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Review of Silvicultural Research: White Spruce and Trembling Aspen Cover Types, Mixedwood Forest Section, Boreal Forest Region, Alberta-Saskatchewan-Manitoba

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CANADA
DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

Review of Silvicultural Research

White Spruce and Trembling Aspen Cover Types
Mixedwood Forest Section
Boreal Forest Region
Alberta-Saskatchewan-Manitoba

by
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by

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INTRODUCTION

The Department of Forestry has been carrying on silvicultural research in the white spruce (*Picea glauca* (Moench) Voss) and trembling aspen (*Populus tremuloides* Michx.) cover types in the Mixedwood Forest Section of Alberta, Saskatchewan and Manitoba for about 40 years. Because of the needs of industry most of this research has been focused on spruce, and only a small portion on aspen. Much of the research is concerned with basic problems and the findings in one area may be applied directly or with minor modification throughout the entire Mixedwood Forest Section. Only a minor part of the total effort is of such an applied nature that application of results is feasible only on a local basis.

At present silvicultural research in the spruce-and-aspen cover types in the Mixedwood Forest Section is done by a group of five research scientists. Three are specialists in regeneration silviculture, one is a specialist in high yield silviculture, and one is a specialist in the autecology of spruce and aspen. Three members, including the group leader, work from the Manitoba-Saskatchewan regional office in Winnipeg and two from the Alberta regional office in Calgary (Figure 1).

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Although close liaison and co-ordination of program has always been maintained between the two regional offices no attempt has been made previously to produce a report of our combined silvicultural research activity. This report attempts to bring together the results of all such research undertaken by the Department of Forestry in the spruce-aspen forests of the three Prairie Provinces, providing both generalized conclusions and results of individual projects. The authors wish to emphasize that this report summarizes only that work done by the Department. Much valuable research pertaining to spruce and aspen has been done by other agencies.

The report is presented in four sections:

- PART I. The ecological framework of the spruce-aspen cover type in the Mixedwood Forest Section of Alberta, Saskatchewan and Manitoba.
- PART II. A summary of research results and conclusions with appropriate references to reports and individual research projects.
- PART III. An index to all research projects in the spruce-aspen cover type based on a subject matter classification by the Oxford Decimal System for forestry literature.
- PART IV. Short individual project summaries emphasizing results in quantitative form and providing sufficient description of experimental methods to permit evaluation of results.

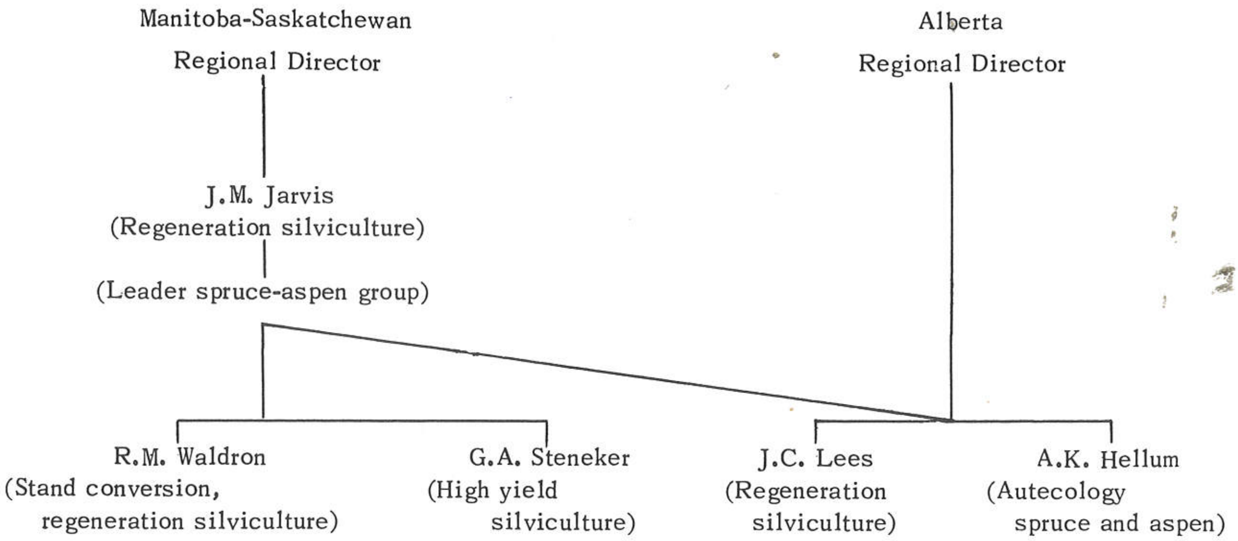

Figure 1. Allocation of research officers (spruce-aspen research group) — Alberta, Saskatchewan and Manitoba.

It is anticipated that the reader will use this report in two ways. For general conclusions and background information he may refer to Part II, Summary of Research Results and Conclusions. In this section reference is made to individual project summaries (Part IV) as well as to manuscripts (published and unpublished) to provide ready access to detailed information on particular points. Perhaps most use will be made of the individual project summaries. These summaries contain specific information on a wide variety of subjects relating to the spruce-aspen cover types.

PART I

THE MIXEDWOOD FOREST SECTION

AND

SUCCESSIONAL SEQUENCES

PART I – THE MIXEDWOOD FOREST SECTION AND SUCCESSIONAL SEQUENCES

1. *The Mixedwood Forest Section (B.18a)*

(a) Extent and species composition

The Mixedwood Forest Section extends from southwestern Manitoba to northeastern British Columbia, occupying the southern portion of the Boreal Forest Region (Rowe 1959). It has a breadth of about 150 miles in central Saskatchewan, broadens out considerably in Alberta, and becomes quite narrow in Manitoba and British Columbia (Figure 2).

The characteristic forest associations on well-drained uplands are mixtures of trembling aspen, balsam poplar (*Populus balsamifera* L.), white birch (*Betula papyrifera* Marsh.), white spruce and balsam fir (*Abies balsamea* (L.) Mill.). Jack pine (*Pinus banksiana* Lamb.) occurs on sandy areas and comprises a portion of some stands on drier till soils. Black spruce (*Picea mariana* (Mill.) BSP.) and larch (*Larix laricina* (Du Roi) K. Koch) are found in wet areas with the former species also occuring on the plateau-like tops of the larger hills. White elm (*Ulmus americana* L.), green ash (*Fraxinus pennsylvanica* Marsh. var. *lanceolata* Borkh. Sarg.), Manitoba maple (*Acer negundo* L.) and bur oak (*Quercus macrocarpa* Michx.) may also be found as minor species in the southeastern part.

(b) Physiography

The Mixedwood Forest Section occupies part of the Interior Continental Plain and comprises the forested part of the Second Prairie Level as outlined by Putnam *et al* (1952). Rowe (1956) described the physiography of the area as follows: "The relief of the area is not extreme except locally in the eastern part. It is chiefly

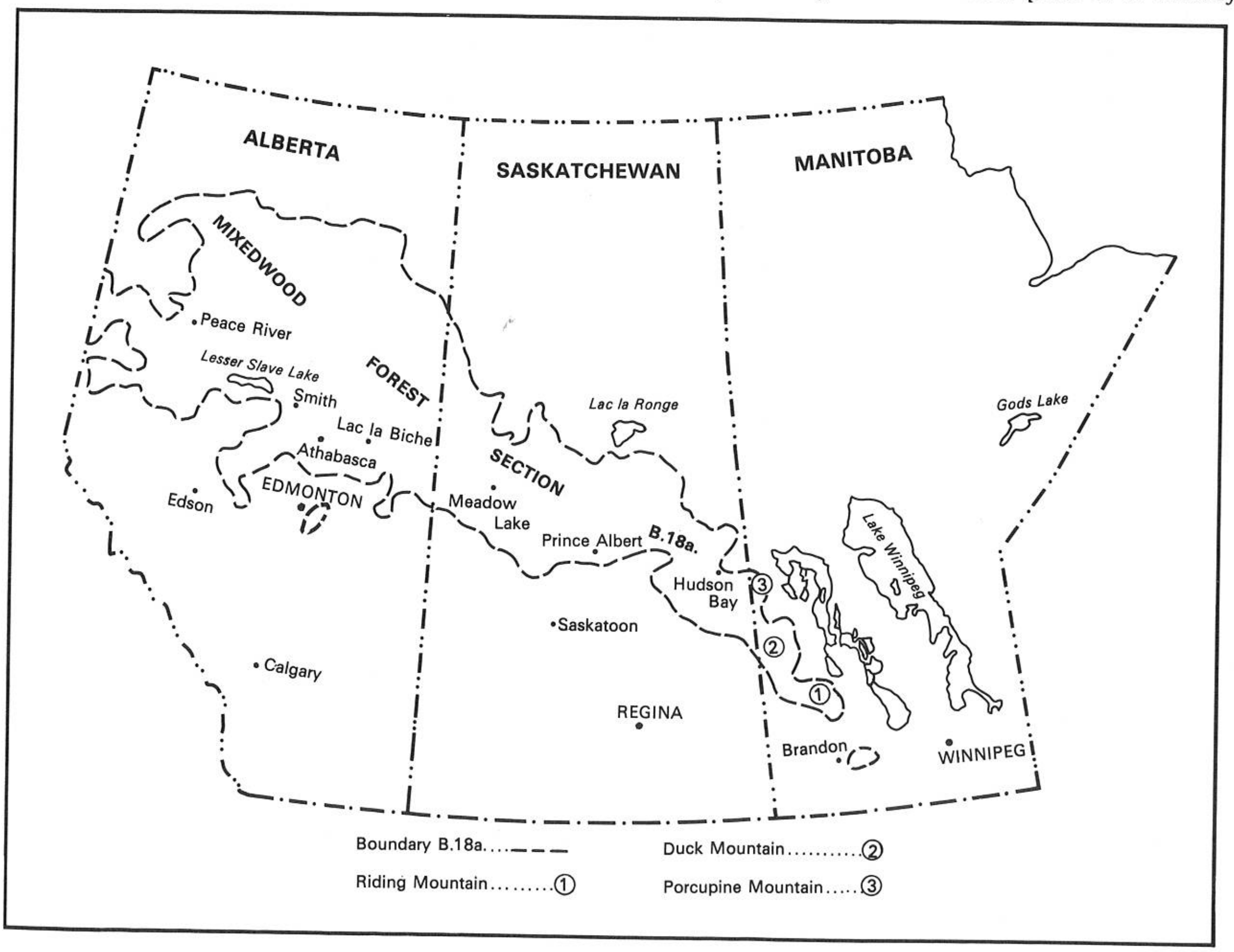

Figure 2. Map showing location of the Mixedwood Forest Section B. 18a.

Figure 3. Fifteen-year-old trembling aspen stand on a mesic site; stand originated after a fire.

a result of pre-glacial erosion of the soft bedrock shales which produced such features as the Cretaceous escarpment and associated hills (Riding Mountain, Duck Mountain, Porcupine Hills, Pasquia Hills and Wapawekka Hills) in the vicinity of the Manitoba-Saskatchewan boundary and the Missouri Coteau farther to the west. Subsequent glaciation modified the landscape, in some places sharpening the relief (as on the escarpment face at the eastern and northern sides of the Hills) and in others reducing it by planation and deposition of drift. The highest points on the Cretaceous Hills are 2,500 to 2,700 feet above sea level, compared to a general elevation of less than 1,000 feet on the Manitoba Lowlands to the east and north below the scarp. Immediately to the west of the Hills there is a less pronounced decrease in altitude to below the 2,000-foot contour, but continuing westward there is a gradual rise across Saskatchewan and Alberta to the foothills of the Rocky Mountains ...."

Generally the topography is rolling with morainic deposits on the uplands and glacio-lacustrine deposits in the lowlands. Well entrenched rivers carry the drainage waters of the plains east and northeast to the Nelson and Churchill Rivers.

(c) Climate

The Mixedwood Forest Section has a somewhat dry continental climate. The temperature regime has a wide spread with average winter temperatures at or below 0°F and average summer temperatures above 60°F. Average annual precipitation is low (about 17 to 20 inches) but much of the rain occurs during the summer months. A summer moisture deficiency is characteristic, however, and varies from about 4 to 6 inches throughout the area. The frost-free period varies from about 100 days in the southeastern part to about 80 days in the northwestern part (Anon. 1957).

(d) Soils

Soils in the Mixedwood Forest Section are of a calcareous nature, having been derived mostly from limestones and shales. The predominant soils on well-drained sites belong to the

Figure 4. Sixty-year-old trembling aspen stand with a 30- to 40-year-old white spruce understorey.

Grey Wooded Great Group of the Podzolic order (Anon. 1960). Such soils tend to be surface rich and support a luxuriant growth of shrubs, herbs and grasses.

2. *Successional Sequences*

Most stands in the Mixedwood Forest Section have originated as the result of some disturbance. Fire must have played a prominent rôle in the past since charcoal can be found in the humus layers of most stands except those which represent recent invasion of grassland. Furthermore, there are very few old stands except in wet places or where the terrain affords protection from fire.

Logging has been responsible also for many of the stands prevalent today. It has been going on for a long time, though heaviest cutting was done during the early part of the present century. Most of the accessible mature spruce has been cut and logging of the last remaining old growth is proceeding rapidly.

(a) Succession – mesic sites

In the Mixedwood Forest Section the most obvious natural successional sequence occurs on mesic sites.[3] Distinct stages are represented by three cover types: softwood (coniferous component greater than 75 per cent), mixedwood (coniferous component 25 to 75 per cent), and hardwood (coniferous component less than 25 per cent).

After fire or cutting, pure stands of trembling aspen usually spring up (Figure 3). However, in the normal course of events some white spruce usually seed-in at, or about, the same time. Once these few spruce begin to produce seed, progression towards mixedwoods is possible (Figures 4 and 5). Sometimes the succession from hardwood to mixedwood may be prevented because of the lack of coniferous seed. In such instances the hardwood type may be relatively permanent.

The mixedwoods which develop from the hardwoods are still but a stage in the natural

[3]A glossary of terms appears as Appendix

Figure 5. Nearly mature mixedwood stand of trembling aspen and white spruce.

Figure 6. Mature softwood stand; many old hardwood stumps and logs in this stand indicate that at one time trembling aspen was well represented.

successional sequence. Evidence shows that the mixedwoods develop into softwoods (Figure 6), and most old stands are either softwood types or mixedwoods with a high softwood content. On the Riding Mountain Forest Experimental Area the trembling aspen component of most of the mixedwood stands is relatively even-aged and over-mature. On the other hand, white spruce is uneven-aged and represented in all diameter classes. Furthermore, the trembling aspen is dying out without being replaced whereas the white spruce is increasing. So, succession appears to be proceeding towards an uneven-aged softwood type.

The invasion of trembling aspen by white spruce and the eventual dying out of the trembling aspen represents the usual development of most softwood stands on mesic sites. Individual white spruce trees seem to reach their best development under these circumstances, possibly because the density of white spruce is limited at first by the trembling aspen. When the latter die the scattered white spruce are free to grow without too much competition from others of their kind. Quite often, if balsam fir seed is available, this species seeds-in and eventually forms a portion of the stands (Figures 7 and 8).

(b) Succession – wet sites

Some white spruce stands on wet sites represent an advanced stage in the succession from grass meadow to forest (Figure 9). Such stands are found in the transitional zone around sloughs, between black spruce-larch types in the wettest areas and the white spruce-trembling aspen types on the uplands. Sites in such transitional zones are generally too wet for trembling aspen to establish itself (although some balsam poplar may seed-in) so, as a rule, no other tree stage precedes the white spruce. Usually the wet ground provides good spruce seed-beds and seedling survival is high. Consequently the stands are dense and usually individual trees are small.

(c) Succession – dry sites

On dry sands and gravels white spruce can often invade prairie vegetation without a hardwood stage (Figure 10). The fact that white spruce can establish itself on these extreme sites indicates that in some respects it is much more tolerant of habitat condition than trembling aspen. Such invasions probably occur only during wet cycles because normally

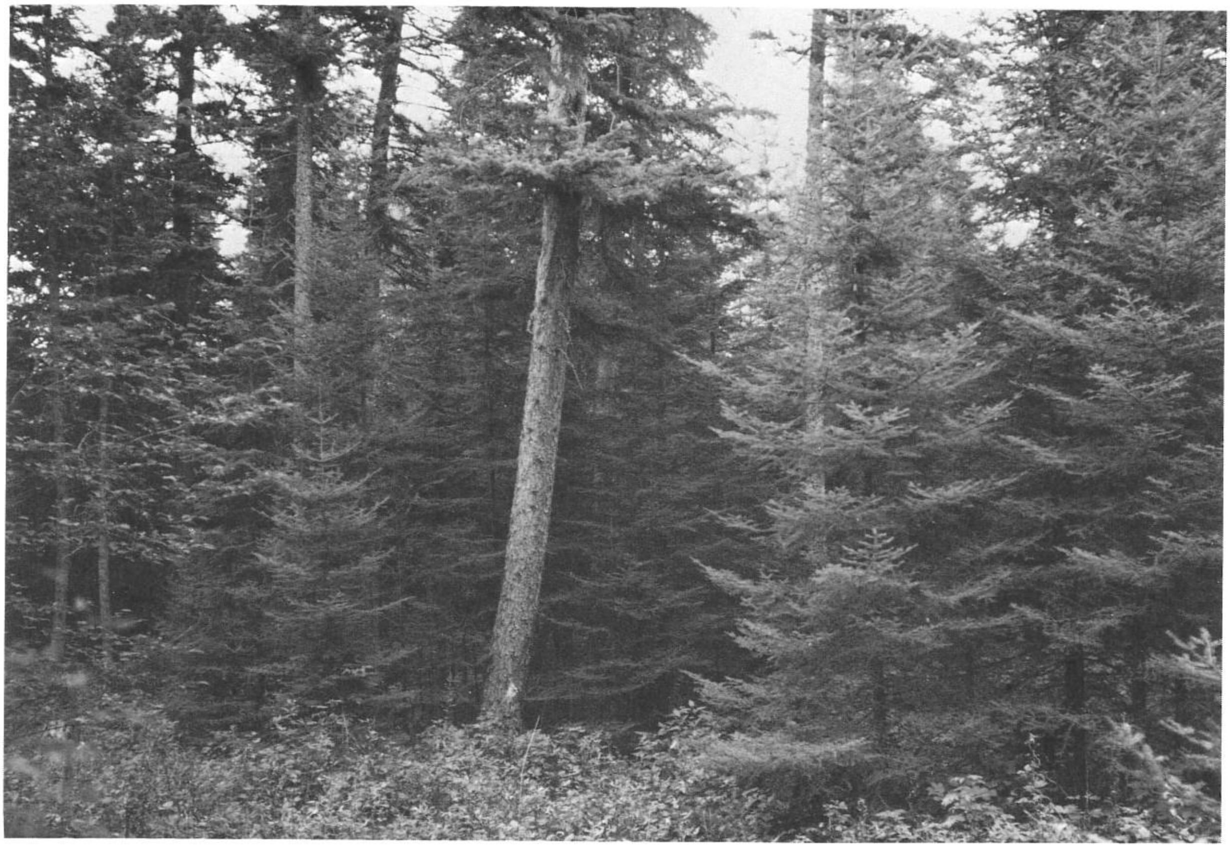

Figure 7. Young balsam fir under a mature overstorey of white spruce.

prairie sites are so dry that white spruce seedlings succumb to drought within a short time after germination. Older stands are sometimes quite dense but individual trees are small, reflecting the severe growing conditions.

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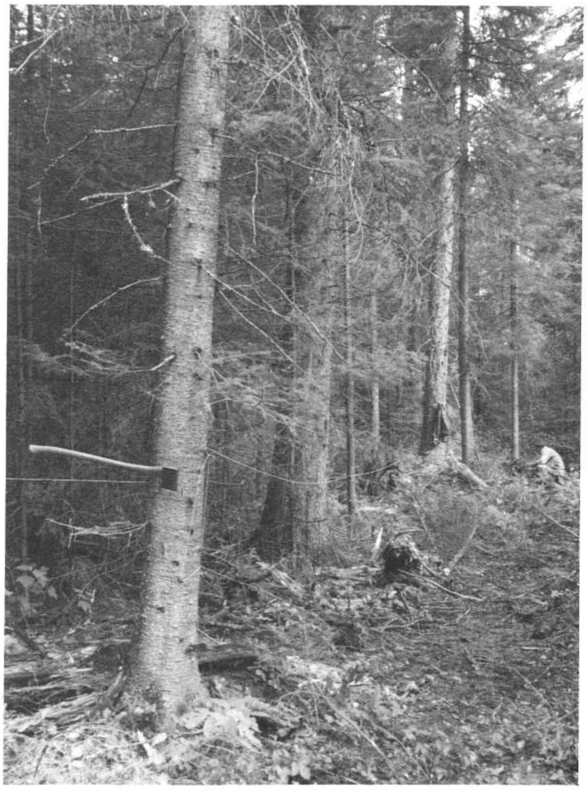

Figure 8. Mature balsam fir and white spruce; note axe in balsam fir.

Figure 9. Wet meadow in the foreground, grading into black spruce and larch in the middle foreground, then grading into white spruce in the background; note the absence of trembling aspen.

Figure 10. Scattered white spruce growing on dry sand dunes; note absence of trembling aspen.

PART II

SUMMARY OF RESEARCH RESULTS AND CONCLUSIONS

PART II – SUMMARY OF RESEARCH RESULTS AND CONCLUSIONS

1. *Productivity*

Studies in the Mixedwood Forest Section have supported those in other areas and indicate white spruce is a hardy species that will grow under a wide range of conditions. However, optimum growth occurs on soils with intermediate moisture levels. In Alberta dominant white spruce reach heights of about 90 to 95 feet in 80 years on fresh tills (loam to clay loam texture) and on fresh to moist alluvium (sand to silt texture). On very moist sand, silts and clays dominant height at 80 years is about 80 feet, on wet clays about 75 feet, and on dry sand about 60 feet. On very wet organic soils dominant height is usually less than 50 feet (Quaite 1955, Duffy 1963) (see project summary A-29).

Results from studies in Manitoba and Saskatchewan (Rowe 1954a and 1957; Jameson 1959, 1960 and 1963) are similar to those of Duffy and Quaite, although maximum height appears to be somewhat shorter on the best sites. On dry sands dominant height at 80 years is about 60 feet, on dry to somewhat fresh sandy loam and clay loam tills about 70 feet, on fresh to somewhat moist clay loam tills and sandy loam alluvium about 85 feet, and on moist to very moist clay loam tills and lacustrine clays about 70 to 75 feet (see project summaries MS-69, MS-168, MS-173, MS-183).

Information available from various thinning and release studies indicate that at age 50 the dominant height of aspen varies from about 50 to 70 feet on somewhat fresh to moist clay loam tills (Steneker 1961a, 1962, 1963a; Jarvis 1960) (see project summaries MS-4, MS-5, MS-6, MS-133, MS-153, MS-155). Observations also indicate that on dry sites the dominant height of aspen at age 50 is only about 40 feet.

Representative volumes of mature natural stands on the principal sites in the Mixedwood Forest Section are shown in Table 1. From this table it can be seen that total volume per acre is greatest on the intermediate moisture classes and on the lighter soils such as water-washed till, alluvium and ponded materials.

TABLE 1 PRODUCTIVITY CHARACTERISTICS, MATURE WHITE SPRUCE-TREMBLING ASPEN COVER TYPES BY PRINCIPAL LAND TYPES AND MOISTURE CLASSES, MIXEDWOOD FOREST SECTION*

Land type	Total volume/acre (cu. ft.)				
	Moisture class				
	Dry to fresh	Fresh	Fresh to moist	Moist to very moist	Very moist
Riding Mountain					
Dumped till		6,080		5,390	
Alberta					
Dumped till		5,630		5,480	
Waterwashed till			7,030		
Alluvium	4,760			7,240	
Ponded			6,830		5,600
Lacustrine				5,370	
ALL	4,760	5,855	6,930	5,870	5,600

* Data obtained from reports by Jameson (1963) and Duffy (1963).

2. *Regeneration Characteristics – White Spruce*

(a) Flowering

In the Mixedwood Forest Section white spruce begins to flower abundantly at about 45 to 60 years of age (Rowe 1955). Flowering usually takes place in May and pollen is shed from about the middle of May to the middle of June. The earliest recorded date for the beginning of pollen shedding at the Riding Mountain is May 25; the latest is June 13 (Rowe 1956).

(b) Seed

Peak seedfall at the Riding Mountain usually occurs in late August or early September, depending upon weather conditions during the summer. Hot dry weather tends to hasten seed dissemination while cool, moist, cloudy weather retards it. In 1954 seed remained in the cones until early October because of late pollination and because exceptionally cool, moist, cloudy weather that summer prolonged the period of seed maturation (Rowe 1956) (see project summary MS-158-2).

Although most seed is shed the same year it matures, evidence indicates that small amounts are sometimes held in the cones over winter and are shed the following spring and summer. In 1953, twenty-five cones from the preceding autumn were picked in June and another seventy-five were picked in August. The former lot yielded 25 seeds of which 5 were viable and the latter lot yielded 70 of which 1 was viable (Rowe 1953a). In 1957 no new cones were observed on spruce trees being examined annually for cone production, but a total of 14,000 seeds per acre were collected in traps below these same trees (Waldron 1962a) (see project summary MS-158-2).

Studies have indicated that there is seldom a scarcity of white spruce seed in the Mixedwood Forest Section. Cone crop records for the Duck Mountain and Porcupine Forest Reserves between 1911 and 1951 indicate heavy crops for 12 out of the 40 years, or once every 3 or 4 years (Rowe 1955). Estimates by provincial field staffs for various other districts in Manitoba and in Saskatchewan for the periods 1923 to 1930 and 1946 to 1955 show that medium or heavy crops occurred on the average once every 2 years, while light to nil crops occurred once every 5 years. Light to medium crops occurred in the intervals (Rowe 1956, Thomson 1958) (see project summary MS-56). Cone crop studies in the vicinity of the Riding Mountain between 1938 and 1962 show that for this period heavy or medium crops occurred 12 times, light crops 10 times and nil crops 3 times (Waldron 1963a).

Records for a mature white spruce stand at the Riding Mountain containing about 190 square feet of basal area per acre show that between 1954 and 1961 seed has fallen every year. The amount has varied from a low of about 10 thousand seeds per acre in 1958 to a high of over 5 million per acre in 1960. In 1954, 1955 and 1961 production was well over 1 million seeds per acre; in 1959 it was over 300 thousand and in 1956 over 100 thousand. Seedfall in 1957 was 14 thousand seeds per acre but it is assumed these seeds were mostly from the 1956 crop since no new cones were visible throughout the summer of 1957 (Waldron 1964) (see project summary MS-158-2).

Results from a new study of seed production in eastern and central Saskatchewan show that seed has been produced each year since the project was started (see project summary MS-211-2).

So far, studies have not revealed any rhythm to cone production for individual trees. However, dominant and co-dominant trees have borne cones more often than intermediate trees and intermediates have borne cones more often than suppressed trees. Also, dominant and co-dominant trees have borne much heavier crops than intermediate and suppressed trees. The latter, even in years of heaviest production, bore only light crops (Waldron 1962a) (see project summary MS-158-2).

The greatest distance of seed dispersal that has been accurately determined in the field is 330 feet (Rowe 1955). However, seed might be dispersed much farther by strong winds. Rowe (1955) postulated that because of wind turbulence and convection currents seed may be carried 1,000 feet or more and that late falling seed might be whisked over the snow for long distances provided conditions are right.

Seed quality is usually better in years of heavy production than in years of light production. For instance, in 1960 and 1961 (heavy seed years) cutting tests revealed that 59 and

71 per cent of the seed was sound, whereas in 1958 (poor seed year) only 15 per cent was sound (Waldron 1962a) (see project summary MS-158-2). Seed quality varies also according to time of dissemination, with early- and late-falling seed being less sound than that which falls during the peak period. This relationship is perhaps explained by the fact that the first seed comes from the smaller less developed scales at the apex of the cone, intermediate seed from well developed scales at the centre, and the last seed from the underdeveloped basal scales (Waldron 1964).

(c) Germination

In the Mixedwood Forest Section white spruce seed will germinate on a wide variety of seedbed media (ranging in pH from "strongly acid" to "moderately alkaline") and under practically all conditions of exposure that occur in the various stands (Rowe 1955, Kolabinski 1964a). However, studies at the Riding Mountain have shown that very little germination takes place on any seedbed until the mean daily temperature has reached and remained for sometime at about 40°F (Rowe 1952). On mineral soil seedbeds, peak germination varies from late June through July depending upon degree of exposure and on prevailing temperatures, especially through May and June (Waldron 1963a).

On mesic sites conditions are such (winter stratification followed by favourable temperatures and moisture) that complete germination is usually assured the first summer following seed dispersal (Rowe 1955) (see project summary MS-161). However, on dry sites, and even on fresh sites during dry years, white spruce seed may by thorough drying achieve a state of dormancy that will preserve it for some years. This was illustrated at the Riding Mountain when stratified white spruce seed, kept cool and moist prior to sowing on flats, germinated almost completely within 22 days. Seed from the same lot thoroughly dried for 2 weeks before sowing did not begin to germinate for 30 days. Thereafter and for the next year small numbers germinated at irregular intervals (Rowe 1958). Other studies have shown that on burned seedbeds, in the open, where heat absorbing capacity is high in relation to mineral soil and duff, white spruce germination was delayed until late summer or until the following year (Rowe 1953b, Kolabinski 1964a).

A study of white spruce germination in relation to microhabitat at the Riding Mountain showed that germination was much better on flat mineral soil than on ridged mineral soil. On ridges, germination was best on north-facing aspects, intermediate on east- and south-facing aspects, and poorest on west-facing aspects (Waldron 1963a) (see project summary MS-191-2).

(d) Factors affecting initial survival

First-year seedlings are small, seldom developing a stem more than 1 inch tall or a root system more than 2 inches long (Rowe 1955). Therefore the frequent drying out of any seedbed to a depth of 2 or 3 inches is detrimental, especially during the first year. Generally seedlings originating from seed that germinates late in the season suffer a higher rate of mortality than those originating from seed that germinates early. This is attributed to the fact that moisture is usually less available near the surface in late summer than in early summer. Also late germinates have less time to harden-off prior to autumn frosts (Phelps 1948a; Rowe 1953b).

Surveys have shown that white spruce regeneration in both disturbed and undisturbed stands in the Mixedwood Forest Section is scarce (Candy 1951). This situation has been attributed primarily to lack of suitable seedbeds. The best natural seedbeds for white spruce exist on decayed logs and stumps, on exposed mineral soil along animal trails and at the base of uprooted trees (Phelps 1940, Bedell 1948, Rowe 1955) (see project summaries MS-37, MS-135). Litter and feather mosses are generally poor seedbeds because they dry out too quickly. However, on moister sites where modifying circumstances assure a continued supply of moisture these media may support good reproduction (Kolabinski 1964a and 1964b) (see project summary MS-216).

Exposed humus and mineral soil resulting from scarification or from burning off the upper organic horizons are favourable seedbeds (Phelps 1948a and 1951; Waldron 1958, 1960 and 1963a; Lees 1963a and 1964; Kolabinski 1964a, 1964b and 1964) (see project summaries MS-124, MS-156, MS-159, MS-166, MS-211-1, MS-216, MS-228, A-12, A-22, A-58). On such seedbeds moisture is usually available near the surface, especially in the early part of the summer when most seedlings are establishing a root system. Initial survival is usually much better on flat seedbeds than on ridged ones. However, on ridged seedbeds east-facing aspects are best for survival, north- and south-facing are intermediate, and west-facing are poorest (Waldron 1963a) (see project summary MS-191-2).

It has been demonstrated quite conclusively by Lees (1963b) that results from a cultural treatment may vary considerably in different years or in different regions because of variations in local climate, which in turn influences seed germination and subsequent seedling survival (see project summary A-63). On fresh sites survival on exposed mineral soil and humus may be low because of a combination of drought and excessively high temperatures, even during years in which precipitation is normal or above normal (Phelps 1948 a; Kastrukoff 1950; Rowe 1961). For good survival rain must occur frequently to ensure a continuous supply of moisture in the upper few inches of soil (see project summary MS-150-2). Studies have shown that seedlings up to 3 years old on mesic sites are susceptible to the effects of drought and heat (Waldron 1963a). Seedlings older than 3 years are usually well enough established to withstand reasonably high temperatures and short periods of drought (Phelps 1948a).

On moist to wet sites drought is not usually a problem but flooding causes serious losses especially in wet years (see project summaries A-12, A-58). For example, in 1956 at the Riding Mountain when June-July rainfall was 12.6 inches (6.4 inches above normal) few germinates were observed on mineral soil seedbeds on the very moist and wet sites as compared with fresh sites (Waldron 1963a). However, in 1961 when June-July rainfall was only 1.9 inches (4.3 inches below normal) germinates were abundant on mineral soil seedbeds on moist, very moist and wet sites, but were scarce on fresh sites. Laboratory experiments have shown that 1- and 2-year-old white spruce seedlings can withstand short periods of flooding reasonably well. However immersion for more than 3½ days causes high mortality. Generally 2-year-old seedlings are more tolerant to flooding than 1-year-old seedlings (Lees 1963c) (see project summary A-75).

On mineral soil seedbeds on mesic sites initial survival is better if there is a partial overstorey present (see project summaries MS-60, MS-211-1). Shade cast by the trees tends to minimize moisture losses and reduce temperatures at the soil surface.

