about the heritability of desirable quality traits.

Status Continuing.

Reports

Unpublished

Holst, M.J. 1963. A single tree progeny test of 300 jack pines to study inheritance of cone characteristics, stem form and branch angle at the Petawawa Forest Experiment Station. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 273).

Holst, M.J. 1963. Would open-coned trees solve the jack pine regeneration problem. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 273).

[1]Project Summary prepared by M.J. Holst.

Project P-156I[1] Research on provenance, population genetics, heritability, and breeding in pine. I. Species hybrids.

Exp. No. 83 Selection of jack x lodgepole pine hybrids from seed collected from a mixed jack pine-lodgepole pine stand in the Spruce Woods Forest Reserve, Manitoba (field planted 1957).

Exp. No. 87 Investigation of jack pine lodgepole pine and their hybrids for resistance to sweet-fern blister rust, (field planted 1945, 1955, 1956, 1958, 1960, 1961 and 1963).

Exp. No. 118 Radiation of jack pine seed with doses from 125 r to 500 r.

Exp. No. 124 Interspecific grafting of red, jack and Scots pine using chilled and unchilled root-stocks (grafted 1955).

Exp. No. 240 Lodgepole pine provenances to be selected for resistance to the sweet-fern blister rust *(Cronartium comptoniae),* growth rate and form, for eventual hybridization with jack pine.

Exp. No. 287 Biochemical determination of hybridity in spruce and pine.

Exp. No. 300 Testing of jack pine provenances, provenance hybrids, and lodgepole x jack pine hybrids on dry and wet sites (field planted 1965).

Exp. No. 324 Hybridization of jack pine and Virginia pine.

Classification
160.24
165.43
165.7
181.65
232.13
232.328
443.3

Investigators Present: M.J. Holst

Objectives To study jack pine species hybrids; their identification, resistance to insects and diseases, ecological amplitude, and silvicultural potential in eastern Canada.

Location Petawawa Forest Experiment Station and elsewhere in Ontario.

Work Done During the period 1955–65 several test plantings were established at the Petawawa Forest Experiment Station to study the relationship between lodgepole pine and jack pine and their hybrids. In 1963 seed of a number of jack pine provenance hybrids and lodgepole x jack pine hybrids were distributed for testing in colder climates in Manitoba and Alberta. In 1965 five lots of jack pine provenances, 14 lots of lodgepole x jack pine hybrids and eight control lots were planted on wet and dry sites at the Petawawa Forest Experiment Station. A similar experiment was planted near Hillsport in the Central Plateau Section (B.8) by the Marathon Corporation of Canada.

The interspecific grafting of red, jack and Scots pine was done in 1955. The cross, jack pine with Virginia pine, was attempted in 1952 and in 1962.

[1]Project Summary prepared by M.J. Holst.

Results

The jack x lodgepole pine hybrid has been tested on a very limited scale in eastern North America. Most of these hybrids were made at Placerville where they showed pronounced hybrid vigour. On the sandy acid sites in the East, jack pine has been superior, the hybrid intermediate, and lodgepole pine the poorest. However only few combinations have been tried. In the Placerville hybrid, the lodgepole pine parent came from Eldorado Co., California and the jack pine parent came from the "East". Better combinations with jack pine may be expected from fast-growing and well-formed types of lodgepole pine originating from acid or sandy sites or perhaps from mid-elevations or even coastal areas.

Some evidence of the gains to be expected is seen in the introgressed lodgepole x jack pine populations from Alberta planted at the Petawawa Forest Experiment Station. The lodgepole pine types are slow growing and of good form, but the jack pine types are more vigorous and typically of undesirable form. It is notable that the trees in these populations are all resistant to sweet-fern blister rust (*Cronartium comptoniae),* although they originated in an area free of the disease owing to the absence of the alternate host, sweet-fern. Blister rust killed most of the pure lodgepole pines planted on deep acid sands at the Petawawa Forest Experiment Station. The same provenances were less susceptible at Valcartier F.E.S. and nearly resistant at the Acadia F.E.S. Hence, there appears to be an interaction between environment and rust susceptibility. The mass introduction and inoculation with *Cronartium* would be the first stage in the introduction and selection of lodgepole pine for the production of species hybrids with jack pine.

Some shore and lodgepole pine populations are notable for their ability to grow on soil of low fertility as well as on poorly aerated acid soils. The lodgepole x jack pine hybrid may be suitable for this type of site in eastern Canada. By testing this hybrid on wet and dry sites in northern as well as in southern Ontario it should be possible to estimate its ecological amplitude.

Seed was collected in 1964 for biochemical determination of the lodgepole x jack pine hybrids.

The attempts to cross jack pine with Virginia pine have failed. New crosses will be made in the near future.

Survival of reciprocal jack-red pine grafts was very low, and when the root-stocks were pruned they all perished. The survival of the reciprocal jack-Scots pine grafts were high.

Comments

Although F_1 hybrids of the lodgepole pine and jack pine do not appear promising in eastern Canada at the moment, further breeding and testing may produce valuable types. Careful selection and heavy grading in the initial populations would be required as well as an extensive test crossing program.

Status

Continuing

Reports

Unpublished

Holst, M.J. 1957. Establishment Report for Exp. No. 83. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Holst, M.J. 1958. Interspecific grafting of jack, red and Scots pine. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS. (Exp. 124).

Reports

Unpublished (continued)

Holst, M.J. 1960. Establishment Report for Exp. No. 87. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Holst, M.J. 1963. Establishment Report for Exp. No. 87. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

Holst, M.J. 1965. Testing of jack pine provenances, provenance hybrids and lodgepole x jack pine hybrids on dry and wet sites at Petawawa Forest Experiment Station. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. (Exp. 300–A).

Waatainen, B. 1965. Testing of jack pine provenances, provenance hybrids and lodgepole x jack pine hybrids on three sites near Hillsport (B.8). Marathon Corporation of Canada. Unpubl. MS. (Exp. No. 300–B).

Published

Holst, M.J. and J.B. Santon. 1958. Interspecific grafting of hard pines. Proc. 6th Meet. Comm. For. Tree Breed. in Canada. Section R.

Holst, M.J. and J.B. Santon. 1966. Reciprocal scion-rootstock combinations of *Pinus banksiana* Lamb., *P. resinosa* Ait. and *P. sylvestris* L. Canada, Dept. Forestry (In press).