Studies have shown also that under a partial canopy seedling survival has been as good on burned seedbeds as on mineral soil exposed by scarifying. Without the benefit of overhead shade, however, survival has been poorer on burned seedbeds, probably because of higher surface temperatures (Waldron 1963a; Rowe 1953b; Phelps 1948a; Kastrukoff 1950; Rowe 1961) (see project summaries MS-150-1, MS-150-2, MS-159).

Laboratory experiments (Cayford and Waldron 1962; Waldron 1962b) and field observations (Kolabinski 1964a) show that a light mulch of spruce needles and/or aspen leaves, which reduces moisture losses at the soil surface, greatly increases initial seedling survival (see project summaries MS-150-2, MS-216, MS-223).

Newly germinated white spruce seedlings have difficulty in competing above ground for light and below ground for moisture with perennials and other plants that have well established root systems (Rowe 1955). White spruce seedlings survive best where conditions hinder other plants from encroaching and monopolizing the light, space and soil moisture. It has been shown that humus, mineral soil and ash seedbeds are good media for the establishment of white spruce seedlings, but if the perennating parts of grasses, herbs, shrubs and trembling aspen are present competition may become so severe as to crowd out the spruce seedlings (see project summaries MS-160-2, MS-160-3, MS-160-4). A detailed examination of 2- to 3-year-old white spruce seedlings growing on seedbeds made with an Athens plough showed that of 1,151 dead seedlings tallied, 52 per cent had died either from direct competition from the ground vegetation or from smothering by aspen leaves (Waldron 1963a).

Late spring frosts soon after seedlings break dormancy can cause serious losses. For example, in 1958 a series of frosts between May 26 and June 12 contributed to the death of about 20 per cent of 1-year-old seedlings under study on mineral soil at the Riding Mountain (Waldron 1963a). In 1945 and in 1951, Rowe

(1955) noted also that late spring frosts had killed many newly flushed needles of seedlings growing in low lying areas. He pointed out that since re-growth of frost-damaged plants the same year is rare, a succession of frosts could kill the seedlings.

Much mortality has also been caused by frost heaving, burial of seedlings by alluvium, trampling by animals, and exposure of roots through seedbed erosion during rainstorms (Jarvis 1963b; Kolabinski 1963 and 1964a; Waldron 1963a; Rowe 1955) (see project summaries MS-159, MS-160-3, MS-211-1). In 1962 several plots were established to study survival trends on various seedbeds made by a bulldozer. Of all the mortality recorded on these plots to the end of the 1963 growing season, 27 per cent was due to frost heaving, 27 per cent to trampling, 16 per cent to leaf smothering, 11 per cent to flooding (moist to wet sites), 2 per cent to burial of seedlings and erosion of seedbeds, and 17 per cent to unknown causes. Many of the seedlings in the last category are believed to have died from the effects of drought and excessive heat (Kolabinski 1964a).

(e) Other limiting agencies

White spruce cones are susceptible to rust (*Chrysomyxa pyrolae)* but the extent of damage is not known. In 1962 this rust occurred quite extensively at the Riding Mountain and nearly every tree was affected to some degree. On some trees nearly every cone was infected but on others the rust occurred sporadically. All seed in every infected cone examined had been destroyed (Jarvis 1963a).

Red squirrels (*Tamiasciurus* spp.), chipmunks (*Tamias* spp. and *Eutamias* spp.), voles and mice (*Clethrionomys* spp. and *Microtus* spp.), consume large quantities of seed (Jarvis 1963a, Rowe 1962 and Wagg 1963). It has been suggested that in light and moderate seed years squirrels consume most of the seed produced (Rowe 1955). In addition to consuming seed squirrels often cut off the leaders and ends of upper branches, especially during years of light seed crops (Rowe 1962). Usually the leader is replaced by a lateral and damage is slight unless two leaders compete to form a fork (Jarvis 1960). Examination of seed spots at the Riding Mountain has indicated that seed losses due to mice and voles is much greater in stands with a dense understorey of brush, herbs and grasses than in stands with a light understorey. Also it has been shown that covering seed with a thin layer of litter greatly reduces the depredations of these animals (Waldron 1963a).

The snowshoe hare *(Lepus americanus)*, especially during population peaks, does considerable damage by browsing (Rowe 1955) (see project summary MS-90). Most severe damage has occurred on seedlings set out close to brush or under a canopy that affords some cover and protection for the hares (see project summaries MS-100, MS-103 to -113). On one study area in eastern Saskatchewan, repeated browsing of trees up to 3 feet tall resulted in complete mortality (Jarvis 1960). Also, in plantations set out in 1961 approximately 75 per cent of the surviving seedlings were browsed the first year (Jarvis 1963b) (see project summary MS-211-1).

3. *Growth*

Aside from inherent qualities, growth rate is dependent upon the above- and below-ground conditions prevailing in the habitat. For instance, at the Riding Mountain, 14-year-old white spruce seedlings growing on mineral soil and on burned seedbeds without an overstorey averaged 44 and 47 inches in height. Seedlings of the same age on similar seedbeds and on similar sites but with an overstorey present averaged only 7 and 14 inches in height (Rowe 1961).

The effect of below-ground conditions on spruce growth is illustrated by the following example. On moist rotten wood under a moderate overstorey, Rowe (1955) found that 7-year-old seedlings averaged 6 inches in height. However seedlings of the same age on ashy mineral soil and under a similar overstorey averaged 24 inches in height.

(a) Terminal growth

Terminal growth behaviour of white spruce saplings at the Riding Mountain has followed the normal pattern established for other species in North America (Waldron 1962c). It is completed in a period of about 48 days beginning in late May and ending in mid-July (see project summary MS-184). Terminal growth varies from year to year and is influenced by climatic conditions during the previous as well as the current growing season. Hot dry weather is detrimental to height growth, whereas warm moist weather is favourable (Wheaton 1958). Most terminal growth occurs at night and the rate is influenced directly by night temperatures.

Terminal growth of young trees is much better in the open than in the shade. In the 5-year period 1955-59 the total average terminal growth of a number of white spruce saplings on moderately fresh clay loam soils without an overstorey was 43.3 inches; on similar sites under an overstorey the growth rate of similar-sized trees for the same period averaged only 27.9 inches (Waldron 1962c).

A stem analysis study in intermediate-aged mixedwood stands in Saskatchewan (Cayford 1957) and release studies in all three Prairie Provinces (Lees 1964b; Jarvis and Steneker 1962; Steneker 1963b) have shown that an aspen overstorey greatly retards the growth of white spruce trees. In addition to a reduced growth rate, white spruce leaders are often damaged or broken off when they reach the crowns of the aspen, resulting in trees of poor quality. Individual spruce trees released from the effects of an aspen overstorey have increased their heigh growth by as much as 55 per cent (see project summaries A-13, MS-153, MS-167).

Shrub and herb competition has a detrimental effect on seedling height growth (see project summaries MS-147-1, MS-160-5). For example, white spruce seedlings set out amid dense hazel (*Corylus cornuta)* at the Riding Mountain averaged only 11 inches in height 4 years after planting. Seedlings from the same stock planted on the same site, but where the hazel had been cut, averaged 17 inches in height 4 years after planting (Waldron 1959a).

(b) Radial growth

At the Riding Mountain radial growth of white spruce starts about the end of May, approximately the same time that height growth starts. Radial growth continues throughout the summer well into September but is most rapid during June and July (Wheaton 1958). Radial growth is better on trees in the open than on trees shaded by an overhead canopy (Cayford 1957). A study in an intermediate-aged mixedwood stand in Saskatchewan has shown that the diameter growth of spruce may be increased by as much as 60 per cent by removing the aspen overstorey (Jarvis and Steneker 1962) (see project summary MS-153-1). Another study has shown that 4- to 6-inch spruce were affected by other trees (aspen and spruce) as far away as 25 feet (the furthest distance studied). Seven- to 10-inch white spruce were affected most by trees within a distance of 15 feet (Steneker and Jarvis 1963a) (see project summary MS-153-2).

(c) Root growth

Root growth begins much earlier and stops much later than terminal or radial growth. At the Riding Mountain root growth usually begins about the end of April and continues well into October (Wheaton 1958). Rate of growth appears to slow down when terminal development is at its peak. Root growth also slows down and may even stop for a period when the soil becomes dry.

The root systems of seedlings growing on decayed wood tend to be weak. They develop slowly and parallel to the axis of the stump or log, and several years may elapse before the root tips extend into the soil beneath. Generally, white spruce produces an extensive lateral root system from which sinkers extend downward into the soil. However, on very moist sites the development of deep roots is restricted. For example, 7-year-old seedlings on very moist sites have been observed which had lateral roots up to 36 inches in length but with tap roots or sinkers only 6 inches in length. On drier sites seedlings of the same age were observed with laterals about 16 inches long and sinkers over 24 inches long (Rowe 1955).

4. *Silvicultural Systems*

Several studies have been undertaken in the Mixedwood Forest Section to investigate the relative value of various silvicultural systems for managing white spruce and trembling aspen. All have been within the framework of a predominantly sawlog economy (see project summaries A-12, A-15, A-22, A-58, MS-37, MS-60, MS-124, MS-156, MS-166, MS-211-1, MS-216, MS-228). Cutting methods tested have included (1) clear cutting in blocks and strips, removing or leaving the merchantable hardwoods, (2) clear cutting with residual spruce seed trees, and (3) partial and "selection" cutting, which was in effect uniform shelterwood cutting (Bedell 1948, Blyth 1952, Quaite 1951 and 1956, Smithers 1959, Jarvis 1963b, Kolabinski

1964a and 1964c, Lees 1963a and 1964a, Phelps 1940 and 1948b, and Waldron 1959b and 1963a).

Uniform two-stage shelterwood cutting shows most promise. Results indicate that a larger volume of merchantable timber will be produced at rotation age if the first cut is made when the stand is about 70 to 80 years of age. The first cutting should leave about 40 to 60 square feet basal area of spruce per acre and the unmerchantable hardwoods. In Alberta, after removing 1,843 cubic feet of spruce per acre in 1951 (67 per cent of the standing volume), the residual stand increased in volume at a rate of 3.1 per cent to yield a standing volume of 1,963 cubic feet per acre in 1961. This volume included a recruitment of 168 cubic feet per acre into the 7-inch diameter class -- the lowest merchantable size. Increase for control stems was 1.7 per cent (Lees 1964a). When marking for the first cut care should be taken to leave those trees which show good growth potential. Time of the final cut will depend upon the residual stand growth and the status of regeneration.

Unless the initial cut can be made while the stand is growing vigorously, shelterwood cutting does not result in sufficient volume production increase or recruitment to merchantable size classes to justify the expense of two cuts. Mature white spruce stands when partially cut are subject to windthrow, sunscald and top break (Quaite 1951).

It has been shown that block clear cutting leaving at least 6 seed trees per acre (Quaite 1956) and strip clear cutting (Kolabinski 1964a) provide seed in relative abundance, but results have indicated quite clearly that canopy manipulation alone will not ensure a future crop of spruce. In fact it has been concluded that successive cuts are likely to eliminate the species unless site preparation is carried out to induce regeneration.

Several studies have been undertaken to determine whether mechanical seedbed preparation will aid spruce regeneration (Phelps 1951; Lees 1963a, 1963d and 1963e; Waldron 1961c; Jarvis 1963b; Kolabinski 1964a and 1964c). Seedbeds have been made using ordinary bulldozer blades (see project summaries A-22, MS-124, MS-156, MS-166, MS-211-1, MS-216 and MS-228), toothed bulldozer blades (Figure 11) (see project summaries A-58 and A-62), Seaman

Figure 11. Crawler-type tractor with a 6-toothed bulldozer blade, 9 feet wide.

Figure 12. Self-driven Seaman tiller.

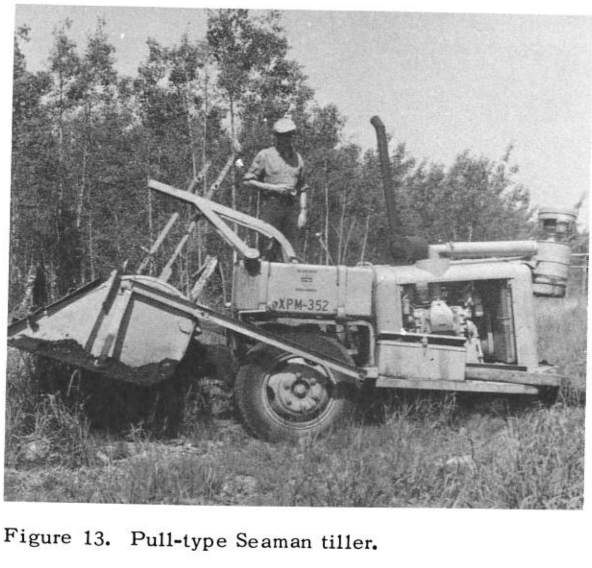

Figure 13. Pull-type Seaman tiller.

Figure 14. Athens plough.

Figure 15. Imset scarifier.

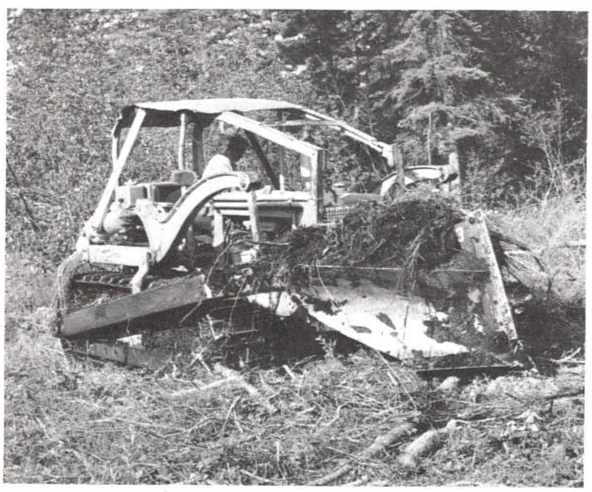

Figure 16. Saskatchewan fire-line plough.

tillers (Figures 12 and 13) (see project summary A-62), Athens ploughs (Figure 14) (see project summaries A-62, MS-124 and MS-156), an Imset scarifier (Figure 15) (see project summary A-62) and a Saskatchewan fire-line plough (Figure 16) (see project summaries MS-211-1 and MS-216).

General results for 7 projects covering intervals up to 12 years after treatment are given in Table 2. They are most encouraging and indicate that mechanical seedbed preparation is a feasible method for regenerating white spruce. Of all the equipment used to prepare seedbeds it has been concluded that the ordinary and toothed bulldozer blades have been the best all-round tools for scarifying on mesic sites. Practically all of the mineral soil seedbeds made by these tools are suitable for regeneration and remain receptive to new seed for some years (Figure 17). Humus seedbeds, resulting from shallow scalping and churning action of the tractor treads, are much less favourable (Figure 18). On these seedbeds competing vegetation is seldom destroyed and it soon crowds out the spruce. Piles of debris dumped when clearing the blade are also poor seedbeds because they dry out too quickly. It has been concluded that scalping should be done in a manner which will create large patches rather than narrow strips. This lessens the possibility of scalped areas becoming game trails, and more important, re-invasion of the seedbeds by root runners, etc., from adjacent undisturbed vegetation is slower. It cannot be emphasized too strongly that on the rich soils characteristic of the Mixedwood Forest Section scalping must be deep enough to remove from the scarified patches the perennating parts of shrubs, herbs, grasses and aspen.

The Athens plough creates suitable media for germination but it does not remove the perennating parts of the competition from the scarified areas. Observations have shown that new shoots soon spring up and offer severe competition to spruce seedlings on areas treated with this implement. The general data given in Table 2 show that per cent stocking on areas treated with the Athens plough is less than that on areas treated with a bulldozer blade (see project summaries MS-124, MS-156).

Trials using the Imset scarifier were carried out in 1961 and results are not yet available. However, like the Athens plough, this tool

Figure 17. Good mineral soil seedbeds made using a straight blade.

Figure 18. Seedbeds made using a straight blade; note piles of debris in the background and area churned up by the tractor treads; these seedbeds are less favourable than those in Figure 17.

TABLE 2 STOCKING TO WHITE SPRUCE ON MECHANICALLY PREPARED AND ON UNDISTURBED SEEDBEDS

Project	Treatment	Years between treatment and last remeasurement	Per cent quadrats stocked*	Number seedlings per acre	Tallest seedlings	
					Av.ht. (inches)	Av. age (years)
MS-124 (1)	Control	12	7	140	9	7
	Disked (Athens plough)	12	20	1,470	8	7
MS-124 (2)	Control	9	7	200	5	6
	Scalped (bull-dozer blade)	9	43	4,900	6	6
MS-156	Control	8	0	0	–	–
	Disked (Athens plough)	8	20	2,800	4	5
	Scalped	8	84	6,080	4	5
MS-166	Control	7	–	–	–	–
	Scalped (bull-dozer blade)	7	72	2,400	5	6
A-22	Control	7	no data	–	–	–
	Scalped (bull-dozer blade)	7	75	–	6	5
MS-124 (3)	Control	4	20	400	–	–
	Disked (Athens plough)	4	34	800	–	–
MS-211 (1)	Control	2	4	no data	2	no data
	Ploughed (Saskat-chewan fire-line plough)	2	63	50,000	2	no data
MS-211 (3)	Control	2	4	no data	2	no data
	Scalped (bull-dozer blade)	2	56	37,000	2	no data
MS-211 (4)	Control	1	1	no data	no data	no data
	Ploughed (Saskat-chewan fire-line plough)	1	40	700	no data	no data
MS-216 (1)	Control	1	1	3	no data	no data
	Scalped (bull-dozer blade)	1	69	11,000	no data	no data
MS-216 (2)	Control	1	2	26	no data	no data
	Ploughed (Saskat-chewan fire-line plough)	1	49	2,500	no data	no data
MS-228 (1)	Control	1	4	25	no data	no data
	Scalped (bull-dozer blade)	1	96	12,000	no data	no data

* Basis – 1/000-acre plots.

does not remove the perennating parts of competing vegetation.

The pulverized seedbeds made by the Seaman tillers provide a promising seedbed, grinding up the organic horizons and mixing them with mineral soil. However, as with the Imset scarifier results are not yet available. It is not known yet how long the seedbeds will stay receptive nor how intense competition will become.

The Saskatchewan fire-line plough appears to be a reasonably good tool for treating the moister sites where footing for the tractor is poor (Figure 19). It can be manoeuvred between and around stumps quite easily without much danger of the tractor becoming stuck. On the other hand, observations indicate that this tool is not so good for the drier sites. In these situations the operator has a tendency to plough too deeply, creating deep furrows and high ridges (Figure 20) (see project summary MS-211-1). Seedlings in the furrows are susceptible to flooding and to burial by alluvium washed down from the ridges. Seedlings on the ridges are susceptible to drought and erosion.

Figure 19. General view of seedbeds made with the Saskatchewan fire-line plough on a very moist site.

Figure 20. Mineral soil seedbed made with a Saskatchewan fire-line plough on a fresh site; note the deep furrow.

5. *Artificial Regeneration*

(a) Seeding

Very little work has been done in the Mixedwood Forest Section to regenerate white spruce by direct seeding. Between 1905 and 1928 some small projects were initiated to test the effectiveness of spot seeding and broadcast seeding under various stand conditions and in the open, and on different seedbed media such as mineral soil, litter and burned duff. Records of these early studies are scanty, consisting of a few field notes, some miscellaneous field summaries and a file of correspondence. In most instances germination appears to have been successful but subsequent seedling survival was poor. Drought was the major factor listed as causing mortality the first two years after seeding, while competition and browsing were listed as chief causes in later years. It would appear from the records that if seedlings had been released from competing vegetation and if browsing had been controlled, more of the tests would have been successful.

The most successful seeding (Haig 1959a) was initiated in 1920 at the Duck Mountain. White spruce seed was broadcast at the rate of 1, 2 and 3 pounds per acre on fresh till soil which had been thoroughly disked 6 times prior to seeding then harrowed. In 1957, 37 years after seeding, stocking to white spruce ranged from 3,400 to 5,000 stems per acre; trees were about 20 feet tall and about 2.5 inches in diameter at breast height (see project summary MS-90).

More recent studies have been undertaken to study germination and seedling survival on various seedbeds (undisturbed litter and mineral soil exposed by burning, hand scarification and mechanical scarification) (see project summaries 150-1, MS-150-2, MS-159, MS-191-1, MS-191-2, MS-226, MS-239). Results from these studies indicate that mesic sandy loam and clay loam sites in the Mixedwood Forest Section can be regenerated to white spruce by artificial seeding (Phelps 1948a, Rowe 1953b, Waldron 1961a and 1963a). Prerequisites for successful establishment are that mineral soil seedbeds must be prepared, potentially competitive cover must be eliminated prior to seeding, and young seedlings must be protected from browsing and competition by reinvading vegetation.

(b) Planting

Several plantations have been established in the Prairie Provinces and some date back to the early 1900's. Of these, some have failed (primarily through neglect or "off-site" planting) but others have flourished, which indicates that white spruce can be planted successfully under certain conditions in the Mixedwood Forest Section.

Surveys of older plantations (Johnson 1953; Jameson 1956; Haig 1956, 1959b, 1959c) (see project summaries MS-100, MS-103 to -113) have shown that: (a) survival of plantations set out on fresh to moist till soils has been much better than that of plantations set out on dry sands and other prairie soils, (b) plantations established in drought years have suffered more mortality than those set out in years with above average precipitation, (c) plantations set out by hand planting in furrows have had reasonably good survival rates, (d) plantations set out in the rough have had poor survival rates, (e) plantations set out on ploughed ground which was cultivated for a number of years after planting have had excellent survival and growth, (f) seedlings set out in or adjacent to dense brush or under aspen have suffered more browsing than those planted in open areas, (g) growth of transplants set out in the open has been much better than that of transplants set out in the shade of an overhead canopy, (h) seedlings planted by the hole method have survived better than those planted by the slit method, (i) major factors causing mortality appear to be drought, competition from surrounding vegetation, and repeated browsing.

More recent studies have been undertaken (Rowe 1954b, 1959; Waldron 1963b, 1963c) (see project summaries MS-147-1, MS-160, MS-211-3, MS-226, MS-229) to compare: (a) survival and growth of various aged stock set out on ground pre-treated in various ways (Athens ploughed, bulldozed and undisturbed), (b) survival and growth of seedlings released from hazel competition with those not released, and (c) survival and growth of seedlings planted at weekly intervals throughout the summer.

Results so far indicate that: (a) planting may be carried out successfully throughout the summer providing rainfall is adequate, (b) pre-planting site preparation greatly improves survival and growth on mesic sites, (c) survival on mesic sites is best on bulldozed areas, intermediate on Athen-ploughed areas and poorest on undisturbed ground, (d) survival on ground prepared in a given manner is poorer on wet sites than on mesic sites, (e) competition from hazel, aspen, grass and tall shrubs is detrimental to the survival and growth of white spruce transplants.

It is quite evident from the results that white spruce can be planted successfully in the Mixedwood Forest Section. For best results, planting should be restricted to the fresh to moist sites. Also pre-planting site preparation to eliminate competition and conserve moisture around the seedling roots is essential.

6. *Tending of Stands and Trees*

(a) Mixedwoods

Trembling aspen forms the upper canopy in young- and intermediate-aged mixedwood stands. As pointed out previously, an overstorey of aspen hinders the development of the spruce beneath. Results from studies to determine the effects of release cutting on the development of spruce show conclusively that all ages and sizes of white spruce respond to treatment. The amount of response has been directly dependent upon the intensity of the release cutting with 30- to 40-year-old trees having the greatest ability to increase their growth rate for a given degree of release (Blyth 1952; Jarvis and Steneker 1962; Steneker and Jarvis 1963a; Steneker 1963b, and Lees 1964b) (see project summaries A-13, MS-8, MS-153-1, MS-153-2).

For the first 10-year period after all trembling aspen has been removed, young- and intermediate-aged white spruce trees in eastern Saskatchewan (15 to 60 years) increased their diameter growth up to 60 per cent. For the same period, individually released trees showed increases in diameter growth up to 80 per cent and in height up to 55 per cent (Jarvis and Steneker 1962) (see project summary MS-153-1).

As a result of increases in diameter and height growth, volume yields per acre have also been increased. In a 50-year-old stand in which up to 60 per cent of the total basal area was removed, the white spruce board-foot volume 21 years after release was almost tripled in comparison to that of the control stand. Total volume (cubic feet) was almost doubled (see project summary MS-8).

In most release cuttings removal of the aspen has been done with saws and axes. However some experimenting has been done using chemicals as a means of killing the undesirable trees. Effective kills of aspen have been attained using 2,4,5-T basal bark sprays and 2,4,5-T applied to frills in the bark (Waldron 1961b) (see project summary MS-147-2). Quaite (1953) reported that "Ammate" poured into notches in cut aspen stumps prevented suckering and that the effect of the poison extended to surrounding live aspen by means of root grafts.

Chemical sprays of various concentrations (2,4-D, 2,4,5-T, and ammate) have been used to release smaller spruce from dense hazel and other shrub competition. All treatments were successful in killing the above-ground portions of the shrubs, but sprouting subsequently occurred, although it was least with the 2,4-D treatment (see project summary MS-147-1). Six years after treatment the tallest spruce were about 5 feet high and were considered to be free from further suppression by hazel which ranged in height from about 3 to 5 feet. Another study, involving the release of 3-2 white spruce stock from hazel by means of 2,4-D spray, showed that 4 years later mortality had been reduced by about 50 per cent as a result of the spraying and the spruce on the sprayed area were about 6 inches taller than those on the unsprayed area (see project summary MS-160-5).

(b) Hardwoods

Work in trembling aspen stands has been confined to thinning, primarily in the young- and intermediate-aged classes (11 to 45 years) (Pike 1947 and 1953; Steneker 1961a, 1961b, 1962, 1963a and 1963c) (see project summaries MS-4, MS-5, MS-6, MS-133, MS-146, MS-155). Results have shown that response to thinning was related directly to the intensity of thinning. All size classes and all age classes responded to treatment. However, the growth rate of the thinned plots in the younger stands was considerably faster than that of the older stands. In 10- to 14-year-old stands annual diameter increment of crop trees has ranged from .16 inches with stand basal areas of about 80 to

90 square feet per acre to as much as .26 inches with stand basal areas of 10 to 20 square feet. Height increment has not been affected by thinning.

As a result of thinning a great amount of mortality, otherwise lost through natural thinning, was salvaged. In the stands under study maximum volume increment at ages 10, 20, 30, 40 and 50 years occurred when basal area was maintained at approximately 30, 50, 65, 85 and 100 square feet per acre, respectively. These stocking levels ranged from approximately 60 per cent (at age 10) to approximately 80 per cent (at age 50) of those of the untreated stands. Basal areas required for maximum volume increment per acre are larger than those required for maximum diameter increment or volume increment per individual tree. Results also indicate that trees about 20 to 30 years of age respond best to any given degree of release (Steneker and Jarvis 1963b).

Studies are presently being undertaken to relate diameter increment of individual trees to point density at the location of these trees. Results, however, are not yet available.

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PART III

LISTING OF ALL PROJECTS BY THE OXFORD DECIMAL CLASSIFICATION

PART III – LISTING OF ALL PROJECTS BY THE OXFORD DECIMAL CLASSIFICATION

Classification		Projects
11. Site Factors		
114.32	Soil, geological considerations, weathering, influence of parent material	A-29, MS-173, MS-69, MS-183, MS-168
114.4	Soil, soil classification, soil types	A-29, MS-173, MS-168, MS-69, MS-183
18. Plant Ecology		
181.2	Mode of life, autecology, atmospheric relations	A-63, MS-135
181.522	Mode of life, autecology, reproductive behaviour, fruiting	MS-156, MS-124
181.523	Mode of life, autecology, reproductive behaviour, seed dispersal	MS-56, MS-158-1, MS-158-2, MS-211-2
181.524	Mode of life, autecology, reproductive behaviour, seedling longevity	MS-161
181.525	Mode of life, autecology, reproductive behaviour, germination, seedling development	A-63, MS-223, MS-191-1, MS-191-2, MS-159, MS-135, MS-150-1, MS-150-2
181.65	Mode of life, autecology, post-seedling development, growth as influenced by environment	MS-184, MS-167, MS-153-2
181.8	Mode of life, autecology, phenology	MS-184
22. Silvicultural Systems		
221.02	High forest systems, shelterwood felling	A-22, A-12, MS-228, MS-166, MS-37
221.21	High forest systems, seed-tree method	MS-37
221.222	High forest systems, alternate clear-strip system	MS-211-1, MS-216, MS-211-2, MS-211-3
221.42	High forest systems, selective logging	A-15
226	Changes of silvicultural system, conversion	MS-226
228.1	Constitution and composition of stands, density, dominance, suppression	MS-167
23. Regeneration and Formation of Stands		
231.31	Natural regeneration, manipulation of canopy	A-12, MS-228, MS-166 MS-60, MS-37, A-15

PART III – LISTING OF ALL PROJECTS BY THE OXFORD DECIMAL CLASSIFICATION

Classification		Projects
231.321	Natural regeneration, manipulation of undergrowth and ground vegetation by cutting, scraping, etc.	A-58, A-62, A-22, A-12, MS-228, MS-191-1, MS-191-2, MS-159, MS-150-1, MS-166, MS-211-1, MS-216, MS-156, MS-124, A-75
231.322	Natural regeneration, manipulation of undergrowth and ground vegetation by burning	MS-159, MS-150
232.21	Artificial regeneration, preparatory work, pretreatment and preparation of site	MS-229, MS-226, MS-160-2
232.213	Artificial regeneration, preparatory work, burning	MS-239
232.33	Artificial regeneration, formation of stands by direct sowing	MS-90, MS-191-1, MS-191-2, MS-159, MS-150-1, MS-226, MS-239
232.4	Artificial regeneration, formation of stands by planting	MS-100, MS-103, MS-104, MS-105, MS-106, MS-107, MS-108, MS-109, MS-110, MS-111, MS-112, MS-113, MS-211-3, MS-226, MS-160-2, MS-229, MS-147-1
232.411.3	Artificial regeneration, formation of stands by planting, grading and size	MS-160-1
232.43	Artificial regeneration, formation of stands by planting, spacing and arrangement in plantations	MS-160-3
232.44	Artificial regeneration, formation of stands by planting, season and time of planting	MS-160-4
235.1	Under planting, advance planting, etc.	MS-160-5
236	Care of regeneration or plantations in the initial stages of establishment	MS-147-1

24. Tending of Stands and Trees

242	Thinnings	MS-4, MS-5, MS-6, MS-8, MS-133, MS-146, MS-155
243	Opening of the canopy (increment fellings, overhead release and improvement fellings)	MS-224, MS-153-1, A-15, MS-8, A-13
243.8	Opening of the canopy, girdling and poisoning	MS-147-2

PART III – LISTING OF ALL PROJECTS BY THE OXFORD DECIMAL CLASSIFICATION

Classification		Projects
42. Injuries from Inorganic Agencies (Excluding Fire)		
422.13	Temperature influences, insolation, frost heaving	MS-159
422.2	Temperature influences, insolation, heat, drought	MS-100, MS-103, MS-104, MS-106 to 111, MS-113
424.2	Soil conditions; erosion effects, flooding, waterlogging	A-75, A-12, MS-211-1, MS-160-5, A-58
44. Damage by Harmful Plants		
441	Forest weeds	MS-147-1, MS-160-3, MS-160-5, MS-103, MS-104, MS-160-2, MS-211-3, MS-105, MS-159, MS-166, MS-100, MS-106 to 111, MS-113
45. Damage by Animals		
451.2	Wild mammals	MS-90, MS-100, MS-106 to 111, MS-105, MS-211-3, MS-103, MS-104, MS-112, MS-113, MS-160-3, MS-160-2
54. Assessment of Site Quality		
541	Based on height diameter volume, etc.	MS-183, A-29
56. Increment Development and Structure of Stands		
561	Increment in height diameter basal area, etc.	A-29, MS-4, MS-5, MS-6, MS-133, MS-146, MS-155, MS-183
562	Volume increment	MS-69
568	Other mensurational studies of stand constitution and changes therein, distribution of growth by tree classes, etc.	MS-69
–01. Research and Testing, Experiments		
–015.7	Measurements, quantitative tests, etc., machines and equipment	A-62

PART IV

PROJECT SUMMARIES

Project A-12	Experimental cutting of white spruce in a mixedwood stand in northern Alberta.
Classification	221.02:231.31:231.321:424.2
Investigators	Past: J. Quaite Present: J.C. Lees
Objective	To develop suitable harvest cutting methods designed to promote maximum yield and satisfactory regeneration in spruce-aspen stands.
Location	The study area is 4 miles south of Fawcett Lake on the Smith-Fawcett Lake West End road, Alberta.

Work done

In 1951, a 150-acre study area in spruce-aspen stands of approximately 100 years of age was selected. Eight harvest cutting methods were randomly assigned to 24,4/10-acre, patches. There was a 1½-chain-wide surround, treated in the same manner as the patch. Treatments were as follows:

A. Control – no disturbance.
B. Heavy residual – leaving 8,500 fbm spruce per acre. Marking removed 47 per cent of spruce by volume.
C. Medium residual – leaving 5,500 fbm spruce per acre. Marking removed 69 per cent of spruce by volume.
D. Light residual – leaving 4,500 fbm spruce per acre. Marking removed 63 per cent of spruce by volume.
E. Selection – Leaving only spruce which showed good growth potentialities – the treatment resulted in 67 per cent removal by volume. It was, in effect, a uniform shelterwood cut based on individual tree marking.
F. Diameter limit – removing all spruce 14 inches in diameter and over at a 12-inch stump height. This treatment resulted in 61 per cent removal of spruce by volume.
G. Seed tree – six seed trees per acre were selected and left. All other spruce over 6 inches in diameter at breast height were removed – 96 per cent of spruce by volume was removed.
H. Clear cut – removing all spruce over 6 inches diameter at breast height. The treatment resulted in 96 per cent removal by volume.

The aspen was unmerchantable and left standing.

Eight hand-scarified plots approximately 5 x 5 feet were placed, together with one control, just outside the boundary of each 4/10-acre patch.

Regeneration on scarified spots was tallied in 1952, 1954 and in 1960. In 1961 regeneration status on the total 150 acres was assessed.

All stems on the 24 patches were tallied in 1952, mortality was noted in 1953 and 1954, and in 1961 all stems were re-tallied. Diameter and height increment were measured on selected dominant and co-dominant spruce 10 years after logging.

Results

Harvest cutting treatment did not significantly affect regeneration stocking on the 5 x 5 foot plots. Only the effect of scarification treatment was significant (Table 3). Scarified spots not stocked to white spruce generally showed signs of flooding. Twenty per cent of scarified spots were affected.

Overall stocking to white spruce seedlings assessed in 1961 on undisturbed seedbeds is below acceptable standards and extensive scarification of the study area is planned. Highest stocking, 30 per cent by milliacre quadrats, was obtained under selection cutting (Table 4).

TABLE 3 WHITE SPRUCE REGENERATION STOCKING ON HAND-SCARIFIED AND CONTROL ¼ MILLIACRE QUADRATS 1954 AND 1960.

(Basis – 24 permanent ¼ milliacre quadrats per treatment)

Treatment	Scarified		Unscarified	
	1954	1960	1954	1960
	Per cent		Per cent	
A Control	88	61	0	5
B Heavy residual	67	50	17	13
C Medium residual	66	52	25	23
D Light residual	75	70	13	6
E Selection	75	54	17	30
F Diameter limit	83	82	17	12
G Seed tree	79	71	17	7
H Clear cut	75	59	0	0

TABLE 4 REGENERATION STATUS BY FELLING TREATMENT OVERALL STOCKING – 1961 SURVEY*

(Basis – 48 temporary milliacre quadrats per treatment)

Treatment	Milliacre stocking – per cent			
	White spruce	Trembling aspen	Balsam poplar	White birch
A Control	12	22	12	–
B Heavy residual	10	35	16	6
C Medium residual	17	38	19	8
D Light residual	21	35	6	6
E Selection	30	38	25	21
F Diameter limit	19	63	21	15
G Seed tree	23	40	13	23
H Clear cut	15	46	21	29

*The cut volumes are summarized in Table 5 while diameter growth data are presented in Table 6.

TABLE 5 SUMMARY OF BOARD FOOT CUT VOLUMES PER ACRE

Treatment	Volume Before Cutting	Cut Volume	Volume after Cutting		Volume 1961	
	White Spruce	White Spruce	White Spruce	Hardwoods	White Spruce	Hardwoods
Control	16,409	--	16,409	5,713	19,857	6,320
Heavy residual	14,536	6,859	7,677	4,020	10,877	4,979
Medium residual	15,036	10,341	5,495	4,197	6,322	4,690
Light residual	10,782	6,774	4,008	6,235	5,215	5,890
Selection	11,744	7,908	3,836	6,237	5,037	6,385
Diameter limit	10,152	6,216	3,936	5,145	6,422	6,135
Seed tree	12,611	12,046	565	3,705	842	3,400
Clear cut	9,433	9,056	377	3,485	457	3,817

TABLE 6 WHITE SPRUCE DIAMETER INCREMENT 1941 TO 1951 AND 1951 TO 1961

Treatment	Average Diameter (inches)	Diameter Increment (per cent)	
	1961	1941–1951	1951–1961
Control	9.9	0.62	0.62
Heavy residual	9.2	0.82	0.93
Medium residual	10.1	0.92	1.12
Light residual	9.0	0.99	1.21
Selection	9.4	1.06	1.13
Diameter limit	8.3	1.24	1.34
Seed tree	7.0	1.04	1.77
Clear cut	5.9	1.24	2.78

Comments

The selection cutting method, in effect a two-cut uniform shelterwood system, resulted in highest stand volume growth rate, low mortality and best regeneration status. A report published in 1964 outlines the following advantages of the shelterwood as applied in this study.

1. Site protection.
2. Seed supply from vigorous parent trees.
3. Shelter for establishing seedlings.
4. Inhibition of colonizing intolerant species such as aspen.
5. Valuable recruitment to merchantable size class.
6. Accelerated growth on crop trees.
7. Increased value of stand production.

There is sufficient promise in the method to warrant its introduction, with seedbed scarification, in mixedwood management.

Future work The proposed work for the study area includes scarification of the total 150 acres using a 6-toothed blade and the removal felling of residual stems following satisfactory establishment of white spruce regeneration.

Status Continuing.

Reports

Unpublished

Quaite, J. 1952. Experimental cutting of white spruce in a mixedwood stand in northern Alberta. Canada, Dept. Resources and Development, For. Br., For. Res. Div.

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Quaite, J. 1956. Survival of white spruce seedlings resulting from scarification in a partially-cut mixedwood stand. Canada, Dept. of Northern Affairs and National Resources, For. Br., For. Res. Div., Tech. Note 44.

Lees, J.C. 1964. A test of harvest cutting methods in Alberta's spruce-aspen forest. Dept. of Forestry of Canada, Publication No. 1042.

Project A–13 Effect of aspen competition on white spruce growth in spruce-aspen stands in northern Alberta.

Classification 243

Investigators Past: J. Quaite, G. Ontkean, L.A. Smithers
Present: J.C. Lees

Objective To determine the effect of the removal of competing aspen on the growth of white spruce in spruce-aspen stands of varying age to determine if and when these stands should be thinned.

Location Smith, Alberta.

Work done Project A–13 was established in 1951 and 1952 when 656 spruce stems located in 26 mixedwood stands were selected to study the effect of release from aspen competition. Cut aspen stumps were treated with "Ammate" poison to prevent sprouting and suckering. The spruce trees were remeasured in 1956 and in 1962.

Results Results to date indicate that stems of all ages and diameter classes responded to release and after 10 years, treated stems showed a continuing response. No significant differences in release were revealed in 1956 between ages or sites. Results of the 1962 remeasurement are currently being analyzed to check these factors. The interim height increment and diameter increment per cent data, presented in Figure 21, indicate the accelerated growth of the released trees and suggest that the 30- to 40-year age class has greatest response to treatment.

Comments Only one treatment was used in this study; the competition within a radius of twice the crop tree crown width was removed. The aspen stump poisoning was very effective in preventing suckering and sprouting. Use of the poison is discussed by Quaite (1953). Remeasurement in 1966 will determine whether further release will be necessary to maintain the current rapid growth rate.

Status Continuing.

Reports

Unpublished

Quaite, J. 1952. Effect of aspen competition on white spruce growth in spruce-aspen stands in northern Alberta. Canada, Dept. Resources and Development, For. Br., For. Res. Div.

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Lees, J.C. 1964. Release of white spruce from aspen competition in Alberta's spruce-aspen forest. Dept. of Forestry of Canada, For. Res. Br.

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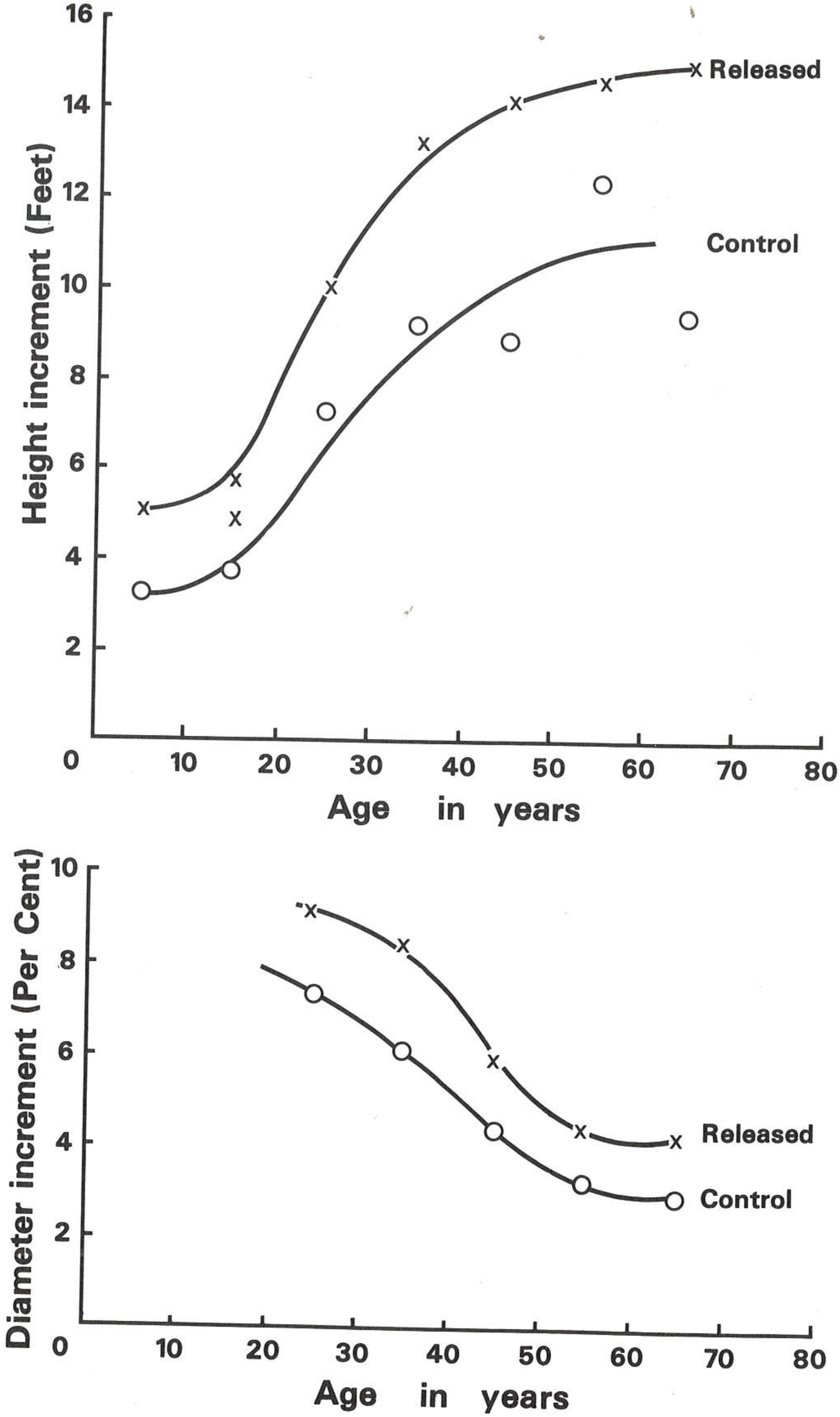

Figure 21. Height Increment and Per Cent Diameter Increment, Released and Control Stems 1951/52 – 1962

Project A-15 Growth and yield of residual stands of white spruce in logged areas of the Boreal forest region of Alberta.

Classification 221.42:231.31:243

Investigators Past: A.W. Blyth
Present: C.L. Kirby

Objective To ascertain the growth rates of residual stands of white spruce in the Boreal forest region of Alberta and to determine whether a system of partial cutting will perpetuate these spruce stands.

Location Permanent 4/10–acre plots are established in the districts of Fawcett Lake, Slave Lake, Faust, Athabasca, Calling Lake, Fort Assiniboine, Whitecourt, Edson, and Alder Flats, Alberta.

Work done A total of 138 4/10–acre plots were established in 1951 and 1952 in white spruce stands which had been cut-over for a period of up to 30 years. Measurements recorded included stem tallies by species in 1–inch diameter classes, and diameter increment from borings. Regeneration was sampled on 80 milliacre quadrats per plot. In 1962, the plots were remeasured and mortality recorded. Increment and regeneration were assessed and site conditions described using the classification developed under project A–29.

Results From the analysis of 1951 and 1952 data, it was concluded that –

1. There was an immediate release in diameter growth of the residual spruce. A residual volume of 1000 cubic feet per acre may be expected to double in volume in less than 20 years and to triple in volume in about 30 years.
2. Spruce regeneration was not adequate and the system of partial cutting would not perpetuate production of spruce (without seedbed preparation).
3. Successive partial cutting would eventually convert the stands to aspen if spruce regeneration was not secured.

Comments The results of the 1962 remeasurement are not yet available. Stand and stock tables will be prepared. Field and regeneration status will be assessed according to 3 main variables:

1. Initial reserve volume.
2. Years since logging.
3. Site.

Status Continuing.

Report *Unpublished*

Blyth, A.W. 1952. Growth and yield of residual stands of white spruce in logged areas of the Boreal forest region of Alberta. Canada, Dept. Resources and Development, Forestry Branch, For. Res. Div.

Project A-22	Mechanical scarification before and after logging to induce spruce regeneration in mixedwood stands marked for partial cutting.
Classification	221.02:231.321
Investigators	Past: J. Quaite, L.A. Smithers, G. Ontkean. Present: J.C. Lees
Objective	To examine a system of partial cutting with individual tree marking and to assess regeneration stocking to white spruce following mechanical scarification before and after logging.
Location	The study area is about 25 miles east of Lesser Slave Lake, Alberta, and 12 miles north of Highway 2 near Smith.

Work done

In 1952, 40 1/2-acre plots were located in 95 to 105 year old spruce-aspen stands and marked to yield the following residual stand densities:–

1. Control – no logging.
2. Heavy residual – leaving 8,000 fbm spruce per acre. On the average, 5,400 fbm per acre was removed.
3. Medium residual – leaving 5,000 fbm spruce per acre. On the average, 3,900 fbm per acre was removed.
4. Light residual – leaving 2,000 fbm spruce per acre. On the average, 5,600 fbm per acre was removed.

In no treatment was aspen or balsam poplar cut, nor was any spruce cut which was under 7 inches in diameter at breast height.

On each 1/2-acre plot, two strips were scarified using a TD9 tractor and straight blade, before and after logging. Regeneration was tallied on scarified, unscarified and dumped (or mounded) seedbeds in 1956, 1957 and 1959. Residual stand growth was assessed in 1959.

Results

Only the scarified seedbeds were suitable for spruce regeneration establishment. Undisturbed and dumped spoil seedbeds were significantly poorer. In 1959 the average milliacre stocking on scarified seedbeds remained high, 75 per cent, and did not vary between stand densities. Scarifying before or after logging did not affect stocking.

Residual stand growth is shown in Table 7.

Mortality and windfall were slight, occurring mainly in stems damaged by scarification or logging. Growth rates for spruce were good, 0.6 feet height increment per annum and up to 2 per cent diameter increment, considering the age of the stands. There was a valuable recruitment to the merchantable, 7 inches dbh, size class. Growth of aspen was poor, many stems being overmature and decadent.

Comments

The advantages of scarified seedbeds are considered sufficient to warrant inclusion of scarification as a standard procedure in regeneration silviculture in spruce-aspen stands following partial cutting.

The residual stand remains vigorous and healthy. If age class distribution is satisfactory, partial cutting could be carried out when stands are 75 years of age.

Future work includes study of time of overstorey removal. This is scheduled for 1965.

Status Continuing.

TABLE 7 VOLUME AND GROWTH PER ACRE

(Total volume in cubic feet)

Treatment	Species	Volume 1952	Volume 1959	Net Increment 1952-1959	Mortality 1952-1959	Gross Increment 1952-1959	Net Volume Increment /ac/year
Control	wS	3,187	3,432	245	92	337	35
	Hwd	2,077	2,033	–44	142	98	–
	Total	5,264	5,465	201	234	435	–
Heavy Residual	wS	2,066	2,437	371	76	447	53
	Hwd	1,907	1,922	15	144	159	–
	Total	3,973	4,359	386	220	606	–
Medium Residual	wS	1,420	1,666	246	49	295	35
	Hwd	2,181	2,219	39	184	223	–
	Total	3,601	3,885	285	233	518	–
Light Residual	wS	740	891	151	30	181	22
	Hwd	2,321	2,374	54	268	322	–
	Total	3,061	3,265	205	298	503	–

Reports

Unpublished

Quaite, J. 1953. Mechanical scarification before and after logging to induce spruce regeneration in mixedwood stands marked for partial cutting. Canada, Dept. Resources and Development. Forestry Branch, For. Res. Div.

Ontkean, G. 1957. Mechanical scarification before and after logging to induce spruce regeneration in mixedwood stands marked for partial cutting. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Smithers, L.A. 1959. Some aspects of regeneration silviculture in spruce-aspen stands in Alberta. Canada Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Mimeo 59-5.

Lees, J.C. 1960. Mechanical scarification before and after logging to induce spruce regeneration in mixedwood stands marked for partial cutting. Dept. of Forestry of Canada, For. Res. Br.

Published

Lees, J.C. 1963. Partial cutting with scarification in Alberta spruce-aspen stands. Dept. of Forestry of Canada, Publication No. 1001.

Project A-29 A site classification for white spruce in the mixedwood Section of Alberta.*

Classification 114.4:114.32:541.

Investigators Past: J. Quaite
Present: P.J.B. Duffy

Objective To present a working basis for the differentiation of land conditions for forest management operations and road construction; to bring general order and continuity to the knowledge of the Mixedwood Section of the Boreal Forest and to establish a description and terminology upon which subsequent more detailed studies can be based. The physiographic approach which is used here is based on the identification and description of the surface materials and their forest capabilities.

Location Study areas are concentrated between the west end of Lesser Slave Lake and Lac la Biche. Reconnaissance data were taken also from forest areas adjacent to the MacKenzie Highway and the Athabasca River north of Athabasca town.

Work done Over 400 temporary sample plots were measured between 1953 and 1957 and 100 more were established in 1962. A site classification was synthesized from these data and a publication prepared.

Results Twelve physiographic site types have been identified in the Mixedwood Section as productive situations for white spruce. They are ranked in order of decreasing productivity in Table 8. The maximum dominant height at 80 years was the criterion used in the ranking process. Figure 22 shows how the dominant heights vary with parent material (left column) and moisture regime (across the top). Table 9 indicates the productivities of the first two groups of sites from Table 8 in terms of basal area, total and merchantable volume and height.

Comments These site types can be recognized on air photographs by an experienced photo-interpreter. Thus in forest management planning those sites which are likely to yield a maximum return for a given input, whether it be planting up denuded areas, scarification, or other cultural measures, are those sites in Productivity Group 1. They are the sites that yield the best height growth and presumably the best volumes per acre at a given index age.

Status Continuing.

Reports

Unpublished

Quaite, J. 1954. A site classification for white spruce in the Mixedwood Section of Alberta. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div.

Quaite, J. 1955. A site classification for white spruce in the Mixedwood Section of Alberta. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Duffy, P.J.B. 1963. A site classification for white spruce in the Mixedwood Section of Alberta. Canada, Dept. of Forestry of Canada, For. Res. Br.

Published

Duffy, P.J.B. 1965. A forest land classification for the Mixedwood Section of Alberta. Dept. of Forestry of Canada. Publication No. 1128.

* Project summary prepared by P.J.B. Duffy.

TABLE 8 PHYSIOGRAPHIC SITES OF THE MIXEDWOOD SECTION, BOREAL FOREST, RANKED ACCORDING TO MAXIMUM DOMINANT HEIGHT OF WHITE SPRUCE AT 80 YEARS. BASIS: 80 ONE-FIFTH ACRE PLOTS.

Parent Material	Texture of Parent Material	Soil Moisture Status	Site Index at 80 yrs. (feet)
PRODUCTIVITY CLASS I: 85 - 95 FEET AT 80 YEARS			
1. Lowland alluvial: (Alluvium, High-Prairie)*	Stratified sand and silt	Moderately well drained to poorly drained	95
2. Alluvial-lacustrine: (Kathleen)	Stratified sandy loam, loam, and silt loam	Well drained to imperfectly drained	90
3. Till: (Braeburn)	Clay loam to heavy clay loam	Well drained to moderately well drained	90
4. Till: with alluvial cap (Braeburn)	Sandy loam to heavy clay loam	Well drained to imperfectly drained	87
PRODUCTIVITY CLASS II: 75 - 84 FEET AT 80 YEARS			
5. Lacustrine: (Donnelly)	Clay loam to clay	Well drained to imperfectly drained	84
6. Alluvial-lacustrine: (Kathleen)	Sand, silt, clay	Imperfectly drained to poorly drained	84
7. Till: (Braeburn)	Clay loam to heavy clay loam	Moderately well drained to poorly drained	84
8. Alluvium: dry elevated terraces (Heart)	Stratified sand and silt	Rapidly drained to well drained	82
9. Till: (clay-rich) (Snipe)	Heavy clay loam to clay	Imperfectly drained to poorly drained	78
PRODUCTIVITY CLASS III: 50 - 74 FEET AT 80 YEARS			
10. Lacustrine: (Kathleen)	Clay	Poorly drained	74
11. Aeolian: sheets and dunes (Heart)	Sand	Rapidly drained	60
PRODUCTIVITY CLASS IV: LESS THAN 50 FEET AT 80 YEARS			
12. Muskeg	Organic cap over heavy clay loam to clay	Very poorly drained	<50

*Some of the soils in the study area resemble mapped soil series (Names in brackets) on the High Prairie and McLennan Sheets (Odynsky W., A. Wynnyk and J.D. Newton 1952. Reconnaisance soil survey of the High Prairie and McLennan Sheets. University of Alberta, Bull. No. 59).

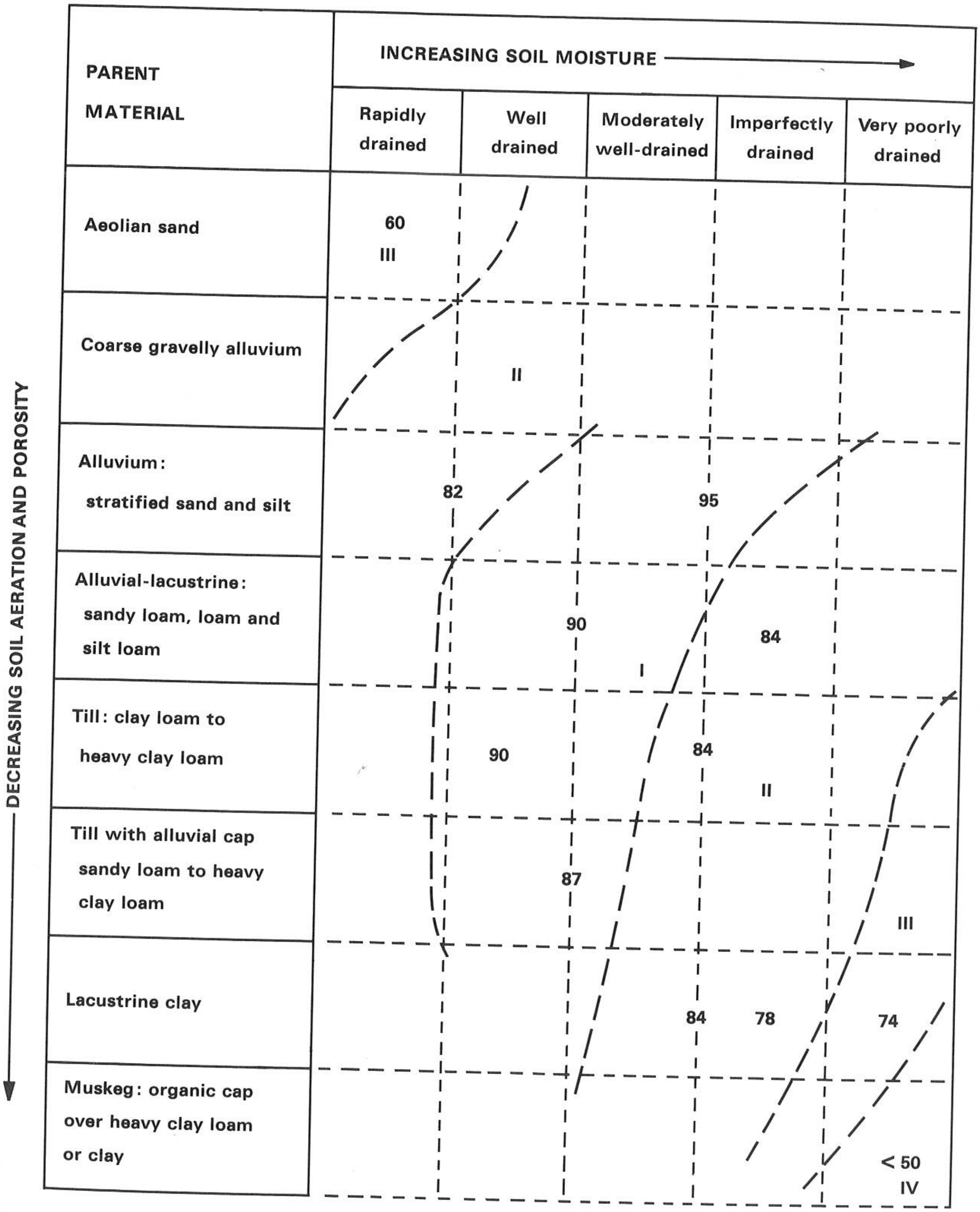

Figure 22. Maximum growth of white spruce (height at 80 years) on selected spans of the site continuum. Oblique lines separate site classes from best (I) to poorest (VI).

TABLE 9 PRODUCTIVITY CHARACTERISTICS OF THE PRINCIPAL SITE TYPES, MIXEDWOOD FOREST

Site type	No. plots	Average age	Basal area per acre (square feet)		Total volume per acre (cubic feet)		Merchantable volume** per acre			Average height of dominant white spruce at 80 years	Average maximum height of dominant white spruce at 80 years	Average D.B.H.	
			Sftwds.	Total	Sftwds.	Total	Softwoods (cubic feet)	Softwoods (board feet)	All species (board feet)			Sftwds.	All species
PRODUCTIVITY GROUP I													
1. Lowland Alluvium, M.R. 3-6	8	110 ± 20*	171 ± 55	197 ± 15	6,459 ± 1,995	7,241 ± 444	6,059 ± 1,874	33,913 ± 11,072	36,233 ± 4,214	90	96	10.5 ± 2.5	10.6 ± 2.4
2. Ponded, M.R. 2-4	10	104 ± 14	151 ± 29	203 ± 12	5,081 ± 1,292	6,833 ± 323	4,695 ± 1,287	22,868 ± 8,007	29,603 ± 3,139	83	87	7.9 ± 3.3	8.3 ± 2.0
3. Dumped Till, M.R. 2-3	16	106 ± 25	144 ± 35	179 ± 20	4,648 ± 968	5,625 ± 786	4,612 ± 1,081	21,433 ± 6,922	24,950 ± 5,957	83	88	10.3 ± 3.9	9.5 ± 3.3
4. Waterwashed Till, M.R. 2-4	11	120 ± 83	158 ± 52	211 ± 31	5,368 ± 1,690	7,029 ± 2,244	5,017 ± 1,610	25,646 ± 11,198	33,069 ± 13,751	83	87	16.4 ± 6.0	9.3 ± 2.1
PRODUCTIVITY GROUP II													
5. Lacustrine, M.R. 4-6	3	85 ± 16	154 ± 39	190 ± 21	4,265 ± 1,109	5,373 ± 292	3,695 ± 1,288	15,242 ± 7,887	17,120 ± 5,263	79	84	10.9 ± 2.4	11.0 ± 2.1
6. Ponded, M.R. 5-6	8	108 ± 28	156 ± 41	177 ± 19	5,075 ± 1,489	5,609 ± 748	4,625 ± 1,469	22,695 ± 9,017	24,317 ± 6,426	79	85	8.2 ± 2.2	8.2 ± 1.9
7. Dumped Till, M.R. 4-6	6	105 ± 19	145 ± 18	176 ± 12	4,660 ± 560	5,479 ± 366	4,220 ± 532	20,561 ± 3,642	23,877 ± 2,443	81	85	8.9 ± 3.1	8.3 ± 2.2
8. Nature Alluvium, M.R. 1-2	6	104 ± 3	149 ± 2	163 ± 3	4,436 ± 20	4,757 ± 6	3,825 ± 202	17,380 ± 2,165	18,322 ± 2,513	79	84	7.3 ± 1.6	7.5 ± 1.7

* Range of two standard deviations about the mean except the lacustrine site where total range is given because of the sparse data in that site type.

**Scribner log rule.

Project A-58 A test of silvicultural practices designed to secure reproduction of partially-cut mixedwood stands in the B.18a Section of Alberta.

Classification 231.321:424.2

Investigator Present: J.C. Lees

Objective To test silvicultural methods designed to obtain adequate white spruce regeneration through the use of partial cutting with individual tree marking, seedbed scarification, aspen sucker control and broadcast seeding on a range of three major site conditions.

Location Smith, Alberta. 150 miles north of Edmonton and 22 miles east of Lesser Slave Lake.

Work done In 1959, scarified seedbeds were created using a medium sized crawler tractor with a 6–toothed blade on three 10–acre blocks on each of three major site groups; Dry Upland, Moist Transition and Wet Bottomland. Partial cutting of the spruce-aspen stands had taken place in 1953. Aspen was poisoned on split plots. Assessment of natural white spruce seed supply and seeding of freshly scarified sample quadrats is carried out each year to assess deterioration of the original scarified seedbed.

Results Stocking levels on scarified and unscarified seedbeds on the three site groups and average seedling growth is shown in Table 10. Survival for new and original scarified seedbeds is presented in Table 11. Table 12 shows survival of the original seedlings for each year and Table 13 gives an estimate of available seed.

TABLE 10 STOCKING BY SEEDBED CONDITION AND SITE, 1963
(Original scarification – 1959)

Site	Per cent seedbeds scarified	Milliacre stocking (300 quadrats on each site)			Avge. ht. tallest wS. (inches)	Average leader length (inches)	Per cent scarified seedbeds flooded
		overall	unscarified	scarified			
Dry	28.6	43.7	28.1	84.6	3.16	1.17	1
Moist	23.6	50.7	34.4	93.3	2.82	1.12	2
Wet	22.3	37.3	27.2	72.7	2.37	0.85	4

TABLE 11 NUMBER OF NEW SEEDLINGS AND PER CENT SURVIVAL ON ORIGINAL AND FRESH SEEDBEDS
(Basis – 27, 1/4-milliacre seedspots on each site)

Site	1960				1961				1962				1963			
	Original seedbed		Fresh seedbed		Original seedbed		Fresh seedbed		Original seedbed		Fresh seedbed		Original seedbed		Fresh seedbed	
	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent	No.	per cent
Dry	139	13.5	–	–	9	42.9	1	12.5	4	44.4	76	59.8	0	0	31	64.6
Moist	1,599	69.9	–	–	40	70.2	29	52.8	40	80.0	188	66.9	9	81.8	21	87.5
Wet	785	61.9	–	–	16	38.1	17	21.4	15	69.6	39	42.9	5	83.3	25	61.0

TABLE 12 SURVIVAL OF 1959 SEEDLINGS

(Total number on 27, 1/40 milliacre seedspots)

Site	1960		1961		1962		1963	
	June	Sept.	June	Sept.	June	Sept.	June	Sept.
Dry	289	139	110	91	60	56	56	55
Moist	1227	1599	1067	954	372	354	243	235
Wet	764	765	488	402	251	222	159	154

TABLE 13 WHITE SPRUCE SEED SUPPLY ESTIMATES

Site	Per cent cone-bearing live-crown length			
	1959	1960	1961	1962
Dry	16	5 approx.	22	less than 5
Moist	17	5 approx.	25	less than 5
Wet	18	5 approx.	31	less than 5

Comments Results to date show that the original seedbed is still receptive to seed 4 years following scarification. The nature of the scarified spot, approximately 8 x 15 feet, created by the toothed blade is entirely satisfactory. Moist sites support a significantly greater number of spruce seedlings than the dry or wet sites. Flooding of scarified spots on moist and wet sites is a major source of mortality. The results are substantiated by statistical analyses.

Regeneration status of the total 90-acres study area will be published in the near future. Removal of the residual stands is planned for 1967.

Status Continuing.

Reports *Unpublished*

Lees, J.C. 1960. A test of silvicultural practices designed to secure reproduction of partially-cut mixedwood stands in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

Lees, J.C. 1961. A test of silvicultural practices designed to secure reproduction of partially-cut mixedwood stands in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

Lees, J.C. 1962. A test of silvicultural practices designed to secure reproduction of partially-cut mixedwood stands in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

Lees, J.C. 1963. A test of silvicultural practices designed to secure reproduction of partially-cut mixewood stands in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

Project A–62 The relative effectiveness of various equipment for scarification in spruce-aspen stands.

Classification 231.321:015.7

Investigator Present: J.C. Lees

Objective To determine which of the available pieces of machinery can most efficiently produce a satisfactory seedbed for spruce.

Location The study is located in spruce-aspen stands, partially cut in 1953, 12 miles north of Highway 2 near Smith, Alberta.

Work done In August 1961 a trial area of 15 acres was divided into strips and each of the following machines was assigned to three strips at random.

1. TD9 tractor with 6–toothed blade.
2. TD9 tractor with Imset scarifier.
3. TD9 tractor with Athens plough.
4. American-Marietta (Seaman) tiller.

Allowance was made for additional machines to be tested.

Results Effective mineral soil seedbed area exposed by each machine was assessed in 1961 and 15 sample 1/4 milliacre seedspots were sown with 100 white spruce seeds. Table 14 shows effective mineral soil seedbed area and Table 15 shows first year seedling survival.