Project P–235 Survival and development of plantations.

Classification 232.4

Investigators Past: E.G. Daly
Present: W.M. Stiell

Objectives To provide useful guides for future reforestation by studying the survival and development of established plantations.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46° 00'N, longitude 77° 30'W.

Work Done Apart from extensively planted white spruce, red pine, white pine and Scots pine, two pure 0.1 to 0.6–acre plantations of jack pine (A and B) were established, both at a spacing of 5 by 5 feet. Plantation A was on a somewhat dry, windblown fine sand and was slit-planted with 2–2 stock. Plantation B was on dry, waterlaid sand and furrow-planted with 3-year-old stock. Both sites supported a blueberry-sweet fern type of vegetation. During the first survey in 1938–39, survival counts and measurements of height and diameter of trees were made in a certain proportion of the rows. In 1951 this survey was repeated, and a number of permanent plots were established. In each case, stand conditions and soils were described in detail (Stiell, 1955).

Results Table 1 shows the development of these plantations. Plantation A was quite dense, and showed signs of overstocking. A small amount of snow breakage and suppression of the smaller trees was noted and live-crown lengths within the stand were reduced to 25 to 30 per cent of total height. Some trees showed a moderate crook,

TABLE 1. SURVIVAL AND DEVELOPMENT OF JACK PINE PLANTATIONS, PETAWAWA FOREST EXPERIMENT STATION

(Stiell 1955)

	Year	A	B
Total age, in years	1938	18	3
	1951	31	16
Trees per acre planted		1,905	1,742
Survival, in trees per acre	1938	1,600	
	1951	1,400	1,510
Survival, in per cent	1938	84.0	
	1951	73.6	86.2
Average height, in feet	1938	17.2	
	1951	35.3	16.6
Height of tallest 10 per cent, in feet	1938	23.8	
	1951	40.5	19.6
Average diameter, in inches	1938	2.6	
	1951	4.1	2.3
Volume, in total cubic feet per acre	1938	440	
	1951	1,720	

but form was generally good. Plantation B had been heavily browsed by white-tailed deer, and the height and diameter values in Table 1 apply only to the 22 per cent of the trees which escaped leader damage (Stiell, 1955).

Comments From a comparison with other tree species, grown in many cases side by side, it was concluded that jack pine and Scots pine were much better suited to dry sites than were white spruce, red pine, or white pine. Generally, jack pine showed faster and more uniform growth and better form than Scots pine; and although both these pines were badly browsed, jack pine was less frequently attacked by porcupines (Stiell, 1955).

Status Continuing

Reports

Unpublished

Daly, E.G. 1951. Survival and development of plantations established in 1934–36 by relief labour. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Stiell, W.M. 1952. Status of the plantations at Petawawa Forest Experiment Station. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Stiell, W.M. 1952. Summary report of Petawawa Forest Experiment Station Plantation. Plot Numbers 1, 3, 3a, 6, 9, 10, 11, 13, 16, 17, 23, 24, 32, 33, 37, 39. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Stiell, W.M. 1957. Survival and development of plantations. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Stiell, W.M. and J.L. Farrar. 1953. Browsing damage by deer in a pine plantation. Canada, Dept. Resources and Development. Forestry Branch, For. Res. Div., Silv. Leafl. 83. 4 pp.

Stiell, W.M. 1955. The Petawawa plantations. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 21. 46 pp.

Project P-366 A study of the effect of environmental factors on the germination of native tree species.

Classification 181.525

Investigators Past: J.W. Fraser, J.L. Farrar

Objectives To determine the effects of seedbed conditions on jack pine and red pine germination.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done Between 1951 and 1953 several experiments were carried out under simulated or controlled conditions. Specifically, the effects of shading, watering, seedbed medium, depth of seeding and direct sunlight on germination and early seedling development were investigated.

Results The experiments concerning jack pine demonstrated that:

(1) Partial shade created conditions which helped jack pine germination. The beneficial effects of shelter arose from the resultant better moisture conditions. Moisture is essential for germination; sunshine and wind are the two most important factors contributing to its loss. The complex shade pattern cast by dead, standing trees and fallen logs on burned areas probably contributes substantially to the good germination often observed on such areas (Fraser and Farrar, 1953a).

(2) Conditions favouring a high moisture content in jack pine seed resulted in good germination. These were: the use of a fine-textured medium, addition of water, shading, and sowing below the surface. The opposite conditions favoured drought, which is associated with higher temperatures. Hence, lower germination occurred where the medium was coarse, no water was added, no shade was provided, and the seeds were sown on the surface. Jack pine root length was greatest at higher light intensities, but hypocotyl length was greatest under heavy shade. This does not represent increased vigour, but it is merely evidence of insufficient light. Increased moisture did not affect growth, indicating that moisture conditions below the depth of the seed were adequate at all time (Fraser and Farrar, 1953b).

(3) Germination on pulverized humus was 42 per cent compared to 48 per cent on mineral soil, indicating that no chemical substance prevents jack pine germination on the forest floor, and suggesting that the reason humus is usually a poor seedbed can be explained in terms of moisture relations. If the physical structure of humus is altered so that it forms a fairly compact mass in contact with the underlying moist mineral soil, or if naturally loose humus is maintained at a high moisture content, good germination of jack pine occurs (Farrar and Fraser, 1953).

(4) Jack pine germinated best on seedbeds that were not exposed to direct sunlight. Germination decreased significantly only when the daily exposure period exceeded four hours. The poorest germination occurred when the seedbeds were exposed constantly. Height growth obviously improved with increased exposure. The germination response was attributed mainly to variations in soil moisture and soil temperature associated with the periods of exposure, and the poorer germination that occurred when the seedbeds were exposed for six hours or more each day was attributed to the combination of soil moisture deficiency and high soil temperature that developed under such conditions. Germination and early growth of red and jack pine in relation to seedbed exposure are compared in Figure 1 (Fraser, 1959).