TABLE 14 AVERAGE NUMBER AND SIZE OF SCARIFIED SPOTS 1961

Machine	Passes to scarify strip	Scarified spots/ strip	Average area (sq. ft.)	Area scarified per strip (sq. ft.)	Area with mineral soil (sq. ft.)
TD9	1	29	96	2784	1054
Imset	2	147	8	1176	443
Athens	2	109	1	no data	109
Seaman	1	16	202	3232	1510

TABLE 15 AVERAGE NUMBER OF FIRST YEAR SEEDLINGS ON 1/4 MILLIACRE QUADRATS, 1962

Machine	Number of seedlings	Per cent survival
TD9	14	74.3
Imset	9	74.3
Athens	9	67.8
Seaman	9	83.5

Comments The tractor-and-toothed-blade combination and the Seaman tiller show much promise in this study. The former is readily available in the region and most operators can quickly become familiar with the techniques required in scarification. The latter is an adaptation of an agricultural breaking tiller which has found world-wide application in road-bed mixing and preparation. A model suitable for woods operation is available and initial results indicate that further study of this machine is warranted. Regeneration performance for each machine will be assessed in 1964.

Status Continuing.

Reports *Unpublished*

Lees, J.C. 1962. The relative effectiveness of various equipment for scarification in spruce-aspen stands. Dept. of Forestry of Canada, For. Res. Br.

Lees, J.C. 1963. The relative effectiveness of various equipment for scarification in spruce-aspen stands. Dept. of Forestry of Canada, For. Res. Br.

Project A–63 The development of a phytometer method in the relationship of local climate and regeneration in the B.18a Section of Alberta.

Classification 181.2:181.525

Investigator Present: J.C. Lees

Objectives To develop a phytometer method in the relationship of local climate and regeneration using germination and survival of conifer seedlings as an index of local climate.

Location Smith, Alberta.

Work done This project was established in 1960. In an open millsite clearing, trays of white spruce and lodgepole pine seedlings were exposed to the effects of local climate. Germination and survival were followed throughout the growing season. To secure a standard growth medium of high moisture holding capacity, five seedbed media were used and the optimum seedbed was selected for subsequent phases of the study viz: standard loam with 35 per cent humus admixture. Net volume constituents were:

sand 44 per cent
silt 19 per cent
clay 11 per cent
humus 26 per cent.

In 1961 and 1962 a phytometer layout of five trays of spruce and pine seedlings was set out at four widely separated regions of Alberta:

1. Crowsnest Forest – Sub Alpine.
2. Kananaskis Forest Experiment Station – Sub Alpine.
3. Hinton – Foothills.
4. Smith – Mixedwood.

The more montane locations proved too severe for the required germination and only the original Smith location provided useful data.

Results Figure 23 shows a comparison of seedling survival for the Smith location in 1960, 1961 and 1962. In 1962 a sheltered location under a residual spruce-aspen stand is compared with the standard open location. The number of surviving seedlings and per cent survival are significantly different from year to year.

Comments As was anticipated, variation in climate between growing seasons produced significantly different responses in the standard phytometer layout. Initial results in the phytometer correspond to performance in the field under associated regeneration project A–58. Future work will include correlation of results for 4 years with results of natural regeneration assessments under A–58. Phytometer trays will then be set out in conjunction with the establishment of other natural regeneration projects in the region.

Status Continuing

Reports *Unpublished*

Lees, J.C. 1961. The development of a phytometer method in the relationship of local climate and regeneration in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

A-63

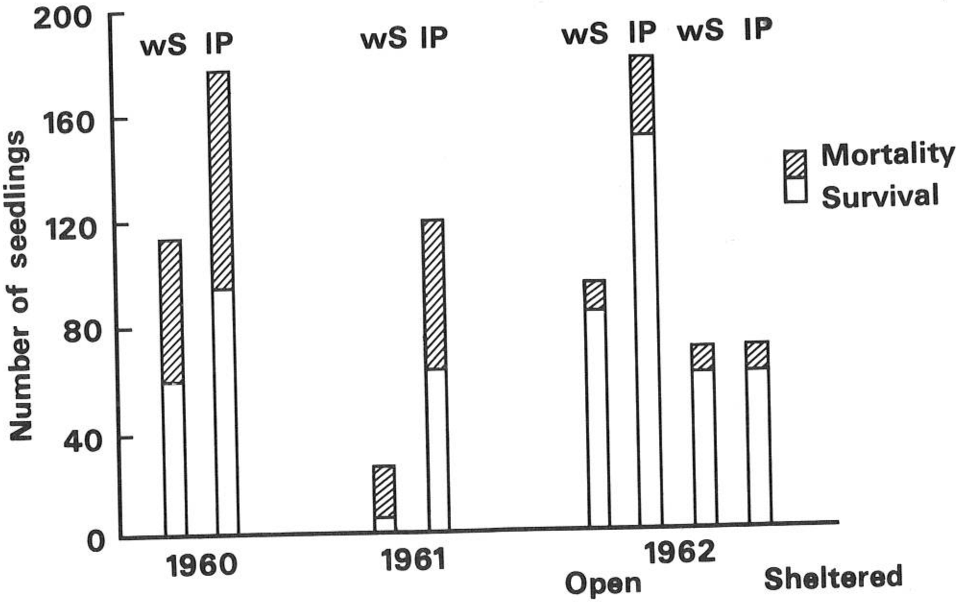

Figure 23. Seedling survival, Phytometer – Smith Location.

Reports *Unpublished (continued)*

Lees, J.C. 1962. The development of a phytometer method in the relationship of local climate and regeneration in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

Lees, J.C. 1963. The development of a phytometer method in the relationship of local climate and regeneration in the B.18a Section of Alberta. Dept. of Forestry of Canada, For. Res. Br.

Project A–75 Tolerance of white spruce seedlings to flooding.

Classification 424.2:231.321

Investigator Past: J.C. Lees

Objective To determine the tolerance of one- and two-year-old white spruce seedlings to various periods of immersion under controlled laboratory conditions.

Location Laboratory, Calgary District Office.

Work done One- and two-year-old white spruce seedlings growing in trays of standard potting mixture were immersed in water for periods of 3½, 7, 10½, and 14 days. There were 10 seedlings per tray and five trays for each immersion period. Mortality was noted at the end of each period and survivors were reimmersed after 8 days, for the same period until total mortality occured.

Results Tolerance of the seedlings to flooding is summarized in Table 16 where numbers of survivors and per cent survival is recorded.

Total mortality was the result of the 14-day immersion period, but a small percentage of seedlings survived the shorter periods and even the repeated immersions for 3½-day periods. Two-year-old seedlings were more tolerant of flooding than one-year-old seedlings.

TABLE 16

SURVIVAL OF WHITE SPRUCE SEEDLINGS FOR IMMERSION TREATMENTS

(Basis – 50 seedlings per treatment)

Immersion period	Seedling age			
	1-year-old		2-year-old	
	Number of survivors	Per cent survival	Number of survivors	Per cent survival
Control	47	94	45	90
3½ days	21	42	32	64
3½ days x 2	12	24	24	48
3½ days x 3	7	14	10	20
3½ days x 4	1	2	1	2
7 days	8	16	17	34
7 days x 2	–	–	–	–
10½ days	6	12	9	18
14 days	–	–	–	–

Comments The laboratory results support field observations of spruce seedling mortality on flooded scarified seedbeds on moist and wet sites in the mixedwood. They illustrate that seedling mortality from this cause is an important factor to consider when scarification is used in regeneration establishment.

Status Closed.

Report *Unpublished*

Lees, J.C. 1963. Tolerance of white spruce seedlings to flooding. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-A-2.

Published

Lees, J.C. 1964. Tolerance of white spruce seedlings to flooding. For. Chron. 40(2): 221-225.

Project MS-4 Thinning aspen polewood, Riding Mountain National Park.

Classification 242:561

Investigators Past: C.K. Smith, G.A. Steneker

Objective To study the effect of thinning on the growth rate of aspen and the influence of thinning on the ability of the trees to withstand fungus attack.

Location Sec. 1, Twp. 21, Rge. 20 in the Riding Mountain National Park, Manitoba.

Work done In 1926 three 1-acre sample plots were established in a 30-year-old trembling aspen stand. On one plot all suppressed and a few intermediate trees were removed, reducing the basal area by 14 per cent. On another plot all suppressed and intermediate trees were removed, reducing the basal area by 24 per cent. A third plot was retained as a control and not thinned. A subsequent thinning in 1940 removed suppressed, intermediate and diseased trees on the thinned plots and reduced the 1940 basal area of the plot thinned lightly in 1926 by 23 per cent, and the 1940 basal area of the more heavily thinned plot by 33 per cent. In 1926 before and after thinning, and in 1940, 1945, 1950 and 1960 all trees were tallied by one-inch diameter classes and height diameter curves were constructed for each plot.

Results Results to 1960 are shown in Tables 17 and 18.

Basal area and total volume in 1940 before the second thinning were greatest on the control plot and smallest on the heaviest thinned plot. This indicates that the first thinning removed somewhat more than the anticipated mortality (Table 17). Merchantable volume increased as a result of thinning. The thinned plots to 1940 produced a greater board foot volume than the control plot.

The subsequent thinning in 1940 resulted in lower basal areas and total volumes to 1960 on the thinned plots than on the control plots. The effect of thinning on merchantable volume in 1960 was small, and except for the moderately thinned plot difference in volumes was insignificant. The subsequent thinning was apparently not very effective in stimulating the growth of the residual trees. Increment of the largest trees over the period 1926–1940 was greater on the thinned plots than on the control (Table 18). Differences between thinned and control plots for the 1940–1960 period were smaller than those for the first period.

Total volume and board foot production to 1960 (volume in 1960 + thinnings) for the control, lightly thinned and more heavily thinned plots was 4,122, 4,468 and 3,992 cubic feet and 8,997, 10,966 and 9,057 board feet respectively. These figures show little difference in production between treatments.

The number and merchantable volume of all trees 9 inches d.b.h. and over are presented in Table 19. The light thinning resulted in 82% more merchantable volume than the control, and the heavy thinning resulted in 55 per cent more merchantable volume.

Status Closed.

Reports *Unpublished.*

Smith, C.K. 1951. Thinning aspen polewood, Riding Mountain. Canada, Dept. of Resources and Development, Forestry Branch.

Steneker, G.A. 1962. Thinning aspen polewood, Riding Mountain. Dept. of Forestry of Canada, For. Res. Br., Mimeo 62-MS-10.

Steneker, G.A. and J.M. Jarvis. 1963. Thinning in trembling aspen stands, Manitoba and Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-26.

TABLE 17 STAND STATISTICS PER ACRE – 1926, 1940 AND 1960

Treatment	No. of trees					Average d.b.h.		Dom. ht.	Basal area (sq. ft.)					Total volume (cu. ft.)					Merchantable volume (bd. ft.)				
	1926		1940		1960	1926		1926	1926		1940		1960	1926		1940		1960	1926		1940		1960
	BT	AT	BT	AT		BT	AT		BT	AT	BT	AT		BT	AT	BT	AT		BT	AT	BT	AT	
Control	1528	1528	767	767	500	3.6	3.6	59	112	112	117	117	145	2188	2188	2922	2922	4122	25	25	657	657	8997
14% BA cut	1549	1100	598	390	358	3.5	3.8	56	103	89	101	77	124	1931	1733	2587	2038	3721	–	–	1163	992	10795
24% BA cut	1704	948	575	322	262	3.4	4.0	55	110	84	100	67	99	1994	1684	2575	1787	2894	206	206	911	651	8797

TABLE 18 DIAMETER INCREMENT OF LARGEST TREES PER ACRE, 1926-1960

Treatment 1926	200 largest trees					50 largest trees					25 largest trees				
	d.b.h.			Increment		d.b.h.			Increment		d.b.h.			Increment	
	1926	1940	1960	26-40	40-60	1926	1940	1960	26-40	40-60	1926	1940	1960	26-40	40-60
Control	5.3	6.6	8.7	1.3	2.1	6.2	7.4	9.8	1.2	2.4	6.3	7.9	10.2	1.6	2.3
14% BA cut	5.0	6.8	9.0	1.8	2.2	5.7	7.7	10.4	2.0	2.7	6.0	8.1	10.9	2.1	2.8
24% BA cut	5.2	6.8	8.8	1.6	2.0	5.8	7.7	10.2	1.9	2.5	6.1	8.1	10.6	2.0	2.5

TABLE 19 NUMBER OF TREES AND MERCHANTABLE VOLUME OF TREES > 9" d.b.h. PER ACRE BY TREATMENT

Treatment	No. of trees	Merchantable volume (bd. ft.)
Control	35	2609
14% BA cut	57	4760
24% BA cut	52	4063

Project MS-5 Thinning aspen, Duck Mountain Forest Reserve, Manitoba.

Classification 242:561

Investigators Past: R.T. Pike

Objective To study the effect of thinning on diameter and height growth, yield in cubic feet, and fungus attack.

Location Duck Mountain Forest Reserve, North side of Sarah Lake. Sec. 23, Twp. 33, Rge. 28, W.P.M., Manitoba.

Work done In 1926 three sample plots, each 1 acre in size, were established in a 35-year-old aspen stand. From one plot all dead, dying and suppressed, and all intermediate trees, were removed, reducing the basal area by 36 per cent. From another plot all dead, dying, suppressed and poorer intermediates were removed, reducing the basal area by 30 per cent. A third plot was retained as control and not thinned. All trees living and dead, before and after thinning in 1926 and in 1946, were tallied to the nearest 1/10-inch.

Results Results to 1946 are shown in Tables 20 and 21.

Comments Up to 1946 the control plot supported the greatest total volume, although it differed little from the total volumes on the thinned plots. Total volume and merchantable volume production were increased as a result of thinning. Little difference existed in total and cordwood volume production between the thinned plots. However these plots were thinned to almost the same intensity in 1926. Board foot production, which is in effect an expression of the number of large sized trees in the stand was greater on the lightly thinned plot than on the heavily thinned plot even though diameter increment on the largest trees was greater on the latter. This suggests that initial tree size as well as thinning had an important influence on production.

Figures for total standing volume in 1946 for the three plots are quite comparable and indicate that little more than anticipated mortality to 1946 was removed in thinning.

Periodic net basal area increment differed little for the two thinned plots (Figure 24), but on the control plot it was much smaller as a result of mortality. The trend in Figure 24 indicates that basal area at an age of 35 years can be decreased at least to 65 square feet without a loss in basal area increment due to inadequate use of the site.

Plots were scheduled for remeasurement in 1960 but one was destroyed, making further comparison between treatments impossible. As thinning in 1926 only removed anticipated mortality (see under "work done") it is likely that total and merchantable volume production between plots will differ little at rotation age (about 80 years). Possibly the effect of thinning was most noticeable in 1946. With succeeding years the effect on merchantable volume production by fewer but larger trees on the thinned plots will likely be more than counterbalanced by the greater number (although somewhat smaller sized) of trees on the control plot.

Status Closed.

Reports *Unpublished*

Pike, R.T. 1952. Thinning aspen, Duck Mountain Forest Reserve, Manitoba. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div.

Steneker, G.A. and J.M. Jarvis. 1963. Thinning in trembling aspen stands, Manitoba and Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-26.

TABLE 20 STAND STATISTICS PER ACRE – 1926 AND 1946

Treatment	No. of trees			Average d.b.h.		Dom. ht.	Basal area (sq.ft.)			Total volume (cu.ft.)			Merchantable volume						Production (vol. 1946 + thinning)		
													Cords			Bd. ft.					
	1926 BT	1926 AT	1946	1926 BT	1926 AT	1926	1926 BT	1926 AT	1946	1926 BT	1926 AT	1946	1926 BT	1926 AT	1946	1926 BT	1926 AT	1946	cu.ft.	cords	bd.ft.
Control	1872	1872	630	3.2	3.2	46	106	106	114	2197	2197	3020	15	15	34	154	154	2688	3020	24	2688
30% BA cut	1720	775	458	3.4	4.2	46	106	74	104	2249	1690	2915	17	16	35	94	94	3698	3474	36	3698
36% BA cut	1884	741	451	3.2	4.0	45	102	65	99	2143	1345	2825	14	12	34	53	53	3116	3023	36	3116

TABLE 21 DIAMETER INCREMENT OF THE 200, 50 AND 25 LARGEST TREES PER ACRE, 1926–1946

Treatment	200 largest trees			50 largest trees			25 largest trees		
	d.b.h.		Increment	d.b.h.		Increment	d.b.h.		Increment
	1926	1946		1926	1946		1926	1946	
Control	5.5	7.5	2.0	6.6	8.9	2.3	7.2	9.6	2.4
30% BA cut	5.5	7.8	2.3	6.5	9.1	2.6	7.0	9.7	2.7
36% BA cut	5.0	7.6	2.6	5.9	9.1	3.2	6.4	9.7	3.3

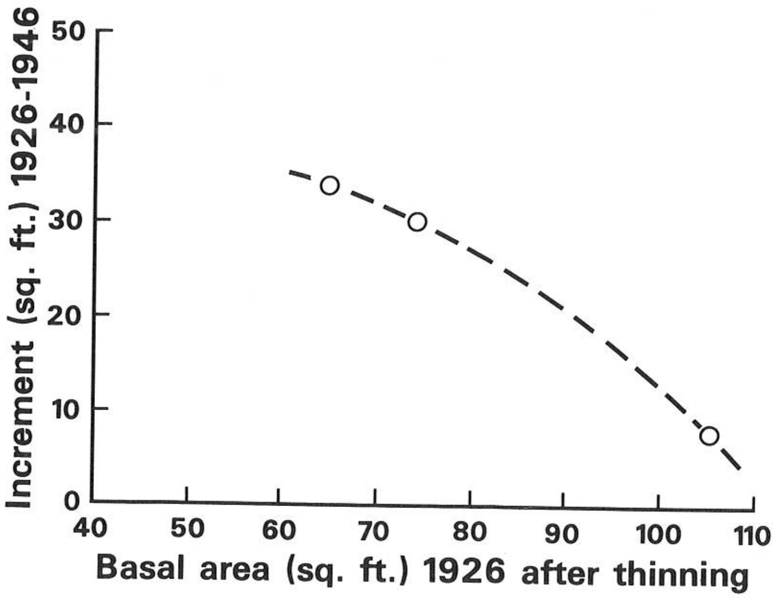

Figure 24. Periodic net basal area increment (1926-1946) related to basal area in 1926 after thinning.

Reports

Published

Pike, R.T. 1953. Thinning aspen, Duck Mountain Forest Reserve, Manitoba. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div., Silv. Leaflet No. 89.

Project MS-6 Thinning in aspen, Duck Mountain Forest Reserve.

Classification 242:561

Investigators Past: R.T. Pike.

Objective To determine the degree of thinning necessary to produce merchantable poplar in the shortest number of years.

Location Duck Mountain Forest Reserve, Manitoba. Sec. 4, Twp. 30, Rge. 24, W.P.M.

Work done In 1937 three 1/2-acre sample plots were established in a 50-year-old aspen stand. From one plot 25 per cent of the basal area was removed in thinning, from the second 50 per cent; the third plot was retained as a control. Thinning was from below. In 1946 the plots were remeasured.

Results Results to 1946 are given in Tables 22 and 23, Figure 25.

Comments Diameter increment was increased as a result of thinning (Table 22). On the heavier thinned plot the diameter increment of the 200, 50 and 25 largest trees was more than doubled. Total volume (cu. ft.) and merchantable volume (cords) production to 1946 were greatest on the control plot, poorest on the lightly thinned plot and intermediate on the heavily thinned plot (Table 23). Board foot production was greatest on the heavily thinned plot, smallest on the lightly thinned plot, and intermediate on the control.

It is difficult to say how much of the difference in production to 1946 is due to the treatment. Average tree size in 1937 before thinning ranged between 4.6 and 5.0 inches for the three plots. The low board foot volume of the lightly thinned plot may be a reflection of the initial small size of the trees. On all plots a loss in net basal area and volume increment occurred. This loss was greatest on the control plot and smallest on the lightly thinned plot (Figure 25).

Regarding only the increment values of plots relative to each other (i.e. disregarding the negative values) it would seem that with a basal area around 90 sq. ft. the greatest increment can be expected. With lower basal areas losses can be expected due to inadequate stocking; with higher basal area losses due to mortality can be expected.

Status Closed.

Reports *Unpublished.*

Pike, R.T. 1947. Thinning in aspen, Duck Mountain Forest Reserve, Manitoba. Canada, Dept. of Mines and Resources, Lands, Parks and Forests Branch.

Steneker, G.A. and J.M. Jarvis. 1963. Thinning in trembling aspen stands, Manitoba and Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-26.

TABLE 22 DIAMETER INCREMENT OF LARGEST TREES PER ACRE, 1937-1946

Treatment	Basal area AT 1937	200 largest trees in 1946			50 largest trees in 1946			25 largest trees in 1946		
		Average d.b.h.		Increment	Average d.b.h.		Increment	Average d.b.h.		Increment
		1937	1946		1937	1946		1937	1946	
Control	137	6.5	7.0	.5	7.3	7.9	.6	7.5	8.2	.7
25 % BA cut	88	5.8	6.5	.7	6.6	7.5	.9	6.9	7.8	.9
50% BA cut	62	6.2	7.4	1.2	7.3	8.9	1.6	7.5	9.3	1.8

TABLE 23 STAND STATISTICS PER ACRE, 1937 AND 1946

Treatment	No. of trees			Average d.b.h.		Dom. ht.	Basal area (sq. ft.)			Total volume (cu. ft.)			Merchantable volume						Total production (volume 1946 + thinning)		
													Cords			bd. ft.					
	1937 BT	1937 AT	1946	1937 BT	1937 AT	1937	1937 BT	1937 AT	1946	1937 BT	1937 AT	1946	1937 BT	1937 AT	1946	1937 BT	1937 AT	1946	cu. ft.	Cords	bd. ft.
Control	1086	1086	676	4.8	4.8	55	137	137	119	3213	3213	2944	37	37	39	183	183	859	2944	39	859
25% BA cut	1046	680	502	4.6	4.9	49	118	88	86	2534	1950	1897	30	24	25	101	101	363	2481	31	363
50% BA cut	904	336	224	5.0	5.8	56	124	62	55	2832	1512	1308	36	20	16	431	431	1386	2628	32	1386

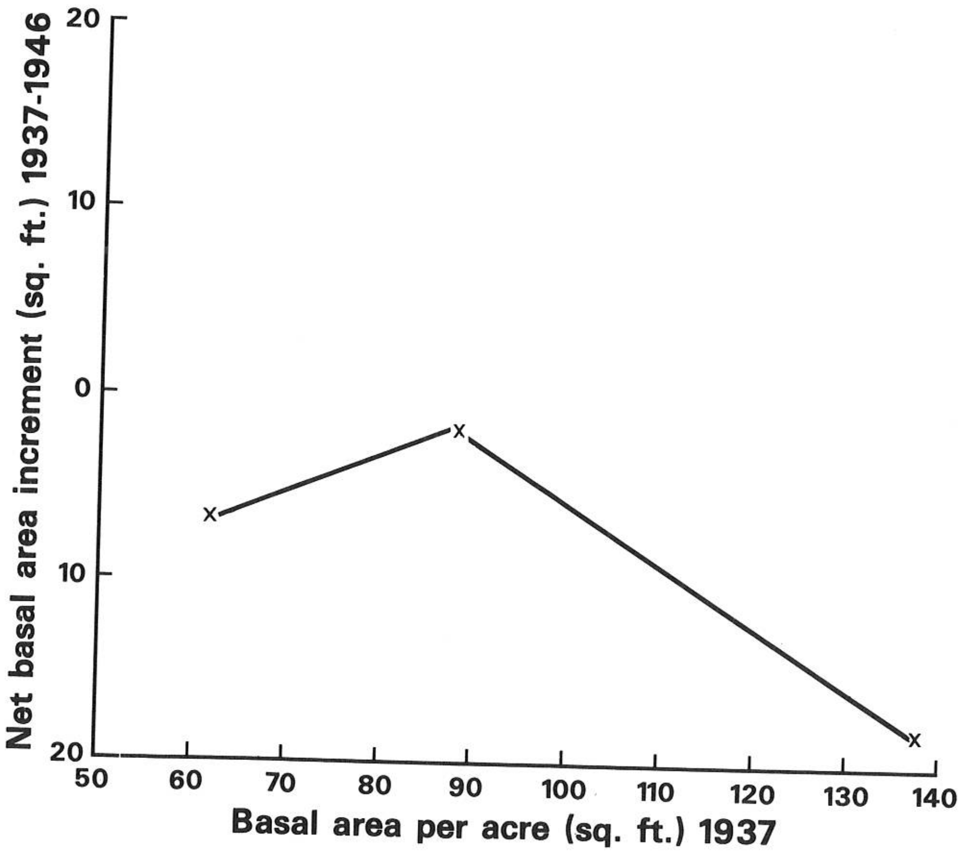

Figure 25. Net basal area increment (1937-1946) related to basal area after thinning in 1937 -- per acre.

Project MS-8	Thinning in second growth mixedwood stands, Duck Mountain Forest Reserve.
Classification	242:243
Investigator	Past: R.T. Pike, R.M. Waldron Present: G.A. Steneker
Objective	To determine whether thinning, to favour white spruce, will result in greater total (cu. ft.) and merchantable (bd. ft.) volume yields of the white spruce.
Location	The experimental area is located east of Singoosh Lake in the Duck Mountain Forest Reserve, Manitoba, Twp. 30, Rge. 27, Sec. 24.
Work done	In 1936 three 1/4-acre permanent sample plots were established in a 50-year-old mixedwood stand. Hardwoods formed the overstorey, softwoods the understorey. Trembling aspen and white spruce comprised 80% of the stand (by number of trees); black spruce, jack pine, balsam poplar, and white birch made up the remainder. On one sample plot 43 per cent of the total basal area was removed in thinning and on the other 60 per cent. The third sample plot was retained as control (no cutting). During the thinning, white spruce and black spruce, in that order, were favoured. Remeasurements have been made at 10-year intervals.
Results	Results are summarized in Tables 24 and 25.
Comments	The thinning, which was essentially a release cutting, has been successful in stimulating the growth of white spruce. Because of great variations in the stand structure and composition of spruce-aspen stands in the Mixedwood Forest Section, prescriptions for releasing spruce are difficult to prescribe. In some instances as little as 40 per cent, and in others as much as 100 per cent of the competitors might have to be removed. In any event release should be given before the spruce crowns have reached those of the overstorey aspen.
Status	A subsequent thinning to remove the remaining hardwoods is anticipated.
Reports	*Unpublished*

Pike R.T. 1948. Thinning in second growth mixedwood stands Duck Mountain Forest Reserve. Canada, Dept. of Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv.

Waldron, R.M. 1958. Thinning in second growth mixedwood stands Duck Mountain Forest Reserve. Canada, Dept. Northern Affairs and National Resources, For. Br. For. Res. Div.

Steneker, G.A. 1961. Thinning in second growth mixedwood stands Duck Mountain Forest Reserve. Dept. of Forestry of Canada, For. Res. Br.

Reports *Published*

Steneker, G.A. 1963. Results of a 1936 release cutting to favour white spruce in a 50-year-old white spruce-aspen stand in Manitoba. Dept. of Forestry of Canada, Publication No. 1005.

TABLE 24 CUBIC FOOT, BOARD FOOT VOLUMES IN 1936 AND 1957 BY STAND COMPONENTS AND TREATMENTS

Control Plot

Species	Total volume (cu. ft.)		Merchantable volume (bd. ft.)	
	1936	1957	1936	1957
White spruce	398	845	212	1510
Other softwoods	643	908	844	2438
Hardwoods	2750	3045	863	4092
Total	3791	4798	1919	8040

Lightly thinned plot (43% basal area removed)

Species	Total volume (cu. ft.)			Merchantable volume (bd. ft.)		
	1936		1957	1936		1957
	BT	AT		BT	AT	
White spruce	504	480	1439	–	–	2602
Other softwoods	680	326	544	528	312	1665
Hardwoods	2244	1105	1258	408	75	1346
Total	3428	1911	3241	936	387	5613

Heavily thinned plot (60% basal area removed)

Species	Total volume (cu. ft.)			Merchantable volume (bd. ft.)		
	1936		1957	1936		1957
	BT	AT		BT	AT	
White spruce	430	356	1502	–	–	4230
Other softwoods	488	193	551	264	102	1120
Hardwoods	3204	912	929	3752	822	2830
Total	4122	1461	2982	4016	924	8180

TABLE 25 NUMBER OF TREES PER ACRE, AVERAGE DIAMETER AT BREAST HEIGHT, AND AVERAGE HEIGHT, WHITE SPRUCE, 1936 AFTER THINNING, AND 1957, BY TREATMENT

Treatment	1936 (after thinning)			1957		
	No./acre	Average d.b.h. (in.)	Average height (ft.)	No./acre	Average d.b.h. (in.)	Average height (ft.)
Control (no cutting)	276	4.2	29	248	5.7	37
Light thinning (43% basal area removed)	376	3.9	29	320	6.3	43
Heavy thinning (60% basal area removed)	264	4.1	29	212	7.7	47

Project MS-37 Reproduction after cutting by shelterwood and seed-tree system in mixedwood stands in Manitoba Highlands.

Classification 231.31:221.02:221.21

Investigator Past: G.H.D. Bedell

Objective To determine the relative value of shelterwood and seed-tree systems in securing reproduction after logging mixed stands of spruce and intolerant hardwoods.

Location Duck Mountain Forest Reserve, Manitoba.

Work done During July and August 1947 a survey was carried out on areas in the Duck Mountain which had been logged between 1935 and 1940 by the shelterwood and seed-tree methods. Strips were run at 4-chain intervals and four milliacre quadrats were established at the end of each chain. A tally was made on every quadrat by species of the largest stem which had become established since logging and the largest stem which had originated prior to logging.

Results Regeneration results are given in Table 26.

TABLE 26 PER CENT QUADRATS STOCKED, 1947

Stands	White spruce only	All species
	Shelterwood cut	
1	21.0	52.6
2	5.3	34.6
3	13.7	46.2
4	13.2	70.3
5	7.7	49.1
6	3.3	39.1
7	10.7	46.3
8	9.8	41.1
18	0.6	81.4
19	5.0	78.8
	Spruce seed-tree cut	
9	1.0	44.6
10	0.5	85.5
11	0	76.8
12	0	66.0
13	1.6	63.3
14	1.1	61.1
15	2.5	48.9
16	0.4	39.2
17	0.6	58.4

Comments Stocking, including all species, was considered satisfactory after cutting by either the shelterwood or seed-tree method. Spruce regeneration was sparse over a large portion of the seed-tree area.

Although the cutting methods employed have apparently had some influence on the amount of regeneration obtained, canopy manipulation alone will not result in adequate spruce regeneration. Observations indicated that seedbed preparation, exposing mineral soil, would be necessary to obtain adequate regeneration.

Status Closed.

Reports *Published*

Bedell, G.H.D. 1948. White spruce reproduction in Manitoba. Canada, Dept. Mines & Resources. Mines, Forests and Scientific Services Branch, Dominion Forest Service, Silv. Res. Note 87.

Project MS-56 Seed crop – Manitoba and Saskatchewan

Classification 181.523

Investigators Past: J.S. Rowe, C.C. Thomson

Objective To gain some understanding of the periodicity of heavy seed production of white spruce to assist in the planning of future seed collections, and in the choosing of suitable periods for experimental work on regeneration by natural seeding.

Location Various ranger districts throughout Manitoba and Saskatchewan.

Work done From 1923 to 1930 inclusive, and again from 1946 to 1955, provincial service field staff and Manitoba-Saskatchewan District field officers submitted "Annual Seed Crop Reports" to the District Office. These reports were based on observations made in white spruce and white spruce-aspen stands within Ranger Districts. Seed crop estimates for white spruce were indirectly determined by estimating cone crop abundance using the following scale:

Nil
Light
Medium
Heavy
Very heavy

Results

TABLE 27 SUMMARY OF WHITE SPRUCE SEED CROP REPORTS FROM VARIOUS PLACES IN THE B.18a FOREST SECTION IN MANITOBA AND SASKATCHEWAN 1923–1955

Description of cone crop	Frequencies of cone-crop description by years																		
	1923	1924	1925	1926	1927	1928	1929	1930		1946	1947	1948	1949*	1950	1951	1952	1953	1954	1955
Nil...........	–	1	–	–	1	5	–	–	No reports	–	1	–	No reports	8	3	2	4	1	–
Light	5	7	5	5	2	3	1	5		2	8	–		8	11	11	13	4	7
Medium	4	3	9	5	5	–	3	–		1	6	5		13	14	–	12	9	11
Heavy or very heavy	1	–	3	2	2	–	3	–		–	–	15		3	12	4	6	15	13
Approx. average	L-M	L	M	L-M	M	N	M-H	L-M		?	L-M	H		L-M	M	L	L-M	H	M-H

*No crop at the Riding Mountain Forest Experimental Area.

Comments Seed crop estimates within a given year varied widely between the ranger districts. However over the entire B.18a Forest Section there generally was a grouping around one or two of the seed crop estimate classes.

For the years reported, medium or heavy crops occurred on the average once every two years while nil and light crops occurred once every five years. Light to medium crops occurred in the intervals.

Status Closed. Similar data using a revised cone crop report form are now collected under project MS-158 (Study 1).

Reports *Unpublished*

Rowe, J.S. 1956. The periodicity dissemination and amount of white spruce seed. Canada, Dept. of Northern Affairs and Natural Resources, For. Br., For. Res. Div.

Thomson, C.C. 1958. Seed crop – Manitoba and Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-30.

Project MS-60 Cutting methods for the management of white spruce, Carrot River Experimental Area.

Classification 231.31

Investigators Past: J.D.B. Harrison, V.H. Phelps, A.L. Best, R.T. Pike, J.S. Rowe, R.M. Waldron.

Objective To study the effects of different methods of cutting on the abundance of white spruce reproduction.

Location Approximately 40 miles southwest of The Pas, Manitoba on the northeast slope of the Pasquia Hills.

Work done In 1924 diameter-limit, seed-tree and strip cuttings were made in a mixedwood stand on the Pasquia Hills in Saskatchewan. Cutting was done on nine 10-acre compartments. Trees were tallied by species and 1-inch diameter classes on 4 permanently established strips, 1/2 x 10 chains, on each compartment. On each strip two single examination plots, each 1/160 acres in size, spaced 5 chains apart, were examined for seedlings and saplings.

In 1925 five permanent sample plots, each 1/10-acre in size, were established on each compartment. All saplings and trees were tallied by species and 1-inch diameter classes. Also on each compartment two 1/60-acre plots were established and on them all reproduction was tallied by species, age and height.

All plots, strips and reproduction plots were remeasured in 1929, 1936, 1946 and 1956.

Results Results are summarized in Table 28.

Comments It appears as though the treated compartments will become as well stocked as they were before logging. It was estimated that during the logging operation seedbeds, covering about one-third the surface area of each compartment, were made inadvertently by skidding and by burning slash. The abundance of white spruce regeneration is perhaps the result of these seedbeds and the fact that there was an exceptionally heavy seed crop in 1924.
Balsam fir is abundant in the seedling class but severe browsing has prevented development into trees. Aspen has passed from the stands and most of the hardwoods in the area are white birch.

Status Closed.

Reports *Unpublished*

Phelps, V.H. 1946. Carrot River Experimental Area. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Forest Service.

Townsend, P.B. 1947. Carrot River Experimental Area. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Forest Service.

Waldron, R.M. 1957. Cutting methods for management of white spruce. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Published

Waldron, R.M. 1959. Experimental cutting in a mixedwood stand in Saskatchewan, 1924. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note No. 74.

Compartment	Treatment	White spruce						Balsam fir				Hardwoods			
		1924	1956					1924	1956			1924	1956		
		before logging 4''d.b.h.+	Residuals from 1925 4''d.b.h.+	Replacement stock*	Seedlings+			before logging 4''d.b.h.+	Residuals from 1925 4''d.b.h.+	Replacement stock*	Seedlings up to 0.5'' d.b.h.	before logging 4''d.b.h.+	Residuals from 1925 4''d.b.h.+	Replacement stock*	Suckers up to 0.5'' d.b.h.
					A	B	C								
1	All spruce down to 12-inch d.b.h. cut. ..	90	20	65	—	25	105	40	20	—	2750	150	50	35	—
2	All spruce down to 10-inch d.b.h. cut. ..	120	30	140	80	25	270	45	25	—	3350	155	50	95	—
3	All spruce down to 7-inch d.b.h. cut. ..	90	30	150	30	—	60	25	15	—	3500	145	40	105	—
4	Spruce seed trees left at 200-foot intervals, rest logged to 10-inch d.b.h. ..	110	40	80	—	—	165	35	15	—	6950	135	45	130	—
5	Spruce seed trees left at 100-foot intervals, rest logged to 10-inch d.b.h. ..	90	20	115	125	30	140	60	60	—	6250	140	70	135	—
6	Spruce seed trees left at 200-foot intervals, rest logged to 10-inch d.b.h., hardwoods girdled.	120	25	95	30	15	85	55	5	—	2150	155	10	615	—
7	Spruce seed trees left at 100-foot intervals, rest logged to 10-inch d.b.h., hardwoods & balsam fir clear cut. ...	110	30	100	80	10	210	10	—	—	800	140	—	705	50
8	Alternate strips 100 feet wide logged for spruce to 10-inch diameter limit.	105	25	100	190	10	105	85	65	5	5000	145	65	65	—
9	No cutting	100	40	35	170	—	85	20	15	—	1400	155	50	20	—

*Replacement stock -- those stems that entered the 1-inch and up diameter classes between 1925 and 1956.
+A = seedlings up to 0.5 feet tall, B = seedlings from 0.6 to 3.0 feet tall and C = seedlings from 3.1 feet tall to 0.5 inches d.b.h.

Project MS-69 Rate of growth survey, Riding Mountain Forest Experimental Area.*

Classification 114.32:114.4:561:562:568

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

Present: I.E. Bella

Objective To obtain information on forest conditions within the Riding Mountain Forest Experimental Area; to follow stand development, and to classify and map the forest cover types, sub types and sites.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done From 1946 to 1948 a grid of 1/10-acre plots spaced at 10-chain intervals was established and measured. Between 1956 and 1958 these plots were remeasured; at the same time soil moisture regime, pore pattern, vegetation, and soil type were described for each plot. In 1961 the cover types, sub types, height classes and density classes were mapped. In 1962 a site classification was drawn up based on the data and on previous work (MS-168). Land types and sites were mapped from air photos (scale 1:31,680 and 1:15,840).

Results Tables 29 to 31 give pertinent data on the distribution of the land types and site types, and on height and volume by sites for specific cover types, height and density classes.

TABLE 29 LAND TYPES, RIDING MOUNTAIN FOREST EXPERIMENTAL AREA

Land type	Description
I	Strongly to moderately rolling, moderately calcareous clay loam till, fresh to moderately moist sites predominate.
II	Moderately and gently undulating to smooth and almost flat, slightly calcareous clay loam till to shaly clay till and shallow lacustrine clay, moist to very moist sites predominate.
III	Smooth and flat to gently undulating, a complex of sandy gravelly stratified deposits and water-worked loamy tills, dry to fresh sites predominate.
IV	Flat depressional organic terrain, very moist to very wet.

Comments Stands are over-mature; the aspen component is largely 100 to 120 years of age and the trees are decadent; the white spruce is all-aged and thrifty. Basal area is lowest in pure aspen stands and increases with increasing spruce content. Total volumes for all sites are quite similar. For the softwood type the moist B site appears to be somewhat more productive than the fresh A site. This is contradictory to results for MS-183 and A-29.

Status Continuing.

Reports *Unpublished*

Johnson, H.J. 1957. Rate of growth survey Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

*Project summary prepared by J.S. Jameson.

TABLE 30 FOREST SITES, RIDING MOUNTAIN FOREST EXPERIMENTAL AREA AND BASIC PRODUCTIVITY DATA

Site	Moisture	Moisture regime	Soil texture and origin	Basal area* (mean)		Total volume (mean)		Height of wS at 80 years
				H/S+	S(wS)+	H/S+	S(wS)+	
A	Fresh	2-4 3	Loam to clay loam till	100.3	98.8	2652	2541	81
B	Moist	4-5	Loam to clay loam till and lacustrine	97.4	113.0	2518	2847	75
C	Very moist	6	Loam to clay till, water washed till and lacustrine	97.4	111.9	2418	2646	70
D	Moderately fresh	1-2	Sandy loam outwash and shallow lacustrine	No data		No data		80 (levels off)
F	Dry	0-1	Gravelly loam, bouldery clay loam alluvial, outwash & till	93.7	85.5	2250	2020	70
G	Wet	6+	Organic muck and peat (forested)	No data	61.8	No data	1500	70
H	Wet	6+	Organic muck and peat (non forested)	--	--	--	--	--

* Data for height class 3 — 56-95' and density class 2 — 36-65%.

+ H/S Hardwood-softwood cover type; S(wS) Softwood cover type, white spruce sub-type.

TABLE 31 AREA SUMMARY (ACRES) LAND TYPES AND SITES RIDING MOUNTAIN FOREST EXPERIMENTAL AREA

Land type	Site							
	A	B	C	D	F	G	H	Total
I	5,424.9	1,369.7	281.0	16.5	48.9	46.1	90.7	7,277.8
II	165.0	3,170.1	1,308.6	0	26.1	121.5	121.0	4,912.3
III	930.4	154.5	28.7	25.2	1,164.5	13.3	24.7	2,341.3
IV	6.8	28.2	291.6	13.2	0	864.4	486.3	1,690.5
Total								16,221.9

Reports *Unpublished (continued)*

Johnson, H.J. 1958. Rate of growth survey Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Jameson, J.S. 1959, Rate of growth survey Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

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

Classification 232.33:451.2

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

Objective To determine whether well stocked stands of jack pine and white spruce could be obtained by seeding on mineral soil seedbeds and to compare the development of jack pine and white spruce on the same site.

Location Duck Mountain Forest Reserve, Manitoba.

History In May 1920, six 1/4-acre plots were established on a moderately fresh sandy clay loam soil. Trees and brush on the plots were removed, then the plots were thoroughly disked (6 times) to provide a mineral soil seedbed. Three plots were sown with varying amounts of jack pine and three others with varying amounts of white spruce. Plots were remeasured 7 times, the last remeasurement being in 1957.

Results Survival and development results are recorded in Table 32.

TABLE 32 SURVIVAL AND DEVELOPMENT

Plot	Species	Seed sown (lbs./acre)	Survival (seedlings/acre)			Development	
						Av. d.b.h. (inches)	Av. ht. (feet)
			1921	1923	1957	1957	1957
1	jP	2	43,560	4,840	20	3.1	21.0
2	jP	3	12,000	4,840	0	–	–
3	jP	4	20,000	4,840	0	–	–
4	wS	1	0	21,000	5,000	2.3	18.8
5	wS	2	few	21,000	3,420	2.5	21.6
6	wS	3	0	21,000	4,760	2.4	23.4

Comments Initial establishment of both species was good but there was no correlation with the amount of seed sown. Jack pine was virtually eliminated between 1929 and 1946 chiefly because of rabbit browsing. For the first 26 years after the plots were sown, both species grew slowly but from 1946 to 1957 spruce growth was normal. In 1957 white spruce trees appeared to be healthy but were in need of thinning.

These results suggest that white spruce and jack pine can be established on moderately fresh sandy clay loam soils by seeding on well prepared seedbeds. Once established, it would appear that white spruce can maintain adequate stocking despite biological hazards. Measures should be undertaken to protect jack pine seedlings from rabbits.

Status Closed.

Reports *Unpublished*

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

Townsend, P.G. 1948. Artificial seeding and planting. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dominion Forest Service.

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

Published

Haig, R.A. 1959. Results of an experimental seeding in 1920 of white spruce and jack pine in western Manitoba. For. Chron. 35(1):5-12.

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-109 ” ” ” , Beaver Hills Forest Reserve MS-110 ” ” ” , Big River Forest Reserve MS-111 ” ” ” , Dundurn Forest Reserve
Classification	232.4:451.2:422.2:441
Investigators	Past: H.J. Johnson
Objective	To determine the feasibility of afforestation and reforestation on the various Reserves.

Location

The Keppel, Elbow, and Dundurn Forest Reserves are located in the Grassland Region of Canada which is characterized by low rainfall and high summer temperatures. The Pines, Nisbet, and Big River Reserves are located in the Boreal Forest Region where rainfall is somewhat greater and summer temperatures are somewhat lower. The Beaver Hills Reserve is in the Aspen Grove Region where the climate is intermediate between the order two Regions. All are located in the province of Saskatchewan.

Planting sites on the Pines, Nisbet, and Dundurn Reserves were dry sands; underbrush was scarce; in the first two Reserves ground vegetation was characterized by ericaceous plants, but on the latter grass was dominant. Planting sites in the Big River, Beaver Hills, Elbow, and Keppel Reserves were mainly mesic loams characterized by more luxuriant underbrush and ground plants.

Work done

From 1934 to 1946 several plantations were established by the Saskatchewan Forest Service. Three planting methods were used: hole, T-notch, and T-notch in furrows. When the latter two were used a preliminary scalping treatment was usually made. Species planted were jack pine, Scots pine, white spruce, lodgepole pine, pitch pine and ponderosa pine. Age of planting stock varied from year to year. In 1948 a survey was made of these plantations. One-half-acre plots were established in each plantation and the diameter and height of all living trees on each plot were recorded.

Results

Survival and growth of the white spruce plantations to 1948 is shown in Table 33. The number of plantations (all species) having more than 150 trees per acre in 1948 is shown in Table 34.

Comments

Seedling survival and growth has been poor in most plantations. Drought, heat and poor planting are reported to have been the major factors causing mortality. Rabbit browsing has been severe, especially in those plantations where suitable cover was provided from predators. Plantations adjacent to or under aspen stands suffered repeated attacks. A profuse growth of minor vegetation, especially on the mesic loam sites, also contributed towards much of the mortality. Ground fires destroyed all of the plantations in the Nisbet Reserve and did some damage in others.

Observations indicate that:

(1) Jack pine could probably be used successfully to restock the Pines, Nisbet and Dundurn Reserves, providing adequate fire and rabbit control could be maintained.

(2) White spruce could be established successfully in the Keppel, Big River, Elbow,

TABLE 33 SURVIVAL AND GROWTH OF WHITE SPRUCE TO 1948

Number of plantations	Age of stock	Number planted per acre	Average number years since planting	Number per acre surviving to 1948	Per cent survival	Fifty tallest trees: Av. ht. (ft.)	Fifty tallest trees: Av. diam. (in.)
			Keppel Forest Reserve				
4	2-3, 3-2	1,210	8	546	45	1.5	–
2	4-0	1,210	6	–	–	–	–
9	2-2	1,210	14	321	27	6	.8
3	2-2	1,210	12	–	–	–	–
13	3-2, 4-1	1,210	5	76	6	–	–
12	3-2	1,058	2	62	6	–	–
			Elbow Forest Reserve				
1	3-2	2,700	32	78	3	7	3.0
			Dundurn Forest Reserve				
1	2-0	2,700	24	30	1	–	–
			Pines Forest Reserve				
2	2-0	2,700	31	432	16	9	1.3
2	2-0	1,350	30	13	1	–	.9
1	1-1	2,700	29	–	–	–	–
1	4-0	2,700	26	–	–	–	0
			Big River Forest Reserve				
4	2-1	2,700	22	505	19	9	1.5
1	2-2	800	20	92	11	3	–
1	2-2	1,100	19	–	–	–	–
			Beaver Hills Forest Reserve				
1	3-3	2,700	31	384	14	9	1.2
1	2-1	2,700	26	–	–	–	–

TABLE 34 PLANTATIONS WITH ONE HUNDRED AND FIFTY OR MORE TREES PER ACRE, 1948

Forest Reserve	Species	Plantations		
		Total number	Number with 150 or more trees/acre	Per cent with 150 or more trees/acre
Pines	Jack pine	7	6	85.7
	Scots pine	5	2	40.0
	White spruce	6	2	33.3
	Lodgepole pine	1	1	100.0
	Pitch pine	1	–	–
	Ponderosa pine	1	–	–
Big River	White spruce	6	3	50.0
	Jack pine	2	1	50.0
Dundurn	Jack pine	9	3	33.3
	Scots pine	3	2	66.7
	White spruce	1	–	–
Elbow	Jack pine	4	–	–
	White spruce	1	–	–
	Scots pine	2	1	50.0
Beaver Hills	White spruce	2	1	50.0
Keppel	White spruce	43	16	37.2
	Jack pine	6	–	–
	Lodgepole pine	6	–	–
	Scots pine	6	–	–
All		122	38	31.2

and Beaver Hills Reserves if provisions are made to relieve seedlings from competition and to control rabbits.

Status Closed

Reports *Unpublished*

Johnson, H.J. 1953. Reforestation of Forest Reserves of Saskatchewan. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div., S. & M. 53-5.

Project MS-103 Reforestation by planting, Duck Mountain Forest Reserve.

MS-104 Reforestation by planting, Riding Mountain.

Classification 232.4:451.2:422.2:441

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

Objective To determine on what sites and under what conditions plantations of white spruce, jack pine, Scots pine, and Siberian larch could be established successfully.

Location The Duck Mountain Forest Reserve and the Riding Mountain National Park.

Work done Between 1918 and 1930, several coniferous plantations were set out in the Riding Mountain National Park and in the Duck Mountain Forest Reserve. Planting was done by hand usually without previous ground preparation. However in some instances seedlings were set out in ploughed furrows. At the Riding Mountain about 1/3 of the plantations were established on a dry sandy outwash plain occupied by typical prairie vegetation. The remainder were set out on fresh to moist clay loam tills that had been clear cut for poplar cordwood a year or two prior to planting.

At the Duck Mountain, plantations were established on fresh to moist clay loam tills. At the time of planting most sites supported herbs and grasses although a few supported fairly dense young aspen stands.

In 1957 all surviving plantations were surveyed; 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 are shown in Tables 35 and 36.

Comments The percentages of "surviving" and "successful" plantations were low. However the results for the Duck Mountain were better than those for the Riding Mountain. This is attributed to the fact that the plantations at the Duck Mountain were on fresh to moist clay loams whereas many of those at the Riding Mountain were on dry sands. At the Riding Mountain mortality on the dry sands was attributed to drought; on the clay loams suppression by aspen and/or hazel, coupled with browsing by rabbits, accounted for most of the mortality. Observations indicated that at the Duck Mountain competition from aspen and brush was much less intense. With the exception of one area on the Duck Mountain where the aspen overstorey was clear cut 20 years after the plantations were established, all plantations established under aspen stands were failures. With few exceptions the white spruce plantations grew slowly. Neither survival nor growth showed much correlation with planting method (in furrows or not in furrows).

Status Closed.

Reports *Unpublished.*

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

Townsend, P.B. 1948. Artificial seeding and planting. Canada, Dept. of Mines and Resources, Lands, Parks and Forests Branch, Dominion Forest Service.

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

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

TABLE 35 PLANTATION ESTABLISHMENT AND SURVIVAL

Location	Species	Number plantations established	Surviving plantations 1957		Successful plantations* 1957	
			No.	Per cent	No.	Per cent
Riding Mountain	White spruce	31	8	26	2	6
	Jack pine	12	1	8	0	0
	Scots pine	3	1	33	0	0
	Larch	2	0	0	0	0
	Total	48	10	21	2	4
Duck Mountain	White spruce	18	8	44	7	39
	Jack pine	7	3	43	1	14
	Scots pine	1	1	100	1	100
	Total............	26	12	46	9	35

*Successful plantations were defined as those with 350 trees per acre. The figure 350 was arbitrarily chosen.

TABLE 36 GROWTH OF WHITE SPRUCE PLANTATIONS

Plantation number	Time since planting (years)	Trees/acre	Average d.b.h. (inches)	Average height (feet)
		Riding Mountain		
4-18	40	91	7.2	39.2
66-27	31	368	4.5	22.2
67-27	31	377	5.4	24.6
68-28	30	87	5.4	19.9
69-28	30	89	5.3	21.6
79-29	29	24	3.3	–
80-29	29	32	4.5	18.2
87-30	28	158	4.6	20.4
		Duck Mountain		
7-20	38	1,228	2.5	16.2
24-24	34	1,190	2.3	16.9
35-25	33	1,137	2.7	16.6
36-25	33	875	2.4	–
37-25	32	1,053	2.9	18.9
38-25	32	500	–	–
42-27	31	108	–	5.1
39-25	32	843	4.5	33.4

Reports *Unpublished (continued)*

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.

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

Classification 232.4:451.2:441

Investigators Past: R.A. Haig.

Objective To determine the best species and method of planting for large-scale reforestation in the Porcupine Forest Reserve.

Location The Porcupine Forest Reserve, about 20 miles north of Pelly, Saskatchewan,

Work done Between 1939 and 1946 the Saskatchewan Forestry Branch planted about 355,000 trees near the Maloneck fire tower on the Porcupine Forest Reserve. Species planted included white spruce, jack pine, Scots pine and lodgepole pine. Various planting methods were employed including hole, T-notch, hole and furrow, T-notch and furrow.

Between 1944 and 1946 fifty-four permanent sample plots (1/2-acre in size) were established in the plantations. In 1948 the Department of Forestry measured the survival and height of the trees on the sample plots.

Results The results for the white spruce plantations are summarized in Table 37.

Comments Definite conclusions are impossible since experimental design was not considered when the plantations were established. However, certain observations are worthy of note. Although survival is generally poor, stock planted by the hole and the hole-and-furrow methods survived better than that planted by the T-notch method. Rabbit damage was severe in many plantations and trees in or adjacent to dense hazel and aspen showed a much higher incidence of damage than those planted in open areas. Observations indicated that much of the mortality was due to the combined effects of suppression by dense hazel and aspen and repeated browsing by rabbits.

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.

TABLE 37 SURVIVAL AND GROWTH OF PLANTATIONS 1939-48 MALONECK, SASKATCHEWAN

Species	Number plots measured	Year planted	Number planted per acre	Refills per acre	Number per acre surviving	Per cent* survival	Average height tallest trees	Planting method	Age of stock	Site	Rabbit damage (per cent)	Remarks
White spruce	4	1939	1,210	306	808	55.3	4.5	hole	2-3	fresh sandy loam	10-90	2/3 dense hazel, 1/3 open grassy, small trees suppressed under hazel.
	1	1940	1,210	470	530	31.5	3.9	hole	3-2	dry sandy loam	50	dense hazel, few open spaces contain most trees.
	5	1941	1,210	–	212	17.5	2.7	T-notch	2-2 3-2	moist grav-elly loam	5-100	dense hazel and aspen, some open places, most seed-lings in the openings.
	6	1942	1,210	–	385	31.8	2.9	hole & furrow	3-2	sandy loam	0-100	heavy aspen cover.
	3	1943	1,210	–	17	1.4	–	hole	3-2	clay loam	0-10	heavy hazel and aspen, planta-tion burned.
	2	1945	1,160	–	17	1.5	1.2	T-notch	3-2	moist loam	–	heavy hazel, aspen and herbs, small open spots contain trees.
	2	1946	1,213	–	47	3.8	.9	T-notch	3-2	moist loam	–	dense hazel and grass.

*Per cent based on total number planted including refills.

Project MS-112	Reforestation by planting, Turtle Mountain Forest Reserve, Manitoba.
Classification	232.4:451.2
Investigators	Past: R.A. Haig
Objective	To determine the most suitable species and planting methods for large scale reforestation programs.
Location	Turtle Mountain Forest Reserve, on the U.S. boundary about 50 miles east of the Saskatchewan boundary.
Work done	Between 1912 and 1925 ten plantations were established on fresh to moist clay loam soils in the Turtle Mountain Forest Reserve. About 65 per cent of the stock was spruce; the remainder was Scots pine. Plantations were examined regularly between 1920 and 1927. No further examinations were made until 1958.
Results	Results are given in Table 38.
Comments	The survival and height growth of the spruce plantations set out in 1912 has been much better than that for the plantations set out in 1920. Cultivation of the older plantations during their first seven growing seasons probably had the effect of reducing competition and improving the supply of available moisture. Observers give this as the reason for their better development. Rabbit damage was extensive, causing (1) almost complete failure of the Scots pine, (2) much mortality to spruce, and (3) considerable deformity among the survivors.
Status	Closed.
Reports	*Unpublished.*

Haig, R.A. 1959. Reforestation by planting, Turtle Mountain Forest Reserve, Manitoba. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

TABLE 38 ESTABLISHMENT AND SURVIVAL OF PLANTATIONS SURVEYED IN 1958, TURTLE MOUNTAIN FOREST RESERVE

Plantation number	Establishment data				Survival and growth data 1958					Remarks
	Year of planting	Species	Number planted	Number refilled in 1921	Age	Number trees per acre	Per cent survival	Average d.b.h. (inches)	Average height (feet)	
1a	1912	White spruce Scots pine	2,100 2,100	0 0	47 47	832 7	61.4 0.5	6.2 8.1	44.8 44.0	Land previously under cultivation, at time of planting, competition light, seedlings planted by hole and furrow method. Plantation cultivated and hoed until 1918. Plantation suffered severe rabbit damage in 1913, 1915, 1925 and 1927 killing practically all of the pine and retarding spruce development.
1b	1912	Scots pine	2,100	0	47	224	7.6	8.5	44.8	Same as above.
2	1912	White spruce Scots pine	1,900 2,000	0 0	47 47	630 0	49.7 0	6.8 0	42.7 0	Site, planting method, post planting treatment as above. Mortality of pine and spruce entirely due to rabbit damage - - many spruce have double or triple stems as a result of early rabbit damage.
6	1920	White spruce	750	695	39	836	27.2	3.9	23.5	In 1920 seedlings planted by the hole and furrow method. By the fall of 1920 more than 90 per cent of seedlings dead because of poor planting and an exceptionally hot dry summer. The 1921 transplants suffered much mortality also due to drought and rabbit damage. Survivors in 1958 looked healthy but there were many double stems as a result of browsing.
7	1920	White spruce	750	768	39	507	9.4	5.2	27.5	Same as plantation 6.
8	1920	White spruce	750	630	39	0	0	0	0	No survivors.
9	1920	White spruce	750	605	39	0	0	0	0	No survivors.
12	1920	White spruce	550	0	37	0	0	0	0	Not located (probable failure).
13	1920	White spruce	680	0	34	0	0	0	0	Not located (probable failure).
14	1920	White spruce	350	0	34	0	0	0	0	Not located (probable failure).

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

Classification 232.4:451.2:422.2:441

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

Objective To determine the species and method most suitable for large scale planting.

Location Spruce Woods Forest Reserve, south-central Manitoba.

Work done From 1904 to 1929 a total of 62 plantations were established in the Spruce Woods Forest Reserve. Species planted were Scots pine, jack pine, lodgepole pine, white spruce, and some Norway spruce. Planting sites were very dry medium to fine sands.

In 1952 the 33 surviving plantations were surveyed. For plantations of one acre or less a 100 per cent tally was made, for larger plantations randomly selected rows were tallied.

Results Inadequate experimental design precluded a comprehensive analysis of growth and mortality. However the data from the 1952 survey and from past records have shown that:

1. Norway and white spruce plantations were complete failures.
2. Average survival in the plantations existing in 1952 was about 40 per cent for jack pine, 35 per cent for lodgepole pine, and 20 per cent for Scots pine.
3. Drought and heat were the chief causes of mortality, white spruce, Norway spruce and Scots pine being most affected.
4. Rabbits, pocket gophers, and competition from grass caused additional losses to all species.
5. Winter-kill caused mortality and damage in Scots pine and white spruce plantations.
6. Planting in furrows was the most successful planting method.
7. Underplanting in poplar was a failure, primarily because of excessive rabbit browsing.

Status Closed

Reports *Unpublished.*

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

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

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

Haig, R.A. 1957. Spruce Woods plantations, 1930-1946. Canada, Dept. of Northern Affairs and National Resources, Forestry Branch.

Published

Jameson, J.S. 1956. Planting of conifers in the Spruce Woods Forest Reserve, Manitoba, 1904-1929. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note No. 28.

Project MS-124 Influence of scarification on white spruce regeneration, undisturbed stands, Riding Mountain.

Classification 231.321:181.522

Investigators Past: R.T. Pike, V.H. Phelps
Present: R.M. Waldron

Objectives
1. To determine the effect of scarification (scalping and discing on the establishment of white spruce seedlings).
2. To relate numbers of white spruce germinates to cone crop estimates.
3. To relate survival of white spruce seedlings with
   (a) number of years since germination
   (b) type of seedbed media.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done Scarification using a tractor-drawn Athens plough and a bulldozer blade was carried out during the summers of 1947 and 1950 respectively in undisturbed stands containing 54 square feet basal area of white spruce and 49 square feet basal area per acre of trembling aspen.

A total of 2,900 circular regeneration quadrats, 1/8000- and 1/4000- acre in size, were systematically set out on both scarified and undisturbed portions of the stands. Annual seedling counts were made between the autumns of 1948 and 1952 on the disced quadrats and between the autumns of 1951 and 1957 on the scalped quadrats. All quadrats which could be relocated were re-examined in the spring of 1960.

Results Results are given in Tables 39,40 and 41.

Comments Stocking in the spring of 1960 was higher on prepared seedbeds than on the undisturbed forest floor and higher on scalped than on disced seedbeds. There were no significant differences in seedling height growth.

A good correlation was obtained between estimated cone crops and number of germinates on the three seedbed media the following autumn. More germinates were found in the year following a heavy cone crop than in years following a moderate or light crop, and more following a moderate crop than after a light crop.

For individual years, more germinates were found on prepared seedbeds than on the undisturbed forest floor. Early seedling survival was considerably higher on scalped than on the undisturbed, but only slightly higher on disced than on the undisturbed. In general, per cent survival of the white spruce seedlings decreased with increased age.

All regeneration quadrats will be re-examined in the spring of 1965.

Status Continuing.

Reports *Unpublished*

Phelps, V.H. 1949. Reproduction cutting survey, Riding Mountain Research Area. Canada, Dept. Mines and Resources, Mines, Forests and Scientific Services, Dominion Forest Service.

Phelps, V.H. 1950. Reproduction cutting survey, Riding Mountain. Canada, Dept. Resources and Development, Forestry Branch.

TABLE 39 STOCKING TO WHITE SPRUCE ON UNDISTURBED, DISCED AND SCALPED SEEDBEDS IN THE SPRING OF 1960

Ground treatment	Number of years of observations	Stocking* of white spruce seedlings in 1960		Average height of tallest seedling on each quadrat (in.)	Average age of tallest seedling on each quadrat (yrs.)
		Quadrats stocked (%)	Number of seedlings (per acre)		
Undisturbed	12	7	140	8.7	7.5
	9	7	200	4.8	5.7
Discing	12	20	1,470	7.6	6.7
Scalping	9	43	4,930	5.9	5.5

* 1/1000-acre basis.

TABLE 40 RELATIONSHIP BETWEEN CONE CROP ESTIMATES AND NUMBER OF WHITE SPRUCE GERMINATES AND BETWEEN SEEDLING SURVIVAL, SEEDBED AND YEAR OF GERMINATION

Year of germination	Cone crop estimate of previous year	Undisturbed (1950)		Scalped (1950)	
		Number of germinates (per ac.)	Survival in autumn 1957 (%)	Number of germinates (per ac.)	Survival in autumn 1957 (%)
1952	light	24	0.0	408	23.5
1953	light	568	50.0	1,344	17.8
1954	light	32	0.0	88	9.1
1955	medium	1,952	2.4	16,032	42.3
1956	medium	392	37.5	3,640	69.9
Totals		2,968	4.8	21,512	45.0

TABLE 41 RELATIONSHIP BETWEEN CONE CROP ESTIMATES AND NUMBER OF WHITE SPRUCE GERMINATES AND BETWEEN SEEDLING SURVIVAL, SEEDBED AND YEAR OF GERMINATION

Year of germination	Cone crop estimates of previous year	Undisturbed (1947)		Disced (1947)	
		Number of geminates (per ac.)	Survival in autumn 1951 (%)	Number of germinates (per ac.)	Survival in autumn 1951 (%)
1948	light	796	0.5	3,333	5.6
1949	extremely heavy	34,828	6.0	63,360	12.8
1950	nil	40	60.0	84	10.7
Totals		35,664	6.0	71,777	12.4

Reports

Unpublished (continued)

Phelps, V.H. 1951. Influence of scarification on white spruce regeneration, undisturbed stands, Riding Mountain Research Area. Canada, Dept. Resources and Development, Forestry Branch.

Haig, R.A. 1956. Influence of scarification on white spruce regeneration, undisturbed stands, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

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Published

Phelps, V.H. 1951. Survival of white spruce seedlings. Canada, Dept. Resources and Development, Forestry Branch, Div. of Forest Research, Silvicultural Leaflet No. 56.

Project MS-133	Thinning aspen, Turtle Mountain Forest Reserve.
Classification	242:561
Investigators	Past: R.A. Haig Present: G.A. Steneker

Objective To study the effect of thinning on diameter, height and volume growth of young aspen.

Location Turtle Mountain Forest Reserve. Sec. 31, Twp. 1, Rge. 20, W.P.M., Manitoba.

Work done In 1948 five 1/5—acre sample plots were established in an 11-year-old stand of fire origin, consisting predominantly of aspen and some balsam poplar. The following treatments were given:

- 2 plots - control, no thinning.
- 1 plot - thinned to 7x7-foot spacing.
- 1 plot - thinned to 5x5-foot spacing.
- 1 plot - alternate 20-foot wide strips clear cut in N-S direction.

Plots were remeasured in 1953 and 1960.

Results Results are shown in Tables 42 and 43, and Figure 26

Comments In 1948 the total volumes of the thinned plots after thinning were much smaller than those of the controls. However by 1960 the volume of the plot thinned to 5x5-foot spacing surpassed that of the controls, while the volume of the plot thinned to 7x7-foot spacing was almost equal. Merchantable volumes by 1960 (cords) were on the average greater on the thinned plots than on the controls, excepting the strip thinned plot.

Diameter increment of the largest trees had increased with thinning; trees on the heaviest thinned plot showed the greatest increase. This increase in diameter increment as a result of thinning is reflected in the figures for merchantable volume in 1960.

A marked drop in basal area increment is shown with basal areas above about 35 sq. ft. (Figure 26). This drop is attributed to mortality, mainly as a result of high stocking. Below 35 sq. ft. a drop in increment occurred, which is due most likely to inadequate stocking.

As a result of the strip thinning, trees on the edge of the strips grew somewhat faster than those in the centre of the strip. This is partly responsible for the somewhat greater increment of the largest trees on the strip thinned plot compared to the control plots (Table 43). However, the strip thinning resulted in a marked loss in basal area increment (Figure 26). The graph indicates that if the same number of trees had been distributed more evenly over the area basal area increment, at least to 1960, could have been increased by about 50 per cent from 49 sq. ft. to about 75 sq. ft. Alternate 20-foot strips are probably too wide and 10-foot wide strips will probably result in a a greater stimulus to residual trees.