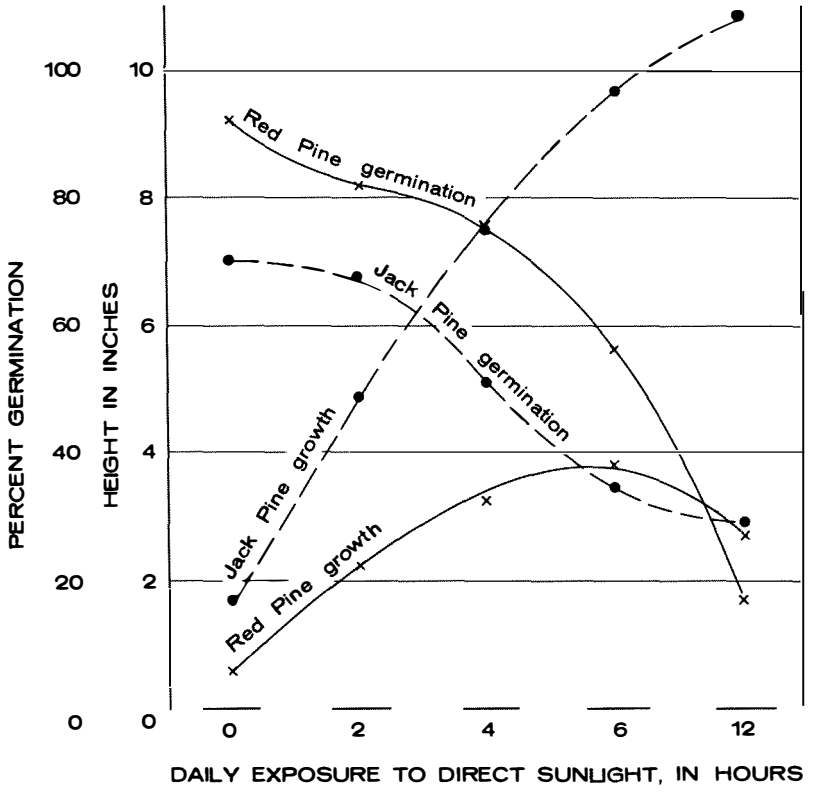

Figure 1. Germination and early growth of red and jack pine in relation to seedbed exposure after two growing seasons. (Fraser 1959).

Comments None.

Status Closed.

Reports *Published*

Farrar, J.L. and J.W. Fraser. 1953. Germination of jack pine seeds on humus. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 91. 2 pp.

Fraser, J.W. and J.L. Farrar. 1953a. Effect of shade on jack pine germination. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 88. 3 pp.

Fraser, J.W. and J.L. Farrar. 1953b. Effect of watering, shading, seed-bed medium, and depth of sowing on jack pine germination. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 90. 4 pp.

Fraser, J.W. ·1959. The effect of sunlight on the germination and early growth of jack pine and red pine. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 71. 6 pp.

Project P-372 Frost resistance of young seedlings.

Classification 181.22
422.1

Investigators Present: J.W. Fraser

Objectives To investigate temperature differences in a natural frost pocket, and to investigate the observed killing effect of frost on jack pine and red pine seedlings.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done In September of 1952, nursery-grown jack pine and red pine seedlings were placed in a shallow kettle that was believed to be a frost pocket. Some seedlings were two months old and woody; others were only a month old and were succulent. Shielded thermometers were placed in the frost pocket and temperatures were recorded daily.

Results The experiment demonstrated the killing effect of frost on young unhardened red pine and jack pine, and results suggested a relation between frost resistance and age. Certain environmental features such as aspect and exposure may increase or lessen the danger of mortality from freezing, depending upon whether they speed up or retard the freezing and thawing processes.

Status Continuing.

Reports *Published*

Fraser, J.W. 1953. Preliminary observations on the mortality of pine seedlings in frost pockets. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Leafl. 87. 4 pp.

Project P-379 Direct seeding of red and white pine under aspen stands on sandy, outwash areas.

Classification 232.216
232.33
232.4

Investigators Past: R.J. McCormack, K.W. Horton

Objectives To test promising economical methods of artificial regeneration with four pine species in an effort to find the best alternative to the expensive method of planting transplant stock.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done The experiment was established in two separate, but similar locations, each on a flat outwash plain with deep medium and fine sand. Drainage was uniformly excessive. Two cover conditions were investigated, one open and the other aspen covered. The experiment was begun in the spring of 1954 and continued during the fall of 1954 and the spring of 1955. the following four methods were tested:

(1) Sowing 20 seeds on the surface of scarified one-foot-square spots.
(2) Sowing 20 seeds on the surface of scarified one-foot-square spots and covering with ¼ inch of mineral soil.
(3) Sowing 5 seeds in a spot scuffed by heel, with soil and humus kicked over seeds.
(4) Planting 2-0 stock on scarified one-foot-square spots.
Seedling examinations were made from 1954-1956 and in 1959.

Results (1) Seeding was generally unsuccessful. Planting trials were more encouraging and 2-0 planting stock survived remarkably well. Cover did not affect survival of planted stock, but did increase stocking on seeding spots to a small extent (Table 1).
(2) Depth seeding gave better results than either of the other seeding methods.

TABLE 1. JACK PINE PERCENTAGE STOCKING 5 TO 6 YEARS AFTER ESTABLISHMENT.

Method	Open blocks	Aspen covered blocks
1. Surface spot seeding	14	31
2. Depth spot seeding	29	39
3. Scuff spot seeding	–	3
4. Planting 2-0 stock	80	78

Comments Although the year 1955 was exceptionally dry, depth sowing in the aspen-covered blocks came close to the minimum acceptable stocking of 50 per cent. Thus, in more favourable seasons, acceptable stocking might result from depth sowing. The small spots employed in this study were susceptible to various adverse effects such as collection of litter, and they soon became overgrown by vegetation. Larger scarified areas and wider broadcasting of seed would probably remedy these drawbacks.

Status Closed.

Reports

Unpublished

McCormack, R.J. 1955a. Direct seeding of red and white pine under aspen stands on sandy, outwash areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

McCormack, R.J. 1955b. Direct seeding of red and white pine under aspen stands on sandy, outwash areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

McCormack, R.J. 1956. Delayed germination of pine seeds on sandy, outwash areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

McCormack, R.J. 1957. Direct seeding in scarified spots as a method of regenerating sandy, outwash areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Krewaz, J. 1957. Seeding of white pine on sandy outwash after fire. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Horton, K.W. 1959. Direct seeding of red and white pine under aspen stands on sandy outwash areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Horton, K.W. and R.J. McCormack. 1961. Economical spot seeding and planting methods for pines on sand plains. Canada, Dept. Forestry, Forest Research Branch, Tech. Note 100. 19 pp.