Status Open.

Reports *Unpublished*

Haig, R.A. 1955. Thinning aspen, Turtle Mountain Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Steneker, G.A. 1961. Thinning aspen, Turtle Mountain Forest Reserve. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

TABLE 42 STAND STATISTICS PER ACRE 1948, 1953 AND 1960

Treatment	No. of trees				BA (sq.ft.)				Average d.b.h.		Height dom. trees 1948	Total volume (cu.ft.)				Merch. volume (cords)			
	1948 BT	1948 AT	1953	1960	1948 BT	1948 AT	1953	1960	1948 BT	1948 AT		1948 BT	1948 AT	1953	1960	1948 BT	1948 AT	1953	1960
Control (a)	2740	2740	2240	1425	44	44	71	88	1.7	1.7	21	655	655	1256	1877	.15	.15	2.4	15.0
Control (a)*	60	60	65	55	15	15	19	22				238	238	343	370				
Control (b)	3470	3470	2930	1565	70	70	69	106	1.9	1.9	25	1065	1065	1778	2274	2.0	2.0	7.2	20.0
20' alt. strips	4240	2260	1905	1440	65	33	55	82	1.6	1.7	20	937	475	879	1612	.05	.05	1.3	10.5
5x5-foot	3280	1470	1430	1125	54	32	73	107	1.7	2.0	20	800	474	1322	2328	.10	.10	5.3	23.2
7x7-foot	3085	805	740	680	62	16	47	81	1.9	2.0	20	951	248	821	1798	1.1	–	4.9	19.5

* Control plot (a) contains a number of elm, birch and oak for which data have been presented separately. Note that these trees are on the average bigger than the aspen.

TABLE 43 DIAMETER INCREMENT OF LARGEST TREES PER ACRE, 1948-1960

Treatment	200 largest trees			50 largest trees			25 largest trees		
	d.b.h. 1948	d.b.h. 1960	Increment	d.b.h. 1948	d.b.h. 1960	Increment	d.b.h. 1948	d.b.h. 1960	Increment
Control (a)	3.0	5.1	2.1	3.3	6.0	2.7	3.6	6.2	2.6
Control (b)	4.0	5.9	1.9	5.3	7.5	2.2	5.6	8.0	2.4
20' alt. strips	2.5	5.0	2.5	3.2	5.9	2.7	3.4	6.2	2.8
5x5-foot	2.8	5.7	2.9	3.2	6.3	3.1	3.3	6.4	3.1
7x7-foot	2.6	6.1	3.5	2.8	7.0	4.2	2.8	7.4	4.6

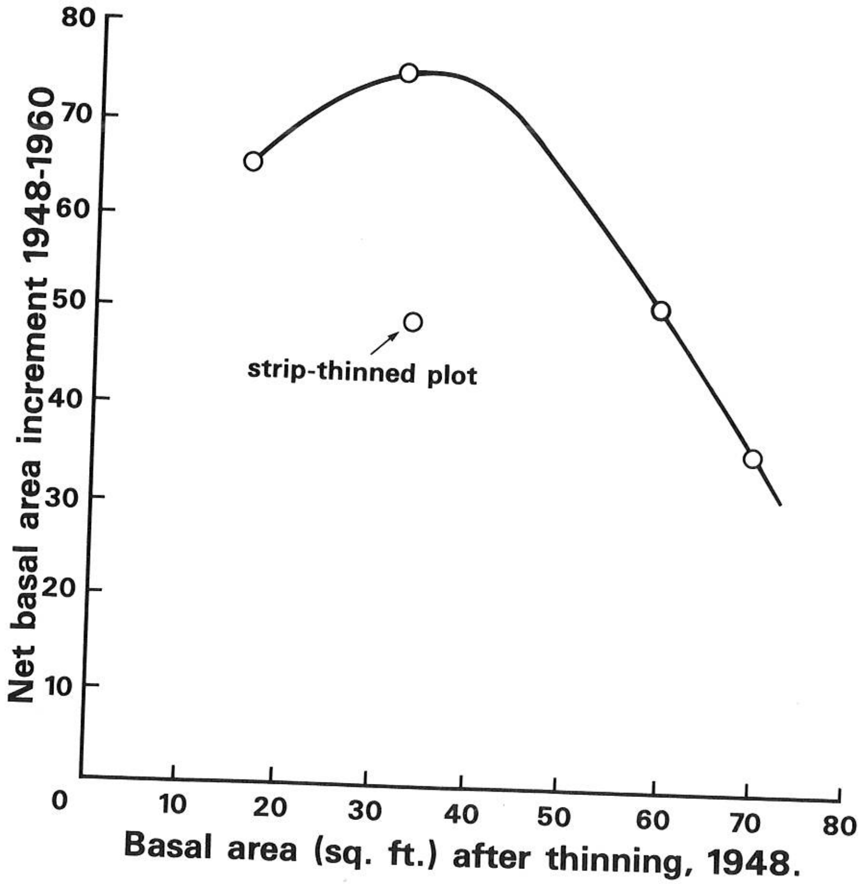

Figure 26. Relationship between basal area after thinning in 1948 and net basal area increment to 1960. Basal area of trees other than aspen have been included for control plot (a).

Project MS-135 Factors influencing coniferous reproduction on cut-over and burned-over lands.

Classification 181.525:182.2

Investigator Past: J.S. Rowe

Objective To study the various environmental factors related to and influencing the establishment and survival of white spruce in undisturbed, cut-over and burned-over stands so that methods may be developed to assist the establishment of this species in understocked and disturbed stands.

Location Various locations throughout the Mixedwood Forest Section of Manitoba and Saskatchewan.

Work done During the summer of 1949, 1950, and 1951 cut-over and burned-over areas, as well as undisturbed forest stands were examined with the view of clarifying relationships between stand history, succession, forest floor conditions, etc. Temporary plots of 1/10-acre or 1/5-acre were established in communities judged suitable for the purpose of the study. On each plot the total plant community and the environmental factors were studied.

Results Germination depends on adequate moistness of the ground surface during June and July. Seedling survival is threatened by extremes of habitat conditions, competition from other plants, and smothering by leaves from herbs, shrubs and trees, especially under hardwood and mixedwood stands.

In undisturbed stands the most favourable seedbed is decayed wood which provides a moist substratum and some protection from leaf smothering since it is usually elevated above the surrounding forest floor. In disturbed stands areas on which mineral soil has been exposed are also suitable for the establishment of spruce. Seedlings on disturbed soil have a better growth rate than those on rotted wood.

Regeneration depends on many fluctuating factors including seed supply, seedbed, climate, biotic influences, etc. For successful establishment, favourable phases of all fluctuating factors must occur at an appropriate time.

In the absence of fire the normal succession on mesic sites is from hardwood to mixedwood to softwood. However, on severely burned sites spruce may invade directly without the intervening poplar stage. Spruce seedlings will invade dry and wet sites if competition from minor vegetation is light.

Light surface fires usually produce unsatisfactory conditions for spruce establishment as they stimulate the growth of competing plants. Severe fires aid spruce regeneration because they expose mineral soil and also reduce competition. Scarification has the same effect as severe burning.

Logging rarely assists regeneration as it does not usually create favourable seedbeds and trees which would eventually produce a rotted wood seedbed are removed. Only the very moist sites seem to regenerate adequately.

Comments Results of this study indicate that scarification of the forest floor prior to logging should aid spruce regeneration. Burning the forest floor should also assist spruce regeneration provided the fire is severe enough to consume most of the humus layer and kill the perennating parts of the competing vegetation.

Status Closed.

Reports

Unpublished

Rowe, J.S. 1950. Progress report on regeneration survey, Phase II, 1949, Manitoba-Saskatchewan. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div.

Rowe, J.S. 1951. Progress report regeneration survey, Phase II, Manitoba-Saskatchewan. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div.

Published

Rowe, J.S. 1955. Factors influencing white spruce reproduction in Manitoba and Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note 3.

Project MS-146 Thinning aspen, Riding Mountain.

Classification 242:561.

Investigators Past: H.J. Johnson

Present: G.A. Steneker

Objective To determine the effect on diameter, height and volume increment of thinning young stands of aspen.

Location Riding Mountain National Park, Manitoba.

Work done In 1950, permanent sample plots were established in 14-, 19- and 23-year-old aspen stands, each thinned to spacings of 8x8, 10x10 and 12x12 feet. In addition control plots were established in each stand. In the 19- and 23-year-old stand, plots were 1/5-acre in size and treatments were replicated once. In the 14-year-old stand plot size was 1/10-acre and there was no replication.

Malformed, suppressed and intermediate trees were removed wherever possible.

All plots were remeasured in 1960.

Results Results are shown in Tables 44 and 45, and Figure 27.

Comments Without exception the control plots supported the greatest number of trees, basal area, and total volume in 1960, and the heaviest thinned plot the smallest.

The number of trees, basal area and total volume per acre to 1960 was inversely related to the intensity of thinning. Cordwood production was, with one exception, greater on the control than on the thinned plots. The unexpectedly large cordwood volume for the 8x8-foot spacing in the 14-year-old stand is attributable to tree size distribution on this sample plot in 1950.

As a result of increased diameter increment of individual trees by thinning, the production of large sized trees to 1960 has increased. This is indicated by the bd. ft. production to 1960 which was greatest for the 12x12-foot spacing (Table 44) and smallest for the control.

Table 45 shows that even the largest 25 trees had benefited from the thinning, as can be seen from their diameter increment between 1950 and 1960.

Diameter increment of the largest trees between 1950 and 1960 was directly related to intensity of thinning, Therefore bigger trees could be expected on the thinned plots than on the controls by 1960. However differences in tree size were not very great. This is attributed to tree size in 1950.

In Figure 27, basal area after thinning is related to net basal area increment between 1950 and 1960. For the 14-, 19- and 23-year-old stand a maximum in increment was reached at a stocking level of about 28, 42 and 52 sq. ft. Losses above these levels are attributed to mortality to 1960. Below these basal areas increment is lost due to inadequate stocking.

Status Continuing.

Reports *Unpublished.*

Johnson, H.J. 1956. Thinning aspen, Riding Mountain. Establishment Report. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

TABLE 44 STAND STATISTICS PER ACRE, 1950 AND 1960

Age in 1950 (years)	Treatment	No. of trees			d.b.h. 1950		Dominant height 1950	Basal area (sq.ft.)			Total volume (cu.ft.)			Merchantable volume					
														Cords			Bd.ft.		
		1950		1960				1950		1960	1950		1960	1950		1960	1950		1960
		BT	AT		BT	AT		BT	AT		BT	AT		BT	AT		BT	AT	
14	12x12	5970	300	260	1.5	2.0	16	70	6	29	907	83	459	–	–	3.7	–	–	–
	10x10	6670	440	410	1.2	2.0	15	55	9	40	714	119	640	–	–	4.5	–	–	–
	8x8	5270	680	630	1.6	2.3	17	71	20	75	988	296	1424	–	–	13.4	–	–	–
	Control	6050	6050	3060	1.3	1.3	15	55	55	103	712	712	1685	–	–	3.8	–	–	–
19	12x12	2458	300	288	2.4	3.0	25	74	14	42	1099	230	768	1.0	.2	8.0	–	–	–
	10x10	2785	435	428	2.3	3.0	25	76	21	53	1232	360	1012	1.0	.6	10.0	–	–	–
	8x8	2138	680	655	2.4	3.0	24	72	35	74	1104	542	1346	1.4	1.2	12.1	–	–	–
	Control	2475	2475	1085	2.6	2.6	26	94	94	94	1524	1524	1847	3.2	3.2	13.2	–	–	–
23	12x12	2165	300	298	2.8	4.0	35	96	27	70	1940	586	1837	8.8	5.6	22.1	–	–	937
	10x10	2448	435	422	2.6	3.8	32	90	34	88	1930	729	2284	6.2	5.6	26.8	–	–	870
	8x8	1682	680	628	3.2	3.8	34	92	54	114	1792	1110	2969	9.0	8.3	35.5	–	–	821
	Control	2610	2610	1557	3.0	3.0	36	129	129	162	2668	2668	4142	15.1	15.1	40.4	–	–	135

TABLE 45 DIAMETER INCREMENT 1950-1960 OF THE 200, 50 AND 25 LARGEST TREES PER ACRE IN 1960

Age in 1950 (years)	Treatment	Number of largest trees per acre								
		200			50			25		
		Av. d.b.h. 1950	Av. d.b.h. 1960	Incr.	Av. d.b.h. 1950	Av. d.b.h. 1960	Incr.	Av. d.b.h. 1950	Av. d.b.h. 1960	Incr.
14	12x12.........	2.0	4.7	2.7	2.3	5.3	3.0	–	–	–
	10x10.........	2.1	4.8	2.7	2.4	5.3	2.9	–	–	–
	8x8	2.6	5.3	2.7	2.7	5.6	2.9	–	–	–
	Control	2.1	4.0	1.9	2.3	4.6	2.3	–	–	–
19	12x12.........	3.0	5.5	2.5	3.3	6.1	2.8	3.6	6.4	2.8
	10x10.........	3.2	5.3	2.1	3.5	5.8	2.3	3.6	6.0	2.4
	8x8	3.5	5.4	1.9	3.9	6.0	2.1	4.1	6.3	2.2
	Control	3.8	5.4	1.6	4.2	6.1	1.9	4.3	6.3	2.0
23	12x12.........	4.3	7.1	2.8	4.9	7.9	3.0	5.2	8.3	3.1
	10x10.........	4.2	6.9	2.7	4.8	7.9	3.1	5.0	8.3	3.0
	8x8	4.6	7.0	2.4	5.3	7.8	2.5	5.5	8.2	2.7
	Control	4.5	6.5	2.0	5.0	7.3	2.3	5.2	7.5	2.3

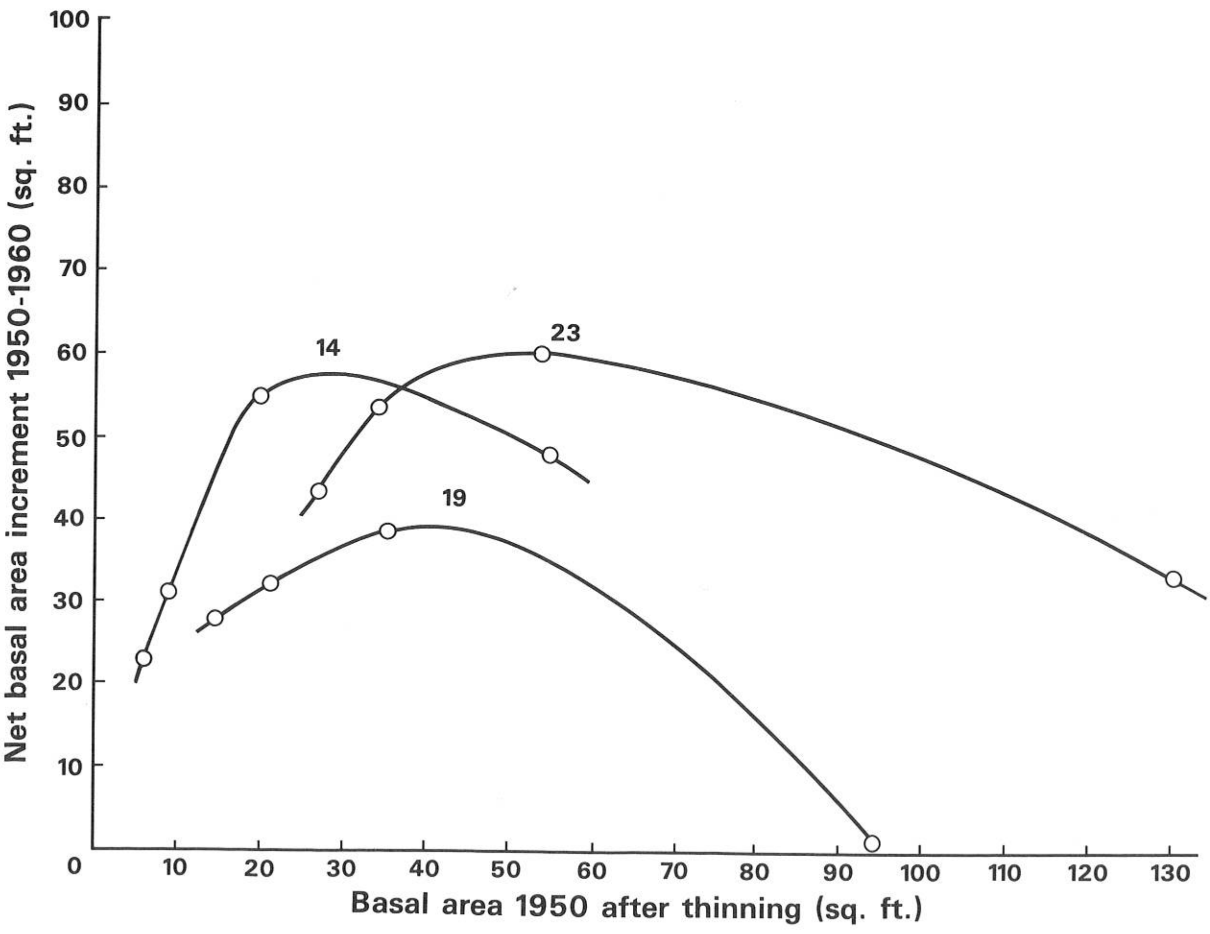

Figure 27. Net basal area increment 1950-1960, related to basal area after thinning in 1950, 14-, 19- and 23-year-old stands.

Reports *Unpublished (continued)*

Steneker, G.A. 1961. Thinning young aspen stands in the Riding Mountain National Park, Manitoba. Dept. of Forestry of Canada, For. Res. Br.

Published.

Steneker, G.A. 1963. Ten-year results of thinning 14-, 19- and 23-year-old aspen to different spacings. Dept. of Forestry of Canada, Publication 1038.

Project MS-147 Control of underbrush and vegetation by herbicides. Study 1.

Classification 236:232.4:441

Investigators Past: R.M. Waldron, R.T. Pike.

Objective To study the use of herbicides as a means of reducing the suppression by dense hazel of natural white spruce reproduction.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done During 1950, nine plots were established in an area of dense hazel (37,000 stems per acre) under scattered mature white spruce and trembling aspen. Each plot was sprayed with an aqueous solution of one of the following chemicals: 2,4-D, 2,4,5-T, ammate or a 50-50 mixture of 2,4-D and 2,4,5-T. These chemicals were applied to the hazel as foliage sprays in varying dosages and concentrations during the first week of August (Table 46).

Annual counts of residual living stems and new stems of all shrub species present on the plots were made at the end of each growing season from 1951 to 1954 inclusive, and again in 1956.

Heights and annual height growth of white spruce reproduction present on the plots were measured in 1958. Similar records for spruce reproduction on the surrounding untreated area were taken.

In May 1954, six 1/40-acre plots were established and each planted with 49 white spruce (3-2 stock). In August, three plots were sprayed with an aqueous solution of 2,4-D at a concentration of 1875 ppm (0.75 ounces of chemical per 1000 shrub stems), and three plots were retained as controls. The survival and height of the spruce on the six plots was recorded in the spring of 1958.

Results Results are given in Tables 46, 47 and 48.

TABLE 46 TREATMENTS AND RESULTS
HERBICIDES USED AS FOLIAGE SPRAYS ON HAZEL IN 1950

Chemical*	Quantity and concentration				Percentage of stems killed by herbicides one year after treatment
	Chemical only		Aqueous solution		
	(oz./M) hazel stems	(oz./ac.)	(p.p.m.)	(gal./ac.)	
2,4-D	1.5	60	3,000	50	100
	1.0	30	1,500	50	97
	0.9	30	750	100	96
2,4,5-T	1.7	60	3,000	50	96
	0.7	30	1,500	50	95
	0.8	30	750	100	74
2,4-D plus 2,4,5-T	1.5 (.75 each)	60 (30 each)	3,000	50	99
Ammate	42.1	1,600	80,000	100	91
	20.5	800	80,000	50	88

*Ammate — ammomium sulfamate 80% acid equivalent
2,4-D — herbate ester 40% acid equivalent
2,4,5-T — ester 40% acid equivalent

TABLE 47 RELATIONSHIP OF WHITE SPRUCE REPRODUCTION TO SURROUNDING HAZEL ON TREATED AND UNTREATED AREAS, 1956

Position of seedling	Number*		Average height (feet)	
	Treated	Untreated	Treated	Untreated
Above hazel	19	–	4.6	–
Even with hazel	8	9	3.8	4.9
Below hazel	7	26	2.7	2.9
Hazel			3.4	5.2

*All seedlings below hazel in 1950.

TABLE 48 SURVIVAL AND HEIGHT OF PLANTED WHITE SPRUCE GROWN UNDER TREATED AND UNTREATED HAZEL

Treatment 1954	Survival 1958 (%)	Height 1958 (inches)	Basis: number of transplants
2,4–D	57.1	16.6	147
Untreated	28.6	11.1	147

Comments All chemicals and spray concentrations tested produced a fairly complete kill of the above-ground portions of hazel. Subsequent sprouting was high, but less after 2,4-D treatments than after the other.

Treatments resulted in an increased growth rate of natural white spruce reproduction under hazel. It was believed that a high percentage of the spruce which were released in this way would not again be overtopped by hazel.

White spruce planted out under hazel had better survival and a higher rate of growth following treatment of the hazel with 2,4-D than with no chemical treatment. Some seedlings were damaged by the chemical.

Status Closed.

Reports *Unpublished*

Pike, R.T. 1955. Chemical control of hazel in the management of white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Pike, R.T. 1956. Control of underbrush and vegetation by herbicides. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1957. Control of underbrush and vegetation by herbicides. Canada, Dept. Northern Affairs and National Resources. Forestry Branch, For. Res. Div.

Waldron, R.M. 1960. Basal spraying of hazel. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1961. Poplar suckering increased by basal spraying of underbrush. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Published

Waldron, R.M. 1959. Hazel foliage treatments to reduce suppression of white spruce reproduction. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note No. 75.

Project MS-147 Control of underbrush and vegetation by herbicides. Study 2.

Classification 243.8

Investigators Past: R.M. Waldron, R.T. Pike

Objective To study the use of herbicides and mechanical girdling as a means of killing mature trembling aspen.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done In August of 1955, 33 trembling aspen were axe girdled at breast height, 31 basal sprayed with 2,4,5-T and 29 sprayed with 2,4,5-T following basal frilling. The chemical was applied as a solution in mixture with diesel oil at 8,000 p.p.m. In June of 1956 more than 114 trees were girdled with a "handi-girdler". Average diameters of the trees ranged from 10 to 12 inches d.b.h.

Visual estimates of percentage leaf kill of each tree were made in mid-August between 1956 and 1957.

Results

TABLE 49 RESULTS OF FOUR METHODS OF KILLING ASPEN

Treatment	Amount of herbicides: Chemical only (ounces per tree)	Amount of herbicides: Solution (ounces per tree)	Time required for treatment (minutes per tree)	Estimated percentage of leaf kill in August of each year: 1956	1957	1958	1959	Basis: number of trees
2,4,5-T basal bark spray	0.59	30.3	0.6	100	100	100	100	31
2,4,5-T basal frills	0.25	12.7	1.0	77	100	100	100	29
Girdling at breast height (axe)			3.6	3	59	97	100	33
Girdling at breast height ("handigirdling") ...			2.1	–	52	98	100	114

Comments All methods resulted in complete mortality of the treated trees. Mortality occurred earlier among the aspen treated with 2,4,5-T as a basal spray and in basal frills than among those girdled.

Status Closed

Reports *Unpublished*

Pike, R.T. 1956. Control of underbrush and vegetation by herbicides. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1957. Control of underbrush and vegetation by herbicides. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1960. Girdling, basal spraying and frilling of mature aspen. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Published

Waldron, R.M. 1961. Girdling, basal spraying and frilling of mature aspen. Timber of Canada 22(12)34-35.

Project MS-150 Effect of periodic drought on survival of white spruce seedlings. Riding Mountain. Study 1.

Classification 181.525:231.321:231.322:232.33

Investigators Past: V.H. Phelps, M. Kastrukoff, J.S. Rowe.

Objective To study the establishment and development of white spruce seedlings on burned seedbeds, mineral soil seedbeds, and litter seedbeds.

Location Riding Mountain National Park.

History In 1940, 1941, and 1942, 29 small experimental plots were established under a mature white spruce-trembling aspen stand. Plot treatments included burning, scarification by raking to mineral soil, and control (no treatment). Seed was supplied artificially in generous amounts and some plots were watered daily to hasten germination and establishment. However, mortality was high. In 1943 there was a heavy influx of seedlings resulting from a bumper crop in 1942. Of the 29 plots established 18 remained intact at the last examination in 1956.

Results The results for the 18 remaining plots are presented below; they include only those seedlings which germinated after 1942.

TABLE 50 NUMBER OF WHITE SPRUCE SEEDLINGS TALLIED, 1943–1956

Seedbed condition	Basis (no. plots)	Year				
		1943	1944	1946	1949	1956
		Plots under a spruce-aspen overstory (shaded)				
Mineral soil	2	0	0	5	8	47
Burn	2	459	438	168	73	173
Litter .... (control)	2	0	0	0	0	0
		Plots in openings (not shaded)				
Mineral soil	4	181	435	171	106	269
Burn	4	321	322	110	70	217
Litter .... (control)	4	30	32	4	2	8
Total............	18	991	1,227	458	259	714

TABLE 51 AVERAGE HEIGHT AND RANGE OF HEIGHTS LARGEST SEEDLINGS ON SCARIFIED AND BURNED PLOTS

Location of plots	Seedbed type			
	Scarified		Burned	
	Av. ht. (inches)	Range (inches)	Av. ht. (inches)	Range (inches)
Under canopy (shaded)	7.5	2-10 (basis 19 seedlings)	14.3	12-17 (basis 20 seedlings)
In openings (not shaded)	43.3	9-53 (basis 36 seedlings)	47.3	10-81 (basis 28 seedlings)

Comments From the data in Table 50 it would appear that under shade burned seedbeds are more favourable for germination and establishment of seedlings than mineral soil seedbeds. However, in the open they appear to be less favourable. The data in Table 51 indicate that (1) seedling growth is somewhat better on burned seedbeds than on scarified seedbeds, and (2) seedlings develop much better in the open than they do under shade.

This experiment shows the beneficial effects of seedbed preparation for spruce regeneration. There seems to be little to choose between scarification and burning as a means of inducing seedling establishment although under a forest cover the latter treatment may be better. Regardless of treatment seedlings grow better in the open than under a canopy.

Status Closed.

Reports *Unpublished.*

Kastrukoff, M. 1950. Effect of periodic drought on survival of white spruce. Canada, Dept. of Resources and Development, Forestry Branch.

Rowe, J.S. 1961. Survival of white spruce seedlings, Riding Mountain. Dept. of Forestry of Canada, For. Res. Br.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Published.

Phelps, V.H. 1948. White spruce reproduction in Manitoba and Saskatchewan. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Silv. Res. Note 86.

Project MS-150 Effect of periodic drought on survival of white spruce seedlings. Study 2.

Classification 181.525

Investigators Past: J.S. Rowe, M. Kastrukoff

Objective To study the effects of applying various amounts of water at different time intervals on the germination and survival of white spruce.

Location Greenhouse in Winnipeg.

History In 1940, Twenty samples of soil profiles were cut from each of three types of seedbed media (litter burned off, mineral soil exposed by raking, litter left in place) and placed in 1-pint cartons. Cartons were then assembled into groups, each group containing 5 soil profiles from each seedbed media. Each group was watered for 42 days as follows:

Group I – received a total amount equivalent to 5.9 inches of rain (applied whenever the investigator thought necessary).

Group II – received a total amount equivalent to 4.0 inches of rain (applied daily).

Group III – received a total amount equivalent to 3.9 inches of rain (applied twice a week).

Group IV – received a total amount equivalent to 3.9 inches of rain (applied once a week).

At the end of the germination period (43 days) all cartons were watered copiously for 1 week after which no further water was added. Seedlings were observed daily and mortality recorded.

Results The results are given in Tables 52 and 53

TABLE 52 TOTAL GERMINATION 43 DAY PERIOD
(expressed as a percentage of total number of seeds sown - 50 in each carton)

Group	Undisturbed litter	Mineral soil	Burn	All seedbeds
I	40	42	37	40
II	31	12	17	20
III	40	5	32	26
IV	30	0	3	11
All	36	16	22	24

TABLE 53 MORTALITY OF WHITE SPRUCE SEEDLINGS
(expressed as a percentage)

Days since watering	Undisturbed litter	Mineral soil	Burn
7	1	1	1
14	4	8	11
21	15	26	24
24	17	28	31
25	100	100	100

Comments

Under the conditions of this experiment, Table 52 shows that total germination was better on undisturbed litter than on the other seedbeds. This would suggest that litter as such is not detrimental to germination. Also the difference in total germination between Group IV (watered once a week) and Group III (watered twice a week) or Group II (watered every day) suggests that interval between watering rather than total amount applied had an important bearing on germination. Thus on a given seedbed the amount of germination that may take place in any given year will be influenced by the frequency of rainstorms, other factors being equal.

Table 53 shows that seedlings died more slowly on the undisturbed litter seedbeds than on the other two. This would suggest that litter may have acted as a mulch conserving moisture.

Status

Closed.

Reports

Published

Phelps, V.H. 1948. White spruce reproduction in Manitoba and Saskatchewan. Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch, Dom. For. Serv., Silv. Res. Note 86.

Project MS-153 Growth and mortality of white spruce under an aspen overstorey. Study 1.

Classification 243

Investigators Past: C.L. Kirby, J.H. Cayford, R.M. Waldron, J.M. Jarvis.

Present: G.A. Steneker

Objective To determine the effect of partial and complete removal of the trembling aspen overstorey on the development of the white spruce understorey.

To study the subsequent development of individually released spruce trees.

Location Eight experimental areas were chosen. They are located near Bertwell, Reserve, Montreal Lake, Candle Lake, and Big River, Saskatchewan and at the Riding Mountain, Manitoba.

Work done Tables 54 and 55 summarize the layout of the experiment and give data on tree size and stand ages. Fifty per cent (by number of trees) of the aspen was cut by means of removing every other aspen throughout the plots. Trees chosen for individual treatment were released by removing all competition within a distance of 2 feet and

TABLE 54 LAYOUT OF EXPERIMENT

Treatment	Location							
	Bertwell	Reserve	Montreal Lake	Candle Lake (1)	Candle Lake (2)	Big River (1)	Big River (2)	Riding Mountain
	Date of establishment							
	1951	1951	1953	1953	1953	1953	1953	1954
	Number of sample plots (-0.1 acre)							
100% tA cut	2	2	2	2	2	2	1	2
50% tA cut	2	2	2	2	2	2	1	2
No tA cut	2	2	2	2	2	2	1	2
	Number of individual trees							
2-foot crown release	0	0	11	16	8	19	6	4
4-foot crown release	0	0	11	16	8	17	6	5

TABLE 55 STAND DATA

Location	Age at establishment		Av. d.b.h. (in.)		Av. height (in.)	
	White spruce	Aspen	White spruce	Aspen	White spruce	Aspen
Bertwell	15-25	25-30	1.2	3.6	11	44
Reserve	30-60	50-60	4.4	6.4	28	65
Montreal Lake ..	20-30	25-35	2.6	4.1	20	52
Candle Lake (1).	15-30	45-60	2.0	5.5	15	55
Candle Lake (2).	15-45	50-60	2.3	6.3	17	54
Big River (1) ...	35-45	55-60	3.1	5.7	28	60
Big River (2) ...	35-45	55-60	3.1	5.7	28	60
Riding Mountain.	20-40	25-40	1.2	4.2	11	45

4 feet around them. Distances were measured between the projections of the crowns at the point of their nearest proximity.

All plots were remeasured 5 years after establishment. Plots established in 1951 and 1953 were also remeasured 10 years after establishment.

Results (all studies) Diameter growth of individually released white spruce trees was increased by about 60 and 80 per cent with a 2- and 4-foot crown release respectively. Height growth increased about 40 and 55 per cent with a 2- and 4-foot crown release.

Diameter growth of white spruce was increased by 22 and 60 per cent by partial removal and complete removal of the aspen overstorey. Height growth of white spruce was less on plots where part or all of the aspen were removed than on plots where no aspen had been removed.

Ten-year results are available for the series of plots at Bertwell and Reserve. Stand statistics and diameter distributions for these plots are presented in Table 56 and Figure 28. Data for the other areas are not yet analysed.

Comments Although the treatments have been of benefit to the growth of white spruce, it is difficult to attribute the growth increase solely to treatment because of confounding due to differences in stocking and stand structure on the various plots as indicated by data in Table 56 and Figure 28.

TABLE 56 STAND STATISTICS PER ACRE FOR 1951 AND 1961 BY TREATMENT AND SPECIES AT BERTWELL AND RESERVE

Treatment	Area	Number of trees					Total volume (cu. ft.)				
		White spruce		Trembling aspen			White spruce		Trembling aspen		
				1951		1961			1951		1961
		1951	1961	B.R.	A.R.		1951	1961	B.R.	A.R.	
Control......	Reserve	125	135	405	405	345	149	272	3154	3154	3874
Partial release ...	Reserve	150	150	465	220	185	447	804	2502	1208	1412
Complete release ...	Reserve	190	185	415	0	0	485	1240	3004	0	0
Control......	Bertwell	1000	1660	775	775	620	81	403	1116	1116	1734
Partial release ...	Bertwell	230	1185	1675	840	740	10	131	2016	1044	2110
Complete release ...	Bertwell	85	820	1330	0	0	4	185	2184	0	0

Status After the 10-year remeasurement in 1964 at the Riding Mountain, this project will be closed.

Reports

Unpublished

Kirby, C.L. 1952. Growth and mortality of white spruce under a poplar overstorey. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div.

Cayford, J.H. 1954. The release of white spruce by the removal of the aspen overstorey. Canada, Dept. Northern Affairs and National Resources, Forestry Branch.

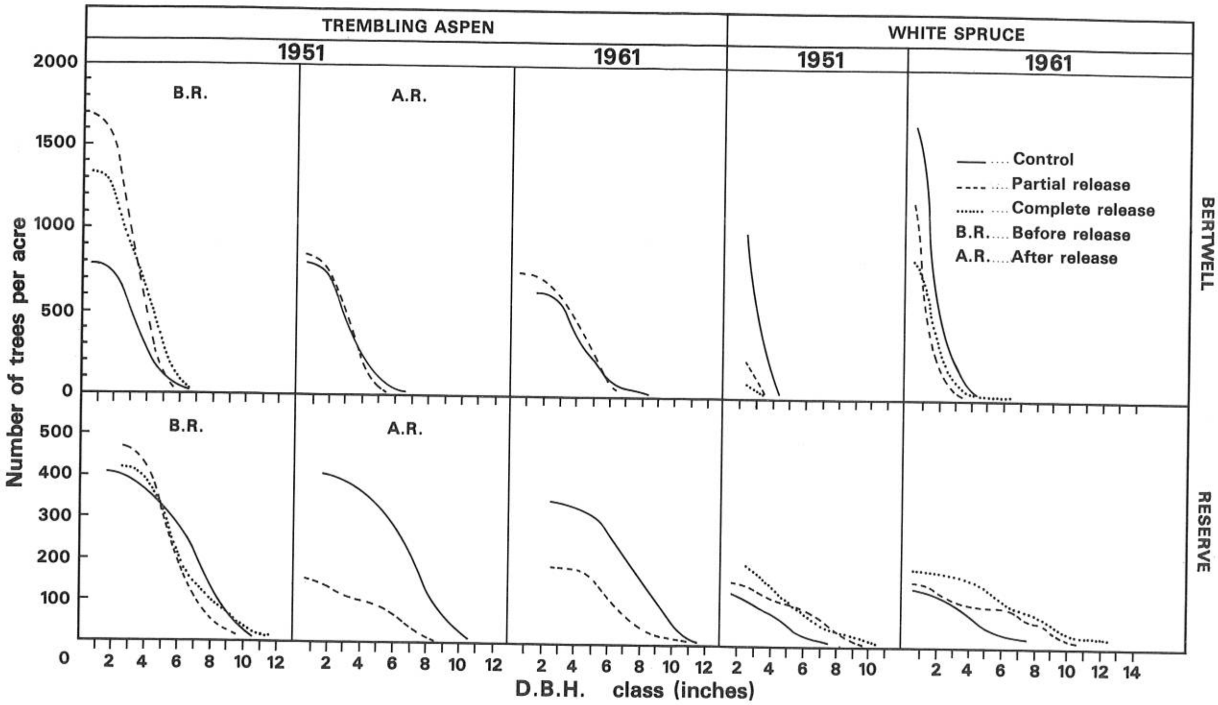

Figure 28. Cumulative frequency curves to show diameter distribution of trembling aspen and white spruce in 1951 and 1961 by treatment at Bertwell and Reserve.

Reports

Unpublished (continued)

Cayford, J.H. 1955. The release of white spruce by the removal of the aspen overstorey, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch.

Waldron, R.M. 1956. Report of the 1956 remeasurement of project MS–153 – Growth and mortality of white spruce under a poplar overstorey. Canada, Dept. Northern Affairs and National Resources, Forestry Branch.

Jarvis, J.M. 1958. Report on the 1958 remeasurement of project MS–153 – Growth and mortality of white spruce under a poplar overstorey. Canada, Dept. Northern Affairs and National Resources, Forestry Branch.

Jarvis, J.M. 1960. Growth of white spruce following release from aspen, Manitoba and Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Jarvis, J.M. and G.A. Steneker. 1962. Growth of white spruce following release from aspen. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 62–MS–13.

Published

Steneker, G.A. and J.M. Jarvis. 1963. A preliminary study to assess competition in a white spruce-trembling aspen stand. For. Chron. 39(3):334–336.

Project MS-153	Growth and mortality of white spruce under an aspen overstorey. Study 2.
Classification	181.65.
Investigators	Past: G.A. Steneker, J.M. Jarvis.
Objective	To determine how much the diameter increment of individual white spruce under an aspen canopy is influenced by the proximity of surrounding trees.
Location	A 40– to 70–year–old white spruce-aspen stand near Reserve, Saskatchewan.
Work done	An analysis of diameter increment of individual white spruce trees was made in 1961 and related to size and proximity of surrounding trees. Study material was provided by sample trees from the permanent plots established at Reserve under project MS–153, Study 1. Ten-year diameter increment (1951–1961) of 38 white spruce trees ranging from 4 to 10 inches d.b.h. was related to various competition indices derived from all surrounding trees within 10, 15, 20 and 25 feet.
Results	Results are given in Table 57
Comments	Basal area summation (index 5) gave the best correlation. For the 4- to 6-inch trees 7 per cent of the variation in diameter increment was accounted for by the basal area of surrounding trees within 10 feet. This percentage increased to 24, 46 and 56 respectively when surrounding trees within 15, 20 and 25 feet radii were used. For 7- to 10-inch trees 55 per cent of the variation in diameter increment was accounted

TABLE 57 COEFFICIENTS OF CORRELATION BETWEEN 10–YEAR INCREMENT OF SAMPLE TREES AND VARIOUS COMPETITION INDICES (1951–1961)

Maximum radius (feet)	Competition indices				
	1	2	3	4	5
	$\sum^{1-n} \frac{d}{D^2}$	$\sum^{1-n} \frac{d^2}{D^2}$	$\sum^{1-n} \frac{d}{D}$	$\sum^{1-n} \frac{d^2}{D}$	$\sum^{1-n}$ BA
	Sample trees 4–6 inches d.b.h. (basis – 20 trees)				
10	–.24	–.26	–.36	–.40	–.26
15	–.28	–.30	–.53*	–.56**	–.49*
20	–.30	–.33	–.58**	–.63**	–.68**
25	–.31	–.34	–.65**	–.68**	–.75**
	Sample trees 7–10 inches d.b.h. (basis – 18 trees)				
10	–.60**	–.58**	–.69**	–.68**	–.74**
15	–.67**	–.67**	–.78**	–.84**	–.87**
20	–.68**	–.69**	–.78**	–.83**	–.86**
25	–.69**	–.70**	–.78**	–.82**	–.81**

d = d.b.h. (inches) of surrounding tree. D = distance (ft.) from a sample tree to a surrounding tree. BA = basal area (sq.ft.) of a surrounding tree. n = no. of surrounding trees within specific radii of sample tree.
* Significant at 5% level. ** Significant at 1% level.

for by the basal area of surrounding trees within 15 feet. When the basal area of trees beyond 15 feet was included, the per cent variation accounted for decreased slightly.

Status Closed.

Reports *Published*

Steneker, G.A. and J.M. Jarvis. 1963. A preliminary study to assess competition in a white spruce-trembling aspen stand. For. Chron. 39(3):334-336.

Project MS-155 Mutliple thinnings in fourteen-year-old poplar, Porcupine Provincial Forest, Saskatchewan.

Classification 242:561

Investigators Past: C.L. Kirby, R.M. Waldron, J.M. Jarvis

Present: G.A. Steneker

Co-operator: Forestry Pathology Section.

Location Porcupine Provincial Forest, Saskatchewan. Sec. 21, Twp. 36, Rge. 32.

Objective To study volume increment and total volume production in young aspen stands thinned periodically to specific stand density indices (S.D.I.) throughout the rotation.

Work done In 1951, fourteen 1/5-acre plots were assigned to each of the following treatments:

1. Control- no thinning, two plots selected with S.D.I. of 186 and 183.

2. Thinned-
   (a) two plots to be maintained at S.D.I. of 120 per cent of that of the controls in 1951 by 5-year periodic thinning.
   (b) two plots as (a) but 100 per cent
   (c) ,, ,, ,, ,, ,, 80 ,, ,,
   (d) ,, ,, ,, ,, ,, 70 ,, ,,
   (e) ,, ,, ,, ,, ,, 60 ,, ,,
   (f) ,, ,, ,, ,, ,, 50 ,, ,,

Plots were remeasured in 1957 and 1962 and thinned to their assigned S.D.I. In 1962 a decay study was made on the trees taken out in thinning by the Forest Pathology Section.

Results Results are presented graphically (Figures 29 and 30) and in tabulated form (Table 58).

Comments Diameter increment of the 200, 50 and 25 largest trees in 1962 was directly related to thinning intensity. Diameter increment of the 25 largest trees did not increase below basal areas of 45 sq. ft. (Figure 29).

Height increment was not affected by thinning.

For the period 1951-1957 losses in net basal area and total volume increment occurred with stocking levels below and above about 55 sq. ft. (Figure 30). For the period 1957-1962 respective losses occurred with stocking levels below and above about 75 sq. ft. Losses below these levels are attributed to inadequate stocking; losses above are attributed to mortality.

Total volume (cu. ft.) and merchantable volume (cords) production to 1962 were influenced by size of trees in 1951 after thinning, as well as by thinning intensity. Total volume production showed a decline with an increase in thinning intensity (Table 58).

Results of the assessment in 1962 of decay incidence in trees taken out in thinning are not available yet.

Status Continuing.

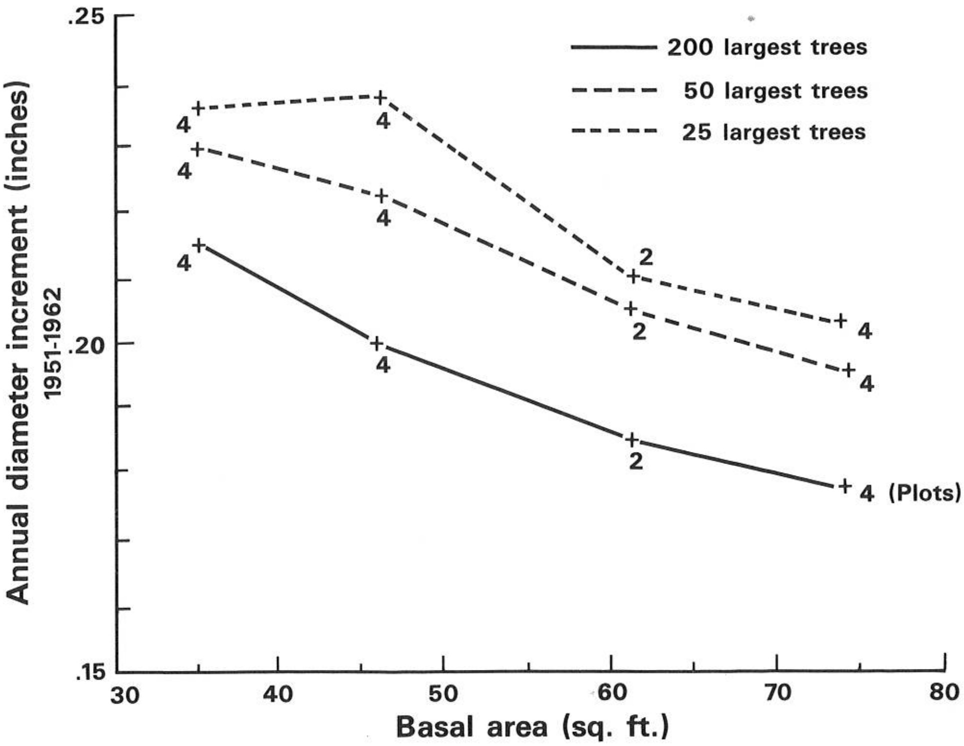

Figure 29. Annual diameter increment (1951—1962) of the 200, 50 and 25 largest trees per acre in 1962, related to basal area per acre after thinning (=average of basal area after thinning in 1951 and 1957).
Basis: 14 sample plots.

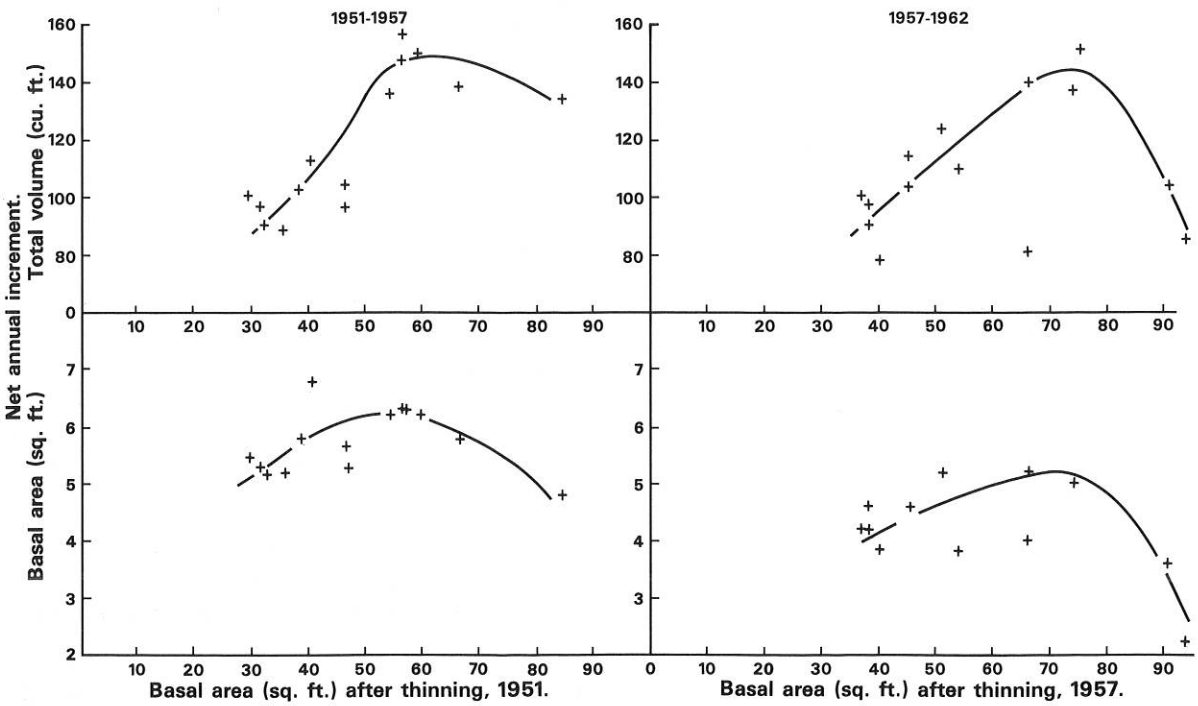

Figure 30. Net basal area and total volume increment per acre over the periods 1951—1957 and 1957—1962 related to basal area per acre after thinning in 1951 and 1957.

TABLE 58 BASAL AREA, TOTAL AND MERCHANTABLE VOLUMES PER ACRE BY TREATMENT IN 1951, 1957 AND 1962

Treatment	Plot no.	Dom. ht. 1951	Average d.b.h. 1951		Basal area per acre (sq.ft.)						Total volume** (cu.ft.)						Merchantable volume*** (cords)					
					1951		1957		1962		1951		1957		1962		1951		1957		1962	
			BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT
Control	11	27	1.6	1.6	54	—	91	—	109	—	570	—	1385	—	1962	—	0	0	.6	—	5.8	—
,,	6	25	1.8	1.8	56	—	94	—	105	—	620	—	1500	—	1929	—	0	0	1.0	—	11.2	—
Thinned to 120% of SDI of	3	30	1.8	1.8	84	84*	113	75	103	81	930	930	1735	1250	2016	1675	0	0	.9	.9	9.4	9.4
control in 1951	10	30	2.0	2.0	66	66*	101	74	99	83	730	730	1560	1225	1914	1647	0	0	1.3	1.3	11.6	11.5
Thinned to 100% of SDI of	9	34	‡	2.4	‡	59	96	66	92	69	‡	705	1600	1165	1867	1486	0	0	2.2	2.2	14.5	13.2
control in 1951	1	28	2.0	2.2	74	56	94	66	86	72	840	655	1560	1121	1532	1296	0	0	2.6	2.2	11.8	10.5
Thinned to 80% of SDI of	13	28	2.0	2.1	58	46	78	51	77	60	645	525	1100	750	1375	1082	0	0	1.2	1.0	9.6	8.5
control in 1951	2	28	1.9	2.2	66	46	80	54	73	60	740	535	1165	820	1371	1124	0	0	2.1	2.0	14.2	12.3
Thinned to 70% of SDI of	5	26	1.7	1.9	52	40	81	45	68	49	555	460	1140	655	1225	880	0	0	.9	.9	9.6	6.9
control in 1951	14	29	2.1	2.2	46	38	73	45	67	52	515	450	1060	680	1197	936	0	0	1.1	1.1	10.6	9.4
Thinned to 60% of SDI of	8	25	1.7	1.9	39	32	63	38	61	42	420	350	885	555	1045	762	0	0	.5	.5	8.2	6.6
control in 1951	7	24	1.8	2.0	48	35	66	40	59	44	520	395	925	580	970	727	0	0	.4	.4	6.0	5.3
Thinned to 50% of SDI of	12	28	‡	2.3	‡	31	63	38	59	41	‡	375	950	575	1024	710	0	0	2.6	2.2	11.3	8.3
control in 1951	4	29	‡	2.4	‡	29	62	37	58	40	‡	355	950	580	1086	788	0	0	2.9	2.7	13.0	9.6

* No thinning was carried out in 1951

** Volume, yield and stand tables for tree species in the Lake States. Univ. of Minn. 1934, Tech. Bull. 39.

‡ No data available

*** Tech. Bull. 39, page 30. Volume of peeled stem above a one-foot stump to a 3-inch top diameter inside bark.

Reports *Unpublished*

Kirby, C.L. 1952. Multiple thinning in fourteen-year-old poplar, Porcupine Provincial Forest, Saskatchewan. Canada, Dept. of Resources and Development, Forestry Branch, For. Res. Div.

Waldron, R.M. 1958. Multiple thinning in fourteen-year-old poplar, Porcupine Provincial Forest, Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Jarvis, J.M. and G.A. Steneker. 1961. Multiple thinning in fourteen-year-old poplar, Porcupine Provincial Forest, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br.

Steneker, G.A. 1963. Multiple thinning in fourteen-year-old poplar, Porcupine Provincial Forest, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br.

Steneker, G.A. and J.M. Jarvis. 1963. Thinning in trembling aspen stands, Manitoba and Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-26.

Project MS-156	Influence of scarification on white spruce regeneration, cut-over stands, Riding Mountain.
Classification	231.321:181.522
Investigators	Past: R.T. Pike Present: R.M. Waldron
Objectives	1. To determine the effect of scarification (scalping and discing) on the establishment of white spruce seedlings, 2. To relate number of white spruce germinates to cone crop estimates, and 3. To relate survival of white spruce seedlings with (a) number of years since germination (b) type of seedbed media.
Location	Riding Mountain Forest Experimental Area, Manitoba.
Work done	Scarification using a bulldozer blade and a tractor-drawn Athens plough was carried out during the summer of 1951 on a cut-over mixedwood stand containing 27 square feet basal area of white spruce and 29 square feet basal area per acre of trembling aspen. A total of 315 circular regeneration quadrats, 1/4000-acre in size, were systematically set out on both scarified and undisturbed portions of the stand. Annual seedling counts were made between the autumns of 1952 and 1957 and again in the spring of 1960.
Results	Results are given in Tables 59 and 60.
Comments	Eight years following scarification, stocking to white spruce was higher on prepared seedbeds than on the undisturbed forest floor, and higher on scalped than on disced areas. There was no significant difference in seedling height growth. A good correlation was obtained between estimated cone crop and number of germinates the following autumn. More germinates were found after years with moderate cone crops than years with light cone crops. For individual years more germinates were found on prepared seedbeds than on the undisturbed forest floor and more on the scalped than on the disced. Early seedling survival was higher on the prepared seedbeds. Per cent survival of white spruce seedlings decreased with increased age. All regeneration quadrats will be re-examined in the spring of 1965.
Status	Continuing
Reports	*Unpublished*

Pike, R.T. 1956. Influence of scarification on white spruce regeneration in cut-over stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1957. Influence of scarification on white spruce regeneration in cut-over stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1960. Influence of scarification on white spruce regeneration in cut-over stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

TABLE 59 STOCKING TO WHITE SPRUCE ON UNDISTURBED, DISCED AND SCALPED SEEDBEDS IN THE SPRING OF 1960

Ground treatment	Stocking* to white spruce seedlings in 1960		Average height of the tallest seedling in each quadrat (inches)	Average age of tallest seedling in each quadrat (years)
	Quadrats stocked (%)	Number of seedlings (per acre)		
Undisturbed	0	0	–	–
Disced	20	2,800	3.6	5.2
Scalped	84	6,080	3.9	5.2

*1/1000 – acre basis.

TABLE 60 RELATIONSHIP BETWEEN CONE CROP ESTIMATES AND NUMBER OF WHITE SPRUCE GERMINATES AND BETWEEN SEEDLING SURVIVAL, SEEDBED, AND YEAR OF GERMINATION

Year of germination	Cone crop estimates of previous year	Undisturbed		Disced		Scalped	
		Number of germinates (per acre)	Survival in autumn 1957 (%)	Number of germinates (per acre)	Survival in autumn 1957 (%)	Number of germinates (per acre)	Survival in autumn 1957 (%)
1952	light	0	–	1	0	148	40.0
1953	light	0	–	444	20.0	1,896	32.8
1954	light	0	–	178	50.0	385	38.5
1955	medium	30	0	2,489	64.3	7,437	64.5
1956	medium	59	50.8	1,689	100.0	8,800	91.2
Total		89	33.7	4,801	72.2	18,666	73.2

Reports *Unpublished (continued)*

Waldron, R.M. 1961. Influence of scarification on white spruce regeneration in cut-over stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1961. Seedbed preparation for white spruce regeneration in the white spruce-aspen stands of Manitoba. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 61-19.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Project MS-158	Supply, periodicity and dissemination of white spruce seed, Riding Mountain. Study 1.
Classification	181.523
Investigators	Past: J.S. Rowe R.M. Waldron
Objective	To study the periodicity of white spruce cone crops in mature white spruce and mixed white spruce-aspen stands in Manitoba and Saskatchewan.
Location	Various ranger districts throughout Manitoba-Saskatchewan.
Work done	Annual cone crop estimates for white spruce were collected under project MS-56, "See crop – Manitoba and Saskatchewan" from 1923 to 1930 inclusive and from 1946 to 1955. In 1956 a revised cone crop report form was prepared and the work transferred to this project. Abundance of spruce cone crops is currently being estimated using the following scale: No crop – none or only a few cones on widely scattered trees. Light – sparse crops at the tops of scattered trees. Medium – most of the trees that are not suppressed bear moderate numbers of cones. Heavy – all trees that are not suppressed bear abundant cones, with crop on dominants extending down over more than one fifth of live crown. Very heavy – striking massing of cones on all except suppressed trees. On dominants the cones extend down over more than one-third the crown. Annual estimates have been received from most ranger districts up to and including 1962.
Results	On the average heavy or medium white spruce cone crops occurred once every two years with light crops in the interval. Nil crops rarely occurred. The longest interval between heavy or medium cone crops was four years.
Status	Closed.
Reports	*Unpublished* Waldron, R.M. 1965. Annual cone crops of white spruce in Saskatchewan and Manitoba 1923-1964. Dept. of Forestry of Canada, For. Res. Br., Mimeo 65-MS-11.

Project MS-158 Supply, periodicity and dissemination of white spruce seed, Riding Mountain. Study 2.

Classification 181.523

Investigators Past: J.H. Cayford, J.S. Rowe
Present: R.M. Waldron

Objective To study the supply, periodicity and dissemination of white spruce seed in a mature even-aged white spruce stand.

Location Riding Mountain Forest Experimental Area.

Work done In 1954 a total of 32 1/4000-acre seed traps were set out on two 1/10-acre plots in a pure white spruce stand containing 190 square feet basal area per acre. From then until 1961 cone crop estimates for individual trees and seed trap collections were made annually. Since 1956 cone crop estimates have been made also for trees within a 20-foot surround of the two 1/10-acre plots.

Results Results are summarized in Tables 61, 62 and 63.

Comments Between 1956 and 1961 the number of trees bearing cones varied considerably. Dominant and co-dominant trees bore cones more often than intermediate trees, and intermediate trees bore cones more often than suppressed trees.

Periodicity of cone production was not apparent for individual trees. However, dominant and co-dominant trees bore heavier crops than intermediate and suppressed trees. Even in heavy seed years intermediate and suppressed trees bore only light crops.

Average annual seed fall varied considerably each year with a low of only about 10 thousand seeds per acre in 1958 and a high of over 5 million in 1960. It appeared that in heavy seed years a greater percentage of the seed was sound than in light seed years.

The seasonal period of peak seed fall generally occurred in late August or early September, although one year it was delayed until early October. The time of peak seed fall in any one year appears to be dependent upon weather conditions. Below normal precipitation and above normal air temperature hastens seed fall, while above normal precipitation and below normal air temperature retards it.

Some seed is held in the cones over winter and is shed the following spring and summer. Such a situation occurred in 1957 when no new cones were observed but 14,000 seeds fell per acre. Similar observations had been made in 1953. In both instances the seed was of low viability.

Status Continuing

Reports *Unpublished*

Cayford, J.H. 1955. Seed supply, periodicity and dissemination of white spruce seed. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Rowe, J.S. 1956. The periodicity, dissemination and amount of white spruce seed, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1957. Supply, periodicity and dissemination of white spruce seed, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

TABLE 61 PERCENTAGE OF WHITE SPRUCE TREES BY CROWN CLASS BEARING CONES IN THE YEARS 1956 TO 1961 PLOTS 1 AND 2 PLUS SURROUNDS

Crown class	Year						Basis: (number of trees)
	1956	1957	1958	1959	1960	1961	
	(Percentage of trees bearing cones)						
Dominant	60	6	50	31	88	62	15-16
Co-dominant	72	4	32	58	71	46	24-25
Intermediate	23	0	25	17	89	33	9-13
Suppressed...........	10	0	5	0	26	5	19-21
All	43	3	27	29	65	37	68-74

TABLE 62 AVERAGE ANNUAL SEED FALL ON PLOTS 1 AND 2, 1954 – 1961

Year	Observation period	Number of days	Total number of seeds (M/acre)	Per cent sound	Total number of sound seed (M/acre)
1954	Sept. 5 – Oct. 17 ...	43	1,185	*	*
1955	Aug. 25 – Oct. 26 ...	63	1,476	*	*
1956	Aug. 16 – Oct. 21 ...	67	128	66	86
1957	Aug. 20 – Oct. 23 ...	65	14	39	5
1958	Aug. 15 – Sept. 30 ..	77	10	15	2
1959	Aug. 11 – Oct. 6	57	324	41	134
1960	Aug. 9 – Oct. 30 ..	83	5,625	59	3,303
1961	Aug. 1 – Nov. 27 ..	119	1,409	71	995

*No data.

TABLE 63 SEASONAL DISTRIBUTION OF SEED FALL PLOTS 1 AND 2, 1954–1961

Observation period	Number of seeds (M/acre)							
	1954	1955	1956	1957	1958	1959	1960	1961
August	–	358	14	1	4	35	509	187
September	238	964	70	6	5	143	4,289	875
October	947	154	44	7	1	146	827	312
November	–	–	–	–	–	–	–	35
Total.............	1,185	1,476	128	14	10	324	5,625	1,409

Reports *Unpublished (continued)*

Waldron, R.M. 1958. Supply, periodicity and dissemination of white spruce seed, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1962a. Supply, periodicity and dissemination of white spruce seed, Riding Mountain. Dept. of Forestry of Canada, For. Res. Br.

Waldron, R.M. 1962b. August-November seed and litter fall in a mature white spruce stand in Manitoba. Dept. of Forestry of Canada, For. Res. Br.

Waldron, R.M. 1962c. Seed maturity in white spruce, Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Waldron, R.M. 1964. Cone production and seedfall in a mature white spruce stand. Dept. of Forestry of Canada, For. Res. Br., Mimeo 64-MS-10.

Published

Rowe, J.S. 1953. Viable seed in white spruce trees in midsummer. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Silv. Leafl. No. 99.

Waldron, R.M. 1963. August-November seed and litter fall in a mature white spruce stand. For. Chron. 39(3): 333-334.

Project MS-159 Influence of litter and humus on white spruce regeneration, cut-over stands, Riding Mountain.

Classification 181.525:231.321:231.322:232.33:422.13:441

Investigator Past: J.S. Rowe

Objective To compare the germination and survival of white spruce seed and seedlings on four prepared seedbeds.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done Thirty-two, 1/1000-acre quadrats were set out in a cut-over, white spruce-aspen stand in the spring of 1951. Eight quadrats were lightly scarified, eight strongly scarified (to mineral soil), eight burned, and eight left as undisturbed controls. All plots were seeded with 600 viable white spruce seed in early June.

Periodic examinations were carried out to 1956.

Results

TABLE 64 EFFECT OF SEEDBED MEDIA ON THE GERMINATION AND EARLY SURVIVAL OF WHITE SPRUCE

Seedbed media	Number of germinates autumn 1951	Seedling survival (per cent)		Average height ten tallest in 1956 (inches)
		Autumn 1952	Autumn 1956	
Lightly scarified...........	549	58.6	10.4	7.0
Strongly scarified (mineral soil)	875	61.0	30.7	11.4
Burned	264	88.6	39.0	9.8
Undisturbed	113	10.6	0.9	–

Comments Germination was highest on seedbeds containing some mineral soil, intermediate on burned seedbeds and lowest on the undisturbed. Seedling survival after six years was highest on the burned and strongly scarified mineral soil, intermediate on the lightly scarified and lowest on the undisturbed. Mortality on the strongly scarified plot was largely attributed to frost heaving in the spring of 1952, and attributed to strong vegetative competition on the lightly scarified, undisturbed and burned seedbed.

Average height of the six-year-old seedlings reflects the degree of competition on the three prepared seedbeds.

Status Closed

Reports *Unpublished*

Rowe, J.S. 1951. Influence of litter and humus on spruce regeneration in cut-over mixedwood stands, Riding Mountain, Manitoba. Canada, Dept. Resources and Development, Forestry Branch.

Rowe, J.S. 1952. Influence of litter and humus on spruce regeneration in cut-over mixedwood stands, Riding Mountain, Manitoba. Canada, Dept. Resources and Development, Forestry Branch.

Rowe, J.S. 1958. The influence of litter and humus on white spruce regeneration in cut-over stands, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Reports

Unpublished (continued)

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Published

Rowe, J.S. 1953. Delayed germination of white spruce seed on burned ground. Canada, Dept. Resources and Development, Forestry Branch, For Res. Div., Silv. Leafl. No. 84.

Project MS-160 Planting white spruce, Riding Mountain Experimental Area. Study 1.

Classification: 232.411.3

Investigators Past: J.S. Rowe
Present: R.M. Waldron

Objective To determine the effect of transplant size (or age of stock) on the early survival and growth of white spruce planted out on grass- and hazel-covered sites.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done *Experiment #1*

In the spring of 1953 two sizes of white spruce transplants (4-inch 3-0 stock and 6-inch 2-2 stock) were set out on a cut-over area on which grass was the dominant minor vegetation. The soils are clay loam in texture. The planting area was classified as a moist site.

Periodic examinations were carried out.

Experiment #2

In the spring of 1954 four sizes of white spruce transplants (12-inch 2-4 stock, 9-inch 2-3 stock, 7-inch 3-2 stock, and 5-inch 3-1 stock) were set out on a cut-over area which later supported a dense cover of hazel and a lesser amount of grass. Soils are clay loam in texture and the planting area was classified as a moderately moist site.

Periodic examinations have been made.

Results

TABLE 65 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING OF 1956 EXPERIMENT #1

Age of stock	Average height when planted (inches)	Number of years since planting	Survival (%)	Average height (inches)	Basis: number of transplants
3–0	4	3	22	11	816
2–2	6	3	23	14	1,800

TABLE 66 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING OF 1956 EXPERIMENT #2

Age of stock	Average height when planted (inches)	Number of years since planting	Survival (%)	Average height (inches)	Basis: number of transplants
2–4	12	2	71	21	196
2–3	9	2	56	22	196
3–2	7	2	66	16	196
3–1	5	2	47	16	196

Comments On the grass covered planting site (expt. #1) there was no difference in transplant survival or height growth, in the spring of 1956, for the two sizes of stock used. This is probably explained by the fact that there was no real difference in total height at the time of planting.

On the hazel covered planting site (expt. #2) the largest stock had the highest survival and the smallest stock the lowest. There was little difference in the height growth of the various sized stock.

Status Continuing

Reports *Unpublished*

Rowe, J.S. 1954. Planting white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, For. Br., For. Res. Div.

Project MS-160 Planting white spruce, Riding Mountain Forest Experimental Area. Study 2.