Project P-386[1] The effect of temperature on germination, early growth, and development of native tree species.

Classification 181.22
181.525

Investigators Present: J.W. Fraser

Objectives To establish the temperature ranges within which optimum germination of native tree species occurs, and to determine the temperature extremes that limit their germination.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done Germination-temperature relationships at constant temperature levels were established for local seed lots, and for one other provenance. A limited investigation of the effect of alternating temperatures on the germination-temperature relationship was carried out under controlled conditions. The effectiveness of mulching to obtain germination on severely exposed areas was also investigated. In all this work, equal emphasis was given to jack pine, red pine and white pine.

Results Not yet available for publication.

Comments Results will be published in the near future.

Status Continuing.

Reports *Unpublished*

Fraser, J.W. 1956. The effect of temperature on germination, growth, and development of native tree species. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

[1] Project summary prepared by J.W. Fraser.

Project P-388[1] Responses of seventeen species of tree seedlings to 13, 25, 45 and 100 per cent of full light intensity.

Classification 181.21
181.525

Investigators Present: K.T. Logan

Objectives To show the effect of four levels of light on growth of seedlings and to compare species responses within each light treatment.

Location Petawawa Forest Experiment Station, Chalk River, Ontario. Latitude 46°00'N, longitude 77°30'W.

Work Done Seedlings of 17 species, including jack pine, were grown for a six-year period in an open area and in shelters admitting 13, 25, and 45 per cent of full light. Twenty seedlings per species were placed in each of two rows located at random in each treatment.

Seedling measurements recorded at the end of each growing season included height, diameter at the mid-point of the leader, and length of typical needles on the leader.

Oven-dry weights of tops and roots of 4-year-old seedlings were determined and, after 6 years, weights of foliage, branch and stem were also measured.

Results Results for jack pine are summarized below.
Height growth: During the first four years, tallest seedlings were in 45 and 100 per cent light, but in the fifth and sixth year the tallest seedlings were those in full light. Average heights at five years were as follows: 13 per cent, 16 inches; 25 per cent, 29 inches; 45 per cent, 39 inches; 100 per cent, 44 inches.

Shoot weight: Trends for shoot weight were similar to those for height growth.

Needle length: Needles reached a maximum length on seedlings in 25 per cent light and decreased in length with increasing light.

Leader diameter and root collar diameter: Diameters increased with each increase in light.

Root weight: Oven-dry weight increased with each increase in light.

Status Continuing

Reports *Unpublished*

Logan, K.T. 1958. Response of seventeen species of tree seedlings to thirteen, twenty-five, forty-five and one hundred per cent of full light intensity. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Logan, K.T. 1959. Response of tree seedlings to four light intensities. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Logan, K.T. 1960. Growth of seedlings in low light. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

[1] Project summary prepared by K.T. Logan

Reports *Unpublished (continued)*

Logan, K.T. 1961. Response of tree seedlings to four light intensities. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Published

Logan, K.T. 1966. Growth of tree seedlings as affected by light intensity. II. Red pine, white pine, jack pine and eastern larch. Canada, Dept. Forestry, Publn. No. 1160. 19 pp.

Project Q-11 Development of plantations at Proulx.

Classification 232.4

Investigators Past: G.C. Cunningham, J.D. MacArthur
Present: A. Demers

Objectives To study the survival and rate of growth of trees planted near Grand'Mère between 1913 and 1932

Location Near Grand'Mère in the valley of the St. Maurice River, Quebec. Latitude 45°35'N, longitude 75°40'W.

Work Done Between 1913 and 1932 a total of 9,600 acres, or nearly 15 square miles, of plantations were established on freehold lands by the former Laurentide Paper Company for the purpose of assuring an adequate supply of pulpwood for their mill at Grand'-Mère.

The oldest jack pine plantation was set out in 1918; it was a mixed plantation with Scots pine. In 1922, an experimental plantation was established to compare the growth of jack, red, and Scots pine, and white spruce planted on abandoned sandy farmland. Additional jack pine was planted, usually in mixture with white spruce, in 1925 and 1926.

In 1946, a survey of the plantations was carried out to determine the rate of growth of the planted trees and to collect any other pertinent information that would be useful in preparing a plan of management.

In 1956, an examination was made in the 1922 plantation that had been established to compare the growth of jack, red, and Scots pine, and white spruce.

Results

(1) Mixed jack pine and Scots pine (1918).
Twenty-eight years after planting, the jack pine, which comprised only 80 per cent of the stand, had a basal area of 130 square feet and a volume of 2,400 cubic feet. Its average diameter was 5.4 inches, and average height 40 feet.

(2) Planting jack pine, red pine, Scots pine, and white spruce (1922).
Thirty-five years after planting, jack pine had a basal area of 143 square feet and a volume of 2,960 cubic feet. Average diameter was 6.2 inches and average height was 48 feet. Mortality was 60 per cent. Although the growth of jack pine was vigorous, the trees were poorly formed. Sweep and crook in the stem and coarse, irregular branching were common. Jack pine and red pine were suitable for planting; Scots pine and white spruce were not suitable.

(3) Mixed jack pine and white spruce (1925).
The jack pine was badly deformed, with short, crooked trunks and wide-spreading crowns of large, twisted branches reaching to the ground. White spruce, while of good form, was not healthy.

Comments Jack pine was suitable for planting on almost level sandy soils of the old marine plain of the St. Maurice River. Its yields were as high as those reported for other localities.

Status Continuing.

Reports

Published

Cunningham, G.C. 1953. Growth and development of coniferous plantations at Grand'Mère, P.Q. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Silv. Res. Note 103. 28 pp.

MacArthur, J.D. 1958. Growth of jack, red and Scots pine and white spruce plantations, 1922 to 1956, at Grand'Mère, Quebec. Pulp Pap. Mag. Can. 60 (Convention Issue): 256...260. (Also published by Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., S. & M. 58-4. 6 pp).

Project Q–35 Forest site classification of the Northeastern Coniferous Section, Boreal Forest Region, Quebec.

Classification 542

Investigators Past: A. Linteau

Objectives To develop a site classification for the Northeastern Coniferous Section of the Boreal Forest Region in Quebec.

Location Northeastern Coniferous Section (B.1) of the Boreal Forest Region of Quebec and the Central Transition Section west of the B.1. Latitude 47° to 52°N, longitude 58° to 75°W.

Work done Plots were established and measurements of height, diameter, age, and crown class made. Reproduction was tallied.

Ground plants such as lichens, mosses, herbs, and shrubs were identified and studied systematically. Sociability was estimated.

The soil profile under each forest stand was examined. Soil profiles and physical descriptions of horizons were recorded as well as depth to water table, depth of root penetration, and local topography.

Results Results are presented in Table 1.

TABLE 1. SITE TYPES SUPPORTING JACK PINE AS A MAIN SPECIES, NORTHEASTERN CONIFEROUS SECTION, BOREAL FOREST REGION

(Linteau 1955)

Site type	Main species		Soil conditions
	Immature stand	Mature stand	
A. *Moss and dwarf shrub forests*			
Hypnum-Kalmia	jP	bS	Imperfectly drained sand to light sandy loam soils near lakes or at foot of mountains
Calliergon-Ledum	jP-bS	bS-jP	Deep alluvium, relatively dry, rapid drainage, sand to silt loam
Calliergon-Vaccinium	jP	bS-jP	Fine sandy loam over loamy fine sand; iron podzol profile
B. *Lichen and dwarf shrub forests*			
Kalmia-Vaccinium	jP	jP-bS	Deep coarse gravelly sand, iron podzol profile. On coarse river deposits along a wide valley, on eskers and kames
Cladonia-Ledum	jP	jP-bS	Sand or gravelly sand, relatively dry, frequently on eskers, poor alluvium, and river terraces
Cladonia-Vaccinium	jP-bS	bS-jP	Similar to Cladonia-Ledum

Q-35

Status Closed.

Reports *Published*

Linteau, A. 1955. Forest site classification of the Northeastern Coniferous Section, Boreal Forest Region, Quebec. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, Bull. 118. 85pp.

Project Q–70 Reforestation studies, York River burn.

Classification 181.525
232.4

Investigators Present: J. D. Gagnon

Objectives To determine which of three cultural methods – (a) none, (b) addition of nitrogen, (c) mixing of lichen crust into mineral soil – is most beneficial to black spruce, jack pine, and red pine plantations.

Location The Gaspé Section, B.2, of the Boreal Forest Region, east of Murdochville, Quebec. Latitude 48° 45'N, longitude 66° 30'W.

Work done The experimental area supported an over-mature black spruce stand that was burned in 1941 and subsequently cut over. Reproduction on the area is sparse. The soil is a deep sandy loam.

In June 1964 planting was carried out using Saguenay planting tools. Jack pine stock was in the 2–2 age class and had been grown at the Petawawa Forest Experiment Station. Mixing of the soil was accomplished with a Gravely tractor equipped with a tiller. Nitrogen was applied as $(NH4)_2 SO_4$ (twenty per cent nitrogen) at the rate of 200 pounds per acre.

Results None available.

Status Continuing.

Reports *Unpublished*

Gagnon, J.D. 1964. Establishment report. Reforestation of York River burn. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64–Q–26.

Project Q–80[1] Comparison of survival and growth of several conifers planted on agricultural land in the Clay Belt – Forest Section B.4.

Classification 232.216
232.4

Investigators Past: J.D. MacArthur
Present: A. Demers

Objectives The purpose is to observe the responses of several coniferous species to the soil and climatic conditions prevailing on formerly cultivated land in the Clay Belt.

Location The area is in the Clay Belt – Forest Section B.4. The nearest town is Amos, about 13 miles north on Route 60. Lake La Motte lies immediately southwest of the area, giving it a pronounced southwestern exposure. Latitude 48°30'N, longitude 77°50'W.

Work done Between 1960 and 1962 experimental planting of various conifers was carried out on old fields on heavy clay soils. Jack pine was included in some of the 1960 and 1961 planting trials.

In 1960, 12,200 jack pine (2–2 stock) were planted. They had been grown at the Valcartier Forest Experiment Station nursery from seed of Dolbeau and Manouan origin. Three methods of planting in furrows were carried out as follows:

(1) Trees placed along the furrow and the whole sod turned back to hold them.
(2) As above but with only a one-foot section of sod turned back for each tree.
(3) Trees planted in slits parallel to the cut edge of the furrow and the sod not turned back.

In 1961, 2,100 jack pine (1–1 stock) of Chapleau, Ontario, origin were planted in ploughed furrows.

Survival counts of the plantations were made in 1961 and 1962.

Results Mortality of the jack pine planted in 1960 was heavy; it ranged by block from 50 to 90 per cent. Much of it resulted from the poor condition of the stock at the time of planting, and from difficulties encountered in planting on the clay soil which had dried and baked. Jack pine grew well once established and promises to continue to do so. In 1962, many surviving trees were 3 to 4 feet tall, had 10– to 12–inch leaders and well-developed healthy foliage.

No results are available for the jack pine planted in 1961.

Comments Jack pine is the most promising of the species tested for old field planting in the Clay Belt. Once established it grows well and appears healthy. White spruce survives well, for the first two years at least, but may be subject to checking and is of doubtful value until a remedy can be found.

In old fields hole-planting is practically impossible and all planting must be in slits. Therefore, judicious root pruning would facilitate planting and probably give better survival and growth. Of the planting methods tested, the best were those giving the most complete closure of the planting slit. They were also the easiest to use. Machine planting (in fact, planting in a continuous slit) seems to be the most practical approach, especially if timed to coincide with favourable soil conditions.

[1]Project summary prepared by J.D. MacArthur.

Extremely dry or wet soil would probably seriously hinder any attempt to plant. Small trees plant well but are often smothered by hay while trees large enough to be more or less immune to smothering are difficult to plant. Determination of optimum stock size for this and other planting sites might be a rewarding undertaking.

Status Continuing

Reports

Unpublished

MacArthur, J.D. 1960. Comparison of survival and growth of several conifers planted on agricultural land in the Clay Belt – Forest Section B.4. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

MacArthur, J.D. 1962. Comparison of survival and growth of several conifers planted on agricultural land in the Clay Belt – Forest Section B.4. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS.

MacArthur, J.D. 1963. Comparison of survival and growth of several conifers planted on agricultural land in the Clay Belt – Forest Section B.4. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63–Q–10.

Published

MacArthur, J.D. 1964. Field planting trials in the Clay Belt – Quebec. Pulp Pap. Mag. Can., Woodlands Review Convention 1964: WR–58–WR–61.