Classification 232.4:232.21:441:451.2

Investigators Past: J.S. Rowe
Present: R.M. Waldron

Objective To determine the effect of mechanically preparing the planting site on the early survival and growth of planted white spruce.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done *Experiment 1*

In the spring of 1951, white spruce transplants were set out on scalped spots, approximately 18 inches square, which had been prepared using grub hoes and on 7-foot-wide strips disced with an Athens plough. Transplants were also set out on undisturbed areas. The planting area had been clear-cut in 1937 and at the time of planting the dominant lesser vegetation consisted of hazel and grasses. Soil texture is clay to clay loam and the planting area was rated as a moderately moist site.

Experiment 2

In the autumn of 1951 white spruce transplants were set out on scalped spots, approximately 18 inches square which had been prepared using grub hoes and on 7-foot-wide strips disced with an Athens plough. Transplants were also set out on undisturbed areas. No overstorey was present and the lesser vegetation consisted of a dense cover of hazel. Soils are clay loam in texture and the planting area was classified as a fresh site.

Experiment 3

In the spring of 1952 white spruce transplants were set out on 50-foot-square plots which had been prepared by scalping with a bulldozer blade and discing with an Athens plough. Transplants were also set out on undisturbed areas. No overstorey was present and the lesser vegetation consisted of dense hazel and lesser amounts of grass. Soils are clay loam in texture and the planting site was rated as being a moderately fresh site.

Periodic examinations have been carried out for the three experiments.

Results Results are given in Table 67.

Comments Survival of white spruce planted in 1951 was higher on prepared sites than on the undisturbed, and slightly higher on scalped than on disced strips. The latter is attributed to the fact that elk used the strips as runways and thereby trampled a large number of transplants.

Survival of white spruce planted in 1952 was higher on scalped plots than on disced or undisturbed plots. Shrub competition in the latter cases accounts for the low survival rate.

Status Continuing.

Reports *Unpublished*

Rowe, J.S. 1951. Planting spruce in disturbed stands, Riding Mountain Research Area. Canada, Dept. of Resources and Development, Forestry Branch.

TABLE 67 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING AND AUTUMN OF 1961

Year of treatment	Treatment	Number of years since planting	Survival (%)	Average height (feet)	Basis: number of transplants
Spring 1951	Scalped (spots)	10	58	4.1	992
	Disced (strips)	10	51	4.0	992
	Undisturbed	10	50	3.8	992
Autumn 1951	Scalped (spots)	10	61	4.4	774
	Disced (strips)	10	56	5.5	781
	Undisturbed	10	48	4.2	767
Spring 1952	Scalped (plots)	10	53	3.6	864
	Disced (plots)	10	35	3.5	216
	Undisturbed	10	37	3.7	864

Reports

Unpublished (continued)

Rowe, J.S. 1954. Planting white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Published

Waldron, R.M. 1964. The effect of pre-planting ground treatment on early survival and growth of planted white spruce. U.S.D.A. For. Ser., Tree Planters' Notes, No. 65:6-8

Project MS-160 Planting white spruce, Riding Mountain Experimental Area. Study 3.

Classification 232.43:451.2:441

Investigators Past: J.S. Rowe
Present: R.M. Waldron

Objective To determine the effect of various spacings on the early survival and growth of planted white spruce.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done *Experiment #1*

In the spring of 1953 white spruce transplants were set out at the following spacings: 1 foot x 1 foot, 2 feet x 2 feet, and 4 feet x 4 feet. The planting site had been clear cut in the winter of 1937 and only a few scattered aspen and spruce remained. Windfall and slash were removed and an Athens plough used to chop up hazel underbrush. The soils are a clay loam in texture and the planting area was classified as a fresh site.

Periodic examinations have been made.

Experiment #2

In the spring of 1953 white spruce were set out in groups of 21 transplants; the groups were spaced approximately 24 feet apart. Eighty-eight groups were set out on an area clear cut in 1942. The texture of the soil is clay loam. The planting area, which was rated as a fresh site, supported a very dense cover of grass.

Periodic examinations have been made.

Results

TABLE 68 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING OF 1956

Spacing (feet)	Number of years since planting	Survival (%)	Average height (in.)	Basis: number of transplants
1x1	3	95	19	300
2x2	3	89	18	300
4x4	3	79	20	300
Groups	3	61	No data	1,848

Comments Early survival was higher at the close spacing than at the wide spacing. The groups, which had a within spacing of three feet but were twenty-four feet apart, had the lowest survival. However, it is felt that the abundance of grass on this planting site, along with trampling by elk, resulted in the low survival.

Status Continuing.

Reports *Unpublished*

Rowe, J.S. 1959. Planting white spruce, Riding Mountain Experimental Area. Canada Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Project MS-160 Planting white spruce, Riding Mountain Experimental Area. Study 4.

Classification 232.44

Investigators Past: J.S. Rowe, C.L. Kirby
Present: R.M. Waldron

Objective To determine the effect of planting white spruce throughout the summer on early survival and growth.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done During the summers of 1952, 1953 and 1954, forty-five white spruce were planted each week between mid-May and early September. Approximately 600 transplants were planted each year. All planting sites were clear cut several years prior to planting. Ground treatments to reduce vegetative competition were carried out. Soils are clay to clay loam in texture. The areas planted in 1953 and 1954 were rated as fresh sites and the areas planted in 1952 as dry sites because of underlying gravel deposits.

Results No numerical data are available but general observation indicated the survival was equally good regardless of the date of planting.

Comments Nil

Status Continuing.

Reports *Unpublished*

Kirby, C.L. 1952. Planting of white spruce during the summer months, Riding Mountain Forest Experimental Area. Canada, Dept. of Resources and Development, For. Br.

Rowe, J.S. 1954. Planting white spruce Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Project MS-160 Planting white spruce, Riding Mountain Experimental Area. Study 5.

Classification 441:235.1

Investigators Past: J.S. Rowe, J.S. Jameson
Present: R.M. Waldron

Objective To determine the effect of lesser vegetation, principally hazel and grass, on the early survival and growth of planted white spruce.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done *Experiment #1*

In the spring of 1951 a small number of white spruce were set out under hazel and on an area cleared of hazel. The overstorey consisted of scattered trembling aspen, the lesser vegetation was dominated by hazel and soil texture was clay loam. The planting area was rated as a fresh site.

Periodic examinations were carried out.

Experiment #2

In the spring of 1954 a small number of white spruce were set out under hazel. One half of the transplants were released from the hazel in the autumn of 1954 by the application of an aqueous solution of 2,4-D as a foliage spray at a concentration of 1,875 p.p.m. Stand and soil descriptions were identical to that above.

Periodic examinations were carried out.

Experiment #3

In the spring of 1954 a mixed plantation of white spruce and jack pine was set out in an area that had been clear cut for aspen fuelwood in the autumn of 1952. At the time of planting a dense stand of hazel and aspen suckers covered much of the area. The site is a fresh-moist clay loam till. Periodic examinations have been carried out.

Experiment #4

In the spring of 1957 a moderate number of white spruce were set out under hazel and on an area cleared of hazel. Stand and soil descriptions are identical to that above.

Periodic examinations were carried out.

Experiment #5

In the spring of 1955 a large number of white spruce were set out in cut-over and undisturbed white spruce-trembling aspen stands. Residual basal areas varied from 30 to 180 square feet per acre; sites on clay to clay loam soils, varied from fresh to very wet. A wide variety of vegetative types were sampled, and for analysis purposes they were grouped as follows: short herbs, tall herbs, grasses, hazel, poplar suckers and alder. An examination was carried out in the spring of 1958.

Results Results are given in Tables 69, 70, 71, 72 and 73.

Comments The presence of herbaceous and underbrush species greatly reduced the early survival of planted white spruce and in the presence of hazel reduced height growth. The highest seedling survival was obtained when all competing vegetation was removed, intermediate survival was obtained where herbs, hazel, and poplar suckers were

TABLE 69 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE AUTUMN OF 1958 EXPERIMENT #1

Treatment	Number of years since planting	Survival (%)	Average height (inches)	Basis: number of transplants
Hazel removed	8	68	27	91
Hazel undisturbed	8	38	28	99

TABLE 70 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING OF 1958 EXPERIMENT #2

Treatment	Number of years since planting	Survival (%)	Average height (inches)	Basis: number of transplants
Hazel sprayed	4	57	17	147
Hazel undisturbed	4	29	11	147

TABLE 71 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING OF 1962 EXPERIMENT #3

Species	Number of years since planting	Survival (%)	Position of trees in relation to underbrush cover		Average height (inches)	Basis: number of transplants
			above	below		
			(% of those living)			
White spruce......	7	58	10	90	19	1,609
Jack pine.........	7	9	18	82	18	1,148

TABLE 72 TRANSPLANT SURVIVAL AND AVERAGE HEIGHT IN THE SPRING OF 1962 EXPERIMENT #4

Treatment	Number of years since planting	Survival (%)	Average height (inches)	Basis: number of transplants
Hazel removed	5	72	19	748
Hazel undisturbed	5	27	8	753

TABLE 73 TRANSPLANT SURVIVAL IN THE SPRING OF 1958 EXPERIMENT #5

Vegetation type	Species cover	Number of years since planting	Survival (%)	Basis: number of transplants
Herbs-grasses	Short herbs..........	3	41	2,114
	Tall herbs	3	32	1,923
	Grasses	3	21	615
Underbrush	Poplar suckers	3	39	589
	Hazel	3	38	1,005
	Alder	3	14	142
Nil	Nil	3	79	81

present, and lowest survival where grasses and alder were present. The low survival under alder probably reflects the periodic flooding which occurs on the wet site where it grows rather than competition for light and moisture. White spruce transplants survived better under dense hazel and aspen suckers than jack pine transplants.

Status Continuing.

Reports *Unpublished*

Rowe, J.S. 1951. Planting spruce in disturbed stands Riding Mountain Research Area. Canada, Dept. of Resources and Development, For. Br.

Jameson, J.S. 1956. Planting white spruce, Riding Mountain. Canada Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1958. Planting white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Wheaton, M.P.H. 1959. Planting white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

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

Waldron, R.M. 1961. Planting white spruce in disturbed stands, Riding Mountain Experimental Area. Dept. of Forestry of Canada, For. Res. Br.

Cayford, J.H. and R.M. Waldron. 1962. Regenerating jack pine on the Riding Mountain National Park in western Manitoba. Dept. of Forestry of Canada, For. Res. Br.

Waldron, R.M. 1963. Planting white spruce in cut-over and undisturbed white-spruce-aspen stands in Manitoba. Dept. of Forestry of Canada, For. Res. Br.

Published

Cayford, J.H. and R.M. Waldron. 1963. Regeneration trials with jack pine on clay soils in western Manitoba. For. Chron. 39(4): 398-400.

Project MS-161 Viable white spruce seed in the humus layer, Riding Mountain.

Classification 181.524

Investigator Past: J.S. Rowe

Objective To determine the amount of viable white spruce seed in the humus layer under a mixedwood stand.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done In June of 1950, approximately twenty months after the heavy seed fall of 1948, and 9 months after the nil seed fall of 1949, ten square-foot samples of the humus layer, each three inches thick, were obtained in the vicinity of mature white spruce trees in a mixedwood stand. These samples were carefully screened and a search made for white spruce seed.

The experiment was replicated in the summer of 1951 following the light seed crop of 1950, only this time the 100 humus samples, each one-foot square and three inches deep, were watered frequently during the summer to keep the surface moist.

Results No sound seeds were found in the humus samples collected in 1950 but one seedling was observed in the 1951 samples.

Comments No evidence was found in this study to support the contention that white spruce seed is stored in the humus layer. Rather, it appears that little if any survives the year following its deposition on the ground.

Status Closed

Reports *Unpublished*

Rowe, J.S. 1958. Viable white spruce seed in the humus layer. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Project MS-166 Cutting methods for management of white spruce, Riding Mountain.

Classification 231.31:231.321:221.02:441

Investigators Past: R.T. Pike
Present: R.M. Waldron

Objective To determine, in conjunction with scarification, which of five methods of cutting white spruce in mixed stands is most favourable to spruce regeneration.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done In the autumns of 1953, 1954 and 1955 the following series of cutting methods was carried out on six 10-acre compartments set out in mixedwood stands on the Riding Mountain Forest Experimental Area:

1. Control – no cutting.
2. Hardwoods only removed.
3. Leaving 15 square feet basal area white spruce per acre and all hardwoods.
4. Leaving 15 square feet basal area white spruce per acre; hardwoods cut.
5. Leaving 30 square feet basal area white spruce per acre and all hardwoods.
6. Leaving 30 square feet basal area white spruce per acre; hardwoods cut.

Prior to cutting, the stands supported approximately 54 square feet basal area of white spruce and 49 square feet basal area of trembling aspen per acre.

In conjunction with these cutting methods, ten scalped strips, four feet wide, ten chains long, and one chain apart, were prepared on each compartment using a light bulldozer and blade during the autumn of 1955.

A total of 3,600, 1/4000-acre quadrats were set out on the scalped strips during the summer of 1956. Seedling counts were made in the autumns of 1957 and 1958, and in the springs of 1960 and 1962.

Results

TABLE 74 STOCKING TO WHITE SPRUCE SEEDLINGS SIX YEARS FOLLOWING SCALPING IN CUT-OVER AND UNDISTURBED MIXEDWOOD STANDS

Cutting method	Residual basal area (sq.ft. per acre)			Stocked quadrats* (%)	Number of seedlings (per acre)	Average height tallest seedling (inches)
	W. spruce	T. aspen	Total			
1	62	56	118	76	2,600	4.5
2	60	–	60	63	1,500	4.3
3	15	43	58	80	3,400	7.0
4	16	–	16	63	1,200	5.4
5	31	49	80	79	3,400	5.1
6	31	–	31	70	2,300	5.5

* 1/1000-acre basis. Conversion from 1/4000-acre quadrats made using Grant's (1952) formula.

Comments Six years following seedbed treatment over 60 per cent of the quadrats were stocked with a minimum of 1,200 seedlings per acre. The highest per cent stocking occurred where the spruce content was reduced to 15 and 30 square feet basal area and the trembling aspen left untouched. Intermediate stocking was obtained on the control and the lowest per cent stocking where the trembling aspen had been removed. These results would indicate that aspen leaves from mature trees are less serious obstacles to the regeneration of white spruce than the increased competition from aspen suckers and other vegetation following the removal of the aspen overstorey.

No definite trends were observed with regard to height growth.

All regeneration quadrats will be re-examined in the spring of 1965.

Status Continuing.

Reports *Unpublished*

Pike, R.T. 1954. Cutting methods for management of white spruce, Riding Mountain research area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For, Res. Div.

Pike, R.T. 1955. Cutting methods for management of white spruce, Riding Mountain Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Pike, R.T. 1956. Cutting methods for management of white spruce, Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1957. Cutting methods for management of white spruce – Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1958. Cutting methods for management of white spruce, Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Wheaton, M.P.H. 1959. Cutting methods for management of white spruce, Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1960a. Cutting methods for management of white spruce. Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1960b. Cutting methods for management of white spruce, Riding Mountain Forest Experimental Area. Canada, Dept. Northern Affairs and National Resources. Forestry Branch, For. Res. Div.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Waldron, R.M. 1964. Cutting methods for management of white spruce, Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 64-MS-13.

Project MS-167 The effect of poplar on white spruce in a mixedwood stand.

Classification 181.65:228.1

Investigator Past: J.H. Cayford.

Objective To provide information on the effect of early aspen dominance on the development of white spruce.

Work done In 1953 five mixedwood stands were selected near Big River and Candle Lake in Saskatchewan. Within each stand, 10 groups of three trees each of similar age (one free growing spruce, one suppressed spruce, and the main competing aspen adjacent to the suppressed spruce) were selected.

Stem analysis was made of each tree. For spruce, radial increment for 5-year periods and bark thickness both at diameter breast height were also recorded.

Results Height and diameter growth of white spruce may be reduced considerably as a result of suppression from the aspen over-storey.

In stands up to 100 years of age the volume of white spruce may be reduced by as much as 50 per cent as compared with that of nearby free growing white spruce.

An aspen overstorey will lower the quality of the white spruce which it suppresses by damaging leaders as a result of whipping and by causing defects such as forked top, crook and sweep.

Comments Release cutting to favour white spruce is suggested as silvicultural treatment, preferably as soon as the white spruce has become established.

Status Closed.

Reports *Published.*

Cayford, J.H. 1957. Influence of the aspen overstorey on white spruce growth in Saskatchewan. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div., Tech. Note No. 58.

Project MS-168 A site classification for the Riding Mountain Experimental Area.*

Classification 114.4:114.32

Investigators Past: J.S. Rowe, J.S. Jameson
Present:

Objective To develop a site classification for the Riding Mountain Experimental Area.

Location Riding Mountain Forest Experimental Area.

Work done During 1951 and 1952 within the Riding Mountain Forest Experimental Area several permanent sample plots belonging to project MS-69 were classified according to soil association, soil profile type, soil moisture regime, soil texture and fabric; lesser vegetation was also described. From these data five forest site types were synthesized for the Riding Mountain Forest Experimental Area.

Results Results are given in Table 75.

Status Continuing.

Reports *Unpublished*

Rowe, J.S. 1954. Forest sites, Riding Mountain Experimental Area, progress report. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

*Project summary prepared by J.S. Jameson.

TABLE 75 FOREST SITE TYPES
RIDING MOUNTAIN FOREST EXPERIMENTAL AREA

Site type no.	Moisture	Moisture regimes	Soil texture and origin	Pore pattern	Vegetation type	Height of white spruce at maturity (feet)
1	Dry to fresh	0–2	Coarse sands gravels and bouldery sandy clay loam till	1–3	Low grass herb (Elymus-Fragaria)	Approx. 70
2	Fresh to moist	2–4	Loam to clay loam tills & lacustrine	4–5	Shrub-herb (Corylus-Aralia)	Approx. 90
3	Moist to very moist	4–6	Clay loam till, loam to clay lacustrine	5–6	Grass-herb (Calamagrostis-Solidago)	Approx. 80
4	Wet	6+	Shallow peat & muck-swamp borders	–	Feather moss (Mnium-Climacium)	Approx. 70
5	Very wet	7+	Deep peat in depressions	–	Sphagnum moss (Sphagnum)	Approx. 60

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

Classification 114.4:114.32

Investigators Past: J.S. Rowe, D. Mueller-Dombois, J.S. Jameson

Objective To develop a site classification for the forested lands of Saskatchewan and Manitoba.

Location District wide.

Work done In 1957 a site classification was synthesized for white spruce, black spruce and jack pine in Manitoba and Saskatchewan. It was based on physiographic co-ordinates and the data used were obtained from various studies throughout the District.

Results A total of 8 site classes (and 8 sub-classes) was defined for white spruce, 7 for jack pine, and 8 for black spruce. Because of a shortage of mensurational data, ranking of site classes according to productivity is somewhat subjective. The classification for white spruce is given in Table 76.

Status Closed.

Reports *Unpublished*

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

*Project summary prepared by J.S. Jameson.

TABLE 76 SITE CLASSES IN THE MIXEDWOOD SECTION

Site class	Origin	Texture	Moisture regime	Height at 80 years (feet)
A	Marginal lake and alluvial deposits, overwash sands on till, waterworked loamy tills	Sandy loam to loam	Fresh to moist	88
B_1	Unmodified tills (slightly calc.). Marginal or ground moraines	Clay loam to clay	Fresh to moist	84
B_2	Unmodified mod. calc. tills	" "	" "	84
C_1	Subluvial, drained depressions on tills, lower slopes of tills.	Clay loam to clay	Moist to very moist	No data
C_2	Alluvial flood plains	Silty sand	" "	" "
C_3	Seepage slopes	Silty sand to clay loam	" "	" "
C_4	Non-telluric undrained depressions	Clay loam to clay	" "	" "

Continued

TABLE 76 (continued).

Site class	Origin	Texture	Moisture regime	Height at 80 years (feet)
D	Marginal lake and alluvial deposits, overwash sands on till, waterworked coarse loamy tills.	Sandy loam to loam	Dry to mod. fresh	Approx. 70
E	Unmodified tills, marginal or ground moraines.	Clay loam to clay	Dry to mod. fresh	Approx. 70
F	Glacial outwash, deltaic deposits, beaches, kames and eskers.	Coarse sand and gravel to fine sand	Mod. fresh to moist	No data
G_1	Telluric mucks.	Muck/lac. clay	Wet	60
G_2	Non-telluric level plains.	Lacustrine clay. Organic terrain from sedge.	Wet	60
H	Glacial outwash, deltaic deposits, beaches, kames and eskers.	Coarse sand and gravel to fine sand.	Very dry to dry	60

Project MS-166 Cutting methods for management of white spruce, Riding Mountain.

Classification 231.31:231.321:221.02:441

Investigators Past: R.T. Pike
Present: R.M. Waldron

Objective To determine, in conjunction with scarification, which of five methods of cutting white spruce in mixed stands is most favourable to spruce regeneration.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done In the autumns of 1953, 1954 and 1955 the following series of cutting methods was carried out on six 10-acre compartments set out in mixedwood stands on the Riding Mountain Forest Experimental Area:

1. Control – no cutting.
2. Hardwoods only removed.
3. Leaving 15 square feet basal area white spruce per acre and all hardwoods.
4. Leaving 15 square feet basal area white spruce per acre; hardwoods cut.
5. Leaving 30 square feet basal area white spruce per acre and all hardwoods.
6. Leaving 30 square feet basal area white spruce per acre; hardwoods cut.

Prior to cutting, the stands supported approximately 54 square feet basal area of white spruce and 49 square feet basal area of trembling aspen per acre.

In conjunction with these cutting methods, ten scalped strips, four feet wide, ten chains long, and one chain apart, were prepared on each compartment using a light bulldozer and blade during the autumn of 1955.

A total of 3,600, 1/4000-acre quadrats were set out on the scalped strips during the summer of 1956. Seedling counts were made in the autumns of 1957 and 1958, and in the springs of 1960 and 1962.

Results

TABLE 74 STOCKING TO WHITE SPRUCE SEEDLINGS SIX YEARS FOLLOWING SCALPING IN CUT-OVER AND UNDISTURBED MIXEDWOOD STANDS

Cutting method	Residual basal area (sq. ft. per acre)			Stocked quadrats* (%)	Number of seedlings (per acre)	Average height tallest seedling (inches)
	W. spruce	T. aspen	Total			
1	62	56	118	76	2,600	4.5
2	60	–	60	63	1,500	4.3
3	15	43	58	80	3,400	7.0
4	16	–	16	63	1,200	5.4
5	31	49	80	79	3,400	5.1
6	31	–	31	70	2,300	5.5

* 1/1000-acre basis. Conversion from 1/4000-acre quadrats made using Grant's (1952) formula.

Comments The oldest trees vary in age from about 100 to 120 years. The spruce is uneven aged; the aspen is mostly even aged. The number of merchantable trees, merchantable and total volume per acre and height of white spruce at index diameters and ages were greater on the fresh site than on the moist. The better growth on the fresh site was attributed to better soil texture, structure, etc. The study has provided valuable data on the capabilities of the two sites. Basal areas in these fully stocked stands were more than double the average for the entire area. The mixedwood types on the fresh sites contained over 1,000 cu. ft. per acre more than similar types on the moist sites (Table 77). For all cover types combined, merchantable volume was also about 1,000 cu. ft. per acre greater on the fresh sites than on the moist.

Status Continuing.

Reports *Unpublished*

Jameson, J.S. 1960. The evaluation of the growth potential of site. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Published

Jameson, J.S. 1963. Comparison of tree growth on two sites in the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, Publication No. 1019.

Project MS-184 Growth studies of white spruce in relation to environment.

Classification 181.65:181.8

Investigators Past: J.S. Rowe, M.P.H. Wheaton
Present: R.M. Waldron

Objective To obtain basic information on the growth of white spruce in the seedling, sapling and tree stages, with particular attention to phenology and rate of growth of terminals, boles and roots, and to relate the observed growth phenomena with measurable features of site, such as temperature and moisture.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done Between 1955 and 1959 phenological observations and measurements of terminal, radial and root growth of white spruce were made on a large number of seedlings and trees situated on various sites and under a variety of stand structures. During the same period records on the following climatic phenomena were kept: air temperature (maximum and minimum), soil temperatures at 10, 20, 50, 100 and 140 c.m. depth, rainfall, dew formation and evaporation. Complete weather records were also available from a nearby permanent weather station.

Results To date, only data concerning the terminal growth of white spruce saplings have been analyzed. Results were as follows:

Phenology. – Terminal growth of white spruce at the Riding Mountain Forest Experimental Area begins in late May or early June and ends in mid-July, a period of some 48 days. The mean air temperature for two weeks prior to the initiation of growth for the years examined averaged 51°F. Day length on the day terminal growth began averaged 16 hours. Soil temperatures were slightly to well above freezing.

Total growth. – Total growth varied from year to year and appeared to be related to climatic conditions during both the previous and current growing seasons. Above normal maximum and minimum air temperatures in 1957 ten days prior to the completion of total terminal growth (approximately at the time when the next year's vegetative buds were being formed) resulted in a significant decrease in terminal growth in 1958 on all plots.

Total growth also varied between plots. Trees growing on dry sites and under dense hazel and aspen overstorey grew significantly less than open-grown trees on a very moist site in every year examined.

Rate of growth. – For all years examined growth during the night was greater than during the day. A definite relationship was found between the rate of growth during the night and minimum air temperature. Decreases in night temperatures were accompanied by decreases in the rate of growth and vice versa. No clear relationship could be found between the rate of growth during the day and maximum air temperature, indicating that other factors were operative during this period.

Comments Results of this study indicate that the terminal growth behaviour of white spruce follows the normal, or more commonly found pattern reported by other investigators for other tree species studied in North America.

Analyses of radial and root growth will be carried out in the near future.

Status Continuing.

Reports *Unpublished*

Wheaton, M.P.H. 1956. Growth studies of white spruce. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Wheaton, M.P.H. 1957. White spruce growth in relation to environment. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Wheaton, M.P.H. 1958a. White spruce growth in relation to environment. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Wheaton, M.P.H. 1958b. White spruce growth in relation to environment. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1962. White spruce growth in relation to environment. Dept. of Forestry of Canada, For. Res. Br.

Project MS-191 A study of the survival of seeded white spruce in relation to microhabitat, Riding Mountain, 1956, Study 1.

Classification 181.525:231.321:232.33

Investigators Past: J.S. Rowe
Present: R.M. Waldron

Objective To study the survival of white spruce seedlings under a variety of environmental conditions, both natural and artificially created, in aspen and in open woodlands, to develop satisfactory techniques for regenerating this species.

Location Riding Mountain Forest Experimental Area Manitoba.

Work done In the spring of 1956 three methods of seeding white spruce – – in the humus layer, in moss, and on scalps – – at the base of aspen were tested in dense young and open mature stands. As a control seeding was carried out on scalped spots prepared between the aspen.

Periodic examinations were carried out until the autumn of 1959.

Results

TABLE 79 FIRST-YEAR STOCKING TO WHITE SPRUCE ON MICRO-HABITATS PREPARED IN THREE STAND CONDITIONS

Stand	Per cent stocking to one-year-old white spruce seedlings			
	Moss at the base of aspen*	Humus at the base of aspen+	Mineral soil scalps	
			Base of aspen	Between aspen
1	3	8	72	96
2	–	–	60	80
3	–	–	17	32

*Average of three trials.
+Average of two trials.

TABLE 80 STOCKING TO WHITE SPRUCE ON MINERAL SOIL SCALPS PREPARED IN THREE STAND CONDITIONS FOUR YEARS AFTER SEEDING

Stand	Per cent stocking to four-year-old white spruce seedlings -mineral soil scalps	
	Base of aspen	Between aspen
1	10	6
2	8	0
3	1	0

Comments Results indicate that scalps prepared at the base of aspen were more favourable for germination of white spruce seed than either of the other two seedbeds tested and for seedling survival more favourable than control scalps prepared between trees. However, the low survival even in the scalps at the base of aspen would tend to discourage the use of this seeding technique as a practical means of stand conversion.

Status Closed.

Reports

Unpublished

Rowe, J.S. 1957. A study of the survival of seeded white spruce in relation to microhabitat, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1958. A study of the survival of seeded white spruce in relation to microhabitat, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Published

Waldron, R.M. 1961. Seeding white spruce at the base of aspen. For. Chron. 37(3): 224-227, 233.

Project MS-191 A study of the survival of seeded white spruce in relation to microhabitat, Riding Mountain, 1956. Study 2.

Classification 181.525:231.321:232.33

Investigators Past: J.S. Rowe
Present: R.M. Waldron

Objective To study the survival of white spruce seedlings under a variety of environmental conditions, both natural and artificially created, in aspen and in open woodlands, to develop satisfactory techniques for regenerating this species.

Location Riding Mountain Forest Experimental Area, Manitoba.

Work done In the spring of 1957 white spruce was seeded on three hand-made microtopographic seedbeds -- mineral soil scalps, mineral soil ridges and humus ridges. The ridges were oriented in both east-west and north-south directions. An equal number of viable seeds was applied to each seedbed.

Periodic seedling counts were carried out until the autumn of 1959.

Results

TABLE 81 EFFECT OF MICRO-TOPOGRAPHY AND ASPECT ON THE GERMINATION OF WHITE SPRUCE SEED ARTIFICIALLY APPLIED ON MINERAL SOIL AND HUMUS SEEDBEDS IN 1957

Micro-topography	Aspect	Seedbed medium	Number of germinates in 1957 M/ac.	Ratio: sound seed sown / number of germinates	Basis: number of germinates
Level (–)		Mineral soil	138	5	1,236
Ridge (∧)		Mineral soil	13	90	76
		Humus	10	115	59
	North	Mineral soil or humus	21	55	135
	East		12	100	
	South		9	130	
	West		5	240	

TABLE 82 EFFECT OF MICRO-TOPOGRAPHY AND ASPECT ON THE SURVIVAL OF WHITE SPRUCE SEEDLINGS GROWING ON MINERAL SOIL AND HUMUS SEEDBEDS, 1957–1959

Micro-topography	Aspect	Seedbed medium	Seedling survival-per cent				Basis: number of germinates
			1957		1958	1959	
			spring	autumn	autumn	autumn	
Level (–)		Mineral soil	100	59	30	28	1,236
Ridge (∧)		Mineral soil	100	69	23	15	76
		Humus	100	60	30	20	59
	North	Mineral soil or humus	100	62	19	14	135
	East		100	75	42	33	
	South		100	78	22	11	
	West		100	40	0	0	

Comments Germination of white spruce seed was higher on level mineral soil seedbeds than on ridged ones. On the ridges germination was only slightly higher on the mineral soil than on the humus seedbed. Germination was highest on a north-facing slope, intermediate on east- and south-facing slopes, and lowest on a west-facing slope.

Seedling survival after three years was low for all seedbed conditions. Survival was higher on level mineral soil seedbeds than on ridged ones (all aspects combined) and slightly higher on humus ridges than on mineral soil ridges. Seedling survival on ridges was highest on the east-facing slope, intermediate on north- and south-facing slopes, and lowest on the west-facing slope.

Status Continuing.

Reports *Unpublished*

Rowe, J.S. 1957. A study of the survival of seeded white spruce in relation to microhabitat, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1958. A study of the survival of seeded white spruce in relation to microhabitat, Riding Mountain. Canada, Dept. Northern Affairs and National Resources, Forestry Branch, For. Res. Div.

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo. 63-MS-30.

Project MS-211 Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Study 1.

Classification 231.321:221.222:424.2

Investigator Present: J.M. Jarvis

Objective To determine whether clear cutting 2-chain-wide strips in an east-west direction in mature white spruce stands and mechanical seedbed preparation will result in adequate spruce regeneration.

Location Study areas to date are located approximately 12 miles south of Hudson Bay, 30 miles north of Prince Albert, and 50 miles southwest of Lac la Ronge, Saskatchewan.

Work done This is a co-operative project; the Saskatchewan government supervises logging and scarification; the Department of Forestry assesses the regeneration. Initial work started in 1959; so far four areas have been established; a fifth area was logged during the winter of 1963-64. Seedbeds on two of the established areas were made with the Saskatchewan fire-line plow; a bulldozer blade was used on the others.

Randomly located permanent milliacre quadrats and permanent transects (2 feet wide) have been established on three of the areas to date to assess regeneration.

Results Results to date are summarized in Tables 83 and 84.

TABLE 83 STOCKING TO WHITE SPRUCE ONE YEAR AFTER SCARIFICATION

Location	Scarifying equipment	Per cent quadrats stocked*		
		Cut and scarified	Cut not scarified	Neither cut nor scarified
Area 1 (near Hudson Bay)	Saskatchewan fire-line plough	63	4	1
Area 2 (near Prince Albert)	Bulldozer blade	56	+	3
Area 3 (near Lac la Ronge)	Saskatchewan fire-line plough	38	1	<1

* Based on randomly located milliacre quadrats (900 on Area 1, 600 on Area 2, and 900 on Area 3).

\+ No data taken.

Comments The results to date show that white spruce regeneration is much more abundant on the scarified areas than on the unscarified areas. Within the scarified areas stocking is usually better on the south half of the strips than on the north half. The south wall of trees casts shade over the south half of the clear-cut strips, creating more favourable environments, thus resulting in better regeneration.

Practically all seedbeds created have been a suitable medium for germination. However mortality has been taking its toll of seedlings and the final outcome is still not known. Mortality has been greater on seedbeds made by the fire-line plow than on those made by the bulldozer blade. The fire-line plow digs a furrow creating a ridge on either side. Often the furrow is deep and the slope from ridge top to furrow bottom is very steep. During rainstorms the furrow is subject to flooding and sedimentation while the slopes are subject to erosion.

TABLE 84 NUMBER WHITE SPRUCE SEEDLINGS