Project Q–81 Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Sault-au-Cochon River, Forest Section B.1a.

Classification 232.216
232.33

Investigators Past: J.D. MacArthur
Present: A. Demers

Objectives To study germination, survival and growth of five coniferous species – black spruce, white spruce, Norway spruce, balsam fir, and jack pine – sown on five different types of seed spots.

Location Twenty-two miles north of the company gate on the Sault-au-Cochon limits of the Anglo-Canadian Paper Mills Ltd., in Forest Section B.1a. Quebec. Latitude 48°55'N, longitude 69°24'W.

Work Done The experimental area is located on a sandy river terrace, on an area that was burned in 1953. The experiment was established in a split-plot design in which there are three levels – year of sowing, seed spot treatment, and species. For each combination of factors, 20 one-square-foot seed spots were established.

The five seed-spot treatments are as follows:

T1 – Control
T2 – Mineral soil
T3 – Mineral soil scarified
T4 – Mineral soil and organic matter mixed
T5 – Furrows running in an east-west direction

Seeding was carried out for three years, 1960–1962, inclusive. Seed and seeding data are summarized for jack pine in Table 1.

The 1960 seed spots were examined in 1961, 1962 and 1964; the 1961 seed spots in 1962 and 1964; and in the 1962 seedspots in 1964.

TABLE 1. JACK PINE SEED AND SEEDING DATA (1960–1962)

(MacArthur 1960, 1961; Choquette 1964)

Year	Seed source	Germination per cent	Date of seeding	Number of seeds sown per spot
1960	Abitibi Co., P.Q.	70	May 27	100
1961	Forestville, Valcartier, Abitibi, P.Q.	80	May 16 to 19	100
1962	Forestville	78	May 15 to 18	128

Results Results for jack pine are presented in Table 2.

TABLE 2. PER CENT STOCKING OF SEED SPOTS – 1961, 1962, 1964

(MacArthur 1961; Choquette 1964, 1965)

Treatment	Sown in 1960			Sown in 1961		Sown in 1962
	1961	1962	1964	1962	1964	1964
T1 – Control	1	3	8	28	31	10
T2 – Mineral soil	31	40	28	65	65	70
T3 – Mineral soil scarified	29	63	59	72	66	74
T4 – Mineral soil and organic matter	29	51	48	70	69	47
T5 – Furrow.....	41	39	36	40	48	56
All	28	39	36	55	56	51

Status Continuing

Reports *Unpublished*

MacArthur, J.D. 1960. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Sault-au-Cochon River: Forest Section B.1a. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

MacArthur, J.D. 1961. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Sault-au-Cochon River: Forest Section B.1a. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Choquette, André. 1964. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Sault-au-Cochon River: Forest Section B.1a. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64–Q–4.

Choquette, André, 1965. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Sault-au-Cochon River, Forest Section B.1a. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65–Q–2.

Project Q–101 Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Little Pabos River, Gaspé Peninsula, Forest Section B.2.

Classification 232.216
232.33

Investigators Past: J.D. MacArthur
Present: A. Demers

Objectives To study germination, survival and growth of five coniferous species – black spruce, white spruce, Norway spruce, balsam fir, and jack pine – sown on five different types of seed spots.

Location Twenty miles from Chandler, Quebec, on the Little Pabos limits of the Gaspesia Pulp and Paper Company in Forest Section B.2. Latitude 48°31'N, longitude 64°53'W.

Work done The experimental area is located in an area burned in 1940. Soils vary in texture from loam to sandy-loam to clay-loam. The experiment was established in a split-plot design in which there are three levels – year of sowing, seed spot treatment, and species. For each combination of factors, 20 one-square-foot seed spots were established.

The five seed-spot treatments are as follows:

T1 – Control
T2 – Mineral soil
T3 – Mineral soil scarified
T4 – Mineral soil and organic matter mixed
T5 – Furrows running in an east-west direction

Seeding was carried out for three years, 1961 to 1963, inclusive. Seed and seeding data are summarized for jack pine in Table 1.

The 1961 seed spots were examined in 1961, 1962, 1963 and 1964; the 1962 spots in 1963 and 1964; and the 1963 spots in 1964.

TABLE 1. JACK PINE SEED AND SEEDING DATA (1961–1963)

(MacArthur 1961; Choquette 1963, 1964)

Year	Seed source	Germination per cent	Date of seeding	Number of seeds sown per spot
1961	Forestville, Valcartier, Abitibi, P.Q.	80	June 17, 18	100
1962	Quebec, Chateau d'Eau, Forestville, Valcartier	70–72	June 6–9	140
1963	Quebec (1960)	56	June 10–11	170

Results Results for jack pine are presented in Table 2.

TABLE 2. PER CENT STOCKING OF SEED SPOTS – 1961 to 1964

(MacArthur 1961; Choquette 1963, 1964, 1965)

Treatment	Sown in 1961				Sown in 1962		Sown in 1963
	1961	1962	1963	1964	1963	1964	1964
T1 – Control	10	16	16	13	11	20	2
T2 – Mineral soil....	40	54	51	51	41	43	24
T3 – Mineral soil scarified	90	60	56	49	58	58	36
T4 – Mineral soil and organic matter..	35	57	56	52	37	49	13
T5 – Furrow.....	25	42	34	32	34	35	14
All	40	46	43	39	36	41	18

Status Continuing

Reports *Unpublished*

MacArthur, J.D. 1961. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Little Pabos River, Gaspé Peninsula, Forest Section B.2. Canada, Dept. Forestry, For. Res. Div., Unpubl. MS.

Choquette, André. 1963. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Little Pabos River, Gaspé Peninsula, Forest Section B.2. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 63–Q–26.

Choquette, André. 1964. Trials of seed spot methods with five coniferous species in a non-reproducing burn on the Little Pabos River, Gaspé Peninsula, Forest Section B.2. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64–Q–6.

Project Q–106 Soil improvement of abandoned farm land for better growth.

Classification 181.525
232.216
232.4

Investigators Present: J.D. Gagnon

Objectives To determine whether the addition of potassium and magnesium fertilizers applied to unscarified and scarified soil will benefit the establishment and development of red pine, jack pine, and Norway spruce set out on abandoned farm land.

Location About three miles west of Ste. Christine, Portneuf County, Quebec, and south of the Ste. Anne River. Latitude 46° 50'N, longitude 72° 00'W.

Work Done The experimental area is located on deep, old marine sand deposits of low fertility. Abandoned for agriculture in 1953, the site had become overgrown with grass.

A factorial design with three levels of potassium, two levels of magnesium and two soil treatments was laid out in completely randomized blocks with four replications for each species. Nine trees were planted per plot. A total of 1,296 trees were planted in May 1964.

The two soil treatments were no scarification and scarification with a Gravely tractor equipped with a tiller attachment. Fertilizers were applied one day after planting. Potassium, as K_2SO_4, was applied at the rate of 100 and 200 pounds per acre, and magnesium, as MgO, was applied at a rate of 100 pounds per acre.

After planting, the heights of all trees were measured. Survival was determined in the fall of 1964.

Results First-year survival of jack pine was 99 per cent on scarified areas and 97 per cent on unscarified areas.

Status Continuing

Reports *Unpublished*

Gagnon, J.D. 1965. Soil improvement for better growth on abandoned farm lands. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65–Q–1.

Project Q–113 Effect of tyrosine on tree growth and resistance to frost.

Classification 181.525
232.4

Investigators Present: J.D. Gagnon

Objectives To determine the effects of tyrosine on tree growth and frost resistance in field plantings.

Location Valcartier Forest Experiment Station, Quebec. Latitude 46° 55'N, longitude 71° 30'W.

Work Done Two areas at the experiment station were selected for the study; the first was in the nursery and the second in a frost pocket. Jack pine was planted only in the latter location.

The experiment was established in a randomized block design; there were six replications of nine treatment combinations. Treatments involved combinations of three levels of fertilization and three levels of tyrosine as follows:

Fertilizer – NPK (2–10–20) zero application
100 pounds per acre
200 pounds per acre

Tyrosine – zero application
– 0.1 gram of powder per tree
– 0.5 gram of powder per tree

Jack pine (2–1) was planted, in addition to several other species, in the frost pocket in the spring of 1963. Survival and height growth of planted trees were measured in 1964 after the growing season.

Results Survival of jack pine after two growing seasons exceeded 95 per cent. There was a response in height growth as a result of treatment with tyrosine, but it was not significant.

Status Continuing

Reports

Unpublished

Gagnon, J.D. 1964. Effect of tyrosine on tree growth and resistance to frost. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64–Q–14.

Gagnon, J.D. 1965. Effect of tyrosine on tree growth and resistance to frost. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 65–Q–6.

Project M-262[1] Planting lodgepole, Scots, jack and red pine and Douglas-fir, Plantation "D". P.S.P.'s. 13-17/1936, Acadia.

Classification 232.4

Investigators Present: J.W. McLeod.

Objectives No specific objective – another trial in the assessment of the suitability of several species for planting in the area.

Location Acadia Forest Experiment Station, New Brunswick. Latitude 46°00'N, longitude 66°14'W.

Work Done The plantation was set out on the Moderately Rich-Fresh coniferous site type (Loucks' classification), on an area where a hardwood stand had been cut during the winter of 1935-36.

In the spring of 1936, a plot of 0.89 acre was planted with 2-3 jack pine stock. The planting was done at a spacing of 8 by 6 feet (900 per acre). The stock was received from the provincial government nursery, Lawrencetown, N.S., but its seed origin is not known.

The plantation was remeasured in 1937, 1941, 1946, 1951, and 1962.

Results Results are presented in Table 1.

TABLE 1. DEVELOPMENT OF JACK PINE PLANTATION

Years since planting	Survival (%)	Avg. height (ft.)	Injuries
1	–	1.9[1]	Most terminal shoots injured by an unidentified aphid.
5	97	6.5[2]	Most plants affected by a "rust", few by aphid.
10[3]	97	12.1[4]	23 per cent of living plants weevilled, another 8 per cent otherwise injured.
15[5]	93	21.0[6]	Injuries regarded as minor.
26	83	35.3[7]	12 per cent of living plants forked or crooked.

[1] Height of healthy plants -- only 18 per cent of those planted were healthy.

[2] Height of all living plants except those still affected by aphid.

[3] Eleven growing seasons.

[4] Height of all living plants.

[5] Sixteen growing seasons.

[6] Height of healthy plants.

[7] Height of plants from ht.-d.b.h. curve; avg. d.b.h. = 4.7 inches.

Comments Survival is satisfactory and growth in height has been generally good. However, height growth was slower in the period from 15 to 26 years than from 10 to 15 years. Increment borings indicate a decreasing rate of diameter growth.

Status Continuing

[1] Project summary prepared by J.W. McLeod.

Reports

Unpublished

Clarke, W.B.M. 1941. Interim report on Plantation "D". Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Unpubl. MS.

Published

McLeod, J.W. 1956. Plantations of the Acadia Forest Experiment Station. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 31. 25 pp.

Project NF-5 Single examination of provincial government forest plantations.

Classification 232.11
232.4
233

Investigators Past: H.S. Lewis

Objectives To examine plantations set out by the Newfoundland Government between 1937 and 1951 with a view to determining some of the reasons for success or failure and to provide some information for future guidance in tree planting in southeastern Newfoundland.

Location The plantations were established in several locations on the Avalon Peninsula in southeastern Newfoundland. Latitudes 46°35' to 48°10'N, longitudes 52°40' to 54°10'W.

Work Done Between 1937 and 1951, approximately 3 million trees were planted in Newfoundland Government plantations. Jack pine was one of the species included. All planting was by hand, at spacings varying from five to seven feet. The stock was produced at a tree nursery operated by the Newfoundland Government at Salmonier and was in the 2-2 age class when planted. Most of the earlier plantations were fenced to prevent browsing by livestock.

In 1951, an examination of the older plantations (1937 to 1948) was made by the Federal Government. One-fifth-acre plots were located mechanically to sample approximately 10 per cent of the planted area. Trees were tallied, total height and height growth measured, and notes were made on form and vigour.

Results Results of planting jack pine are summarized in Table 1.

TABLE 1. RESULTS OF PLANTING JACK PINE IN NEWFOUNDLAND – 1951

(Lewis 1954)

Location	Year of planting	Average height (ft.)	Average d.b.h. (in.)	Per cent mortality	Form of surviving trees		
					Good (%)	Fair (%)	Poor (%)
Park Road, Salmonier	1937	13.0	2.7	–	–	–	–
Collier's Ridge	1942	4.2	–	–	18	22	60
Collier Station Road	1948	No survival					
Bonavista	1945	2.6	–	–	41	43	16
Catalina	1944	1.6	–	54	12	38	50
Windsor Lake	1948	2.2	–	13	41	32	27

Comments It was concluded that exposure rather than soil conditions played the major role in plantation failure and that fencing of plantations to prevent browsing by livestock was a necessity except in remote areas. It was also concluded that afforestation of sheltered slopes and hollows in otherwise windswept barren country is possible through planting of jack pine (Lewis 1954).

Status Closed.

NF-5

Reports

Published

Lewis, H.S. 1954. Forest plantations in Newfoundland. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., S. & M. 54-3. 15 pp.

Project NF-11 Direct comparison of various species and classes of planting stock on non-forested areas.

Classification 232.11
232.4
233

Investigators Past: H.S. Lewis, F. F. Tusko.
Present: D.E. Nickerson, W.C. Wilton

Objectives To determine which of several tree species and strains (including jack pine) are most suitable for afforestation purposes and to determine the sites and locations most favourable to each.

Location The plantations have been set out in four locations on the Avalon Peninsula.

(1) Near Trepassey at the southeastern extremity of the peninsula. Latitude 46° 43' N, longitude 53°23' W.
(2) Brigus barrens. Latitude 47°25' N, longitude 53°15' W.
(3) Tilton, northwest of Conception Bay near Harbour Grace. Latitude 47°37'N, longitude 53°22' W.
(4) Sunnyside, on the east side of the isthmus joining the Avalon Peninsula to the main Island of Newfoundland. Latitude 47°50' N, 54°00' W.

Work Done In 1952, three small plantations were established at each of the locations, using nine exotic species and strains of trees. Eighteen specimens of each class of planting stock were planted at five-foot spacing in two-tree cells by Latin square design in each plantation. Trees were hand planted by the pit method and each plantation was fenced. Mortality was replaced in May 1953. Periodic measurements were made and a complete examination made in 1961. At that time all stems were tallied, total height was measured, and trees rated by form.

The three plantations at each location were established to provide a range of local conditions. One was fully exposed, one was as sheltered as possible in open barren land in the area, and the third was in an intermediate position. The soils are commonly glacial tills varying in texture from silt loam to sandy loam and exhibiting varying degrees of stoniness. All areas supported forest at some time and all have a fire history. All are within one mile of salt water.

Results Results in 1961 for jack pine are presented in Table 1. Survival of 2-2 jack pine was generally satisfactory, whereas that of 2-0 jack pine was inferior. The form was generally poor and none of the plots produced nine well-formed stems. However, two of the 2-2 jack pine plots produced more than six well-formed stems, but even here it was clearly outranked by two strains of Scots pine. No relationships were found between exposure and performance of jack pine.

Comments There would seem to be little justification for planting jack pine except for its possible use for further experimental purposes.

Status Continuing.

TABLE 1. NUMBER OF LIVING JACK PINE IN 1961 BY EXPOSURE AND STEM CLASSIFICATION

(Nickerson, Wilton and Tusko 1964)

Planting stock	Stem classification[2]	Trepassey			Brigus Barrens			Harbour Grace			Sunnyside		
		106[1]	107	108	111	110	109	114	113	112	117	116	115
Ontario 2-0	Total	9	11	14	5	10	11	6	12	4	2	6	7
	W	0	5	0	4	6	5	2	7	1	2	0	5
	WF	0	2	0	1	1	0	2	5	1	0	0	2
Ontario 2-2	Total	11	16	13	12	16	17	8	15	8	10	10	10
	W	5	10	3	10	6	10	4	11	5	4	2	5
	WF	3	7	2	2	1	2	3	7	3	1	1	4

[1] Permanent sample plot numbers. The plot at the left of each group is the plot originally assumed to be most exposed to wind, that at the right least exposed.

[2] Total number of surviving stems of 18 originally planted.
W – Total number of surviving stems 4.5 feet in height or higher.
WF – Total number of well-formed surviving stems 4.5 feet in height or higher.

Reports

Unpublished

Lewis, H.S. 1952. Direct comparison of various species and classes of planting stock on non-forested areas. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Wilton, W.C. 1953. Initial examination of experimental plantation plots. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div., Unpubl. MS.

Wilton, W.C. and D.L. Armstrong. 1954. Direct comparison of various species and classes of planting stock on non-forested areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Wilton, W.C. 1957. Direct comparison of various species and classes of planting stock on non-forested areas. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

Nickerson, D.E., W.C. Wilton and F.F. Tusko. 1964. Test of exotic species for afforestation purposes on the Avalon Peninsula, Newfoundland. Canada, Dept. Forestry, Forest Research Branch, Unpubl. MS. 64-N-14.

Project NF-50 Introduction of jack and Scots pine to the Labrador sand plains.

Classification 232.11
232.4

Investigators Present: W.C. Wilton

Objectives To establish and test the behaviour of jack pine and Scots pine in the valley of the Hamilton River in eastern Labrador.

Location The experimental area is located on Department of National Defence property, within the perimeter of Goose Airport, and approximately 1¾ miles west of the RCAF Station. Latitude 53°20'N, longitude 61°00'W.

Work Done Approximately 800 each of jack pine and Scots pine were planted on unprepared ground in 1959. Planting stock was obtained from the Quebec forest tree nursery at Berthierville; jack pine was in the 2-1 age class, and transplants were between 10 and 12 inches high. The design consisted of three main plots, each measuring 180 by 90 feet and divided into two sub-plots. Each sub-plot contained 15 rows of 15 plants at six-foot spacing. In addition, two radial plots were established, one for each species, having as a pivot a cluster of black spruce. Eight lines radiated from the spruce trees, and 10 trees were planted along each at two-foot distances.

Results None available.

Comments[1] A casual inspection made in 1962 indicated that the performance of both jack and Scots pine had been poor. Mortality exceeded 50 per cent; the survivors were in poor health and no leaders were longer than three inches. However, the planting stock arrived in very poor condition and the planting took place under extremely hot and dry conditions. A detailed examination will be made in 1965 which will provide more information on the study.

Status Continuing.

Reports

Unpublished

Wilton, W.C. 1960. Introduction of jack and Scots pine to the Labrador sand plains. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Unpubl. MS.

[1] D.E. Nickerson, Memorandum January 5, 1965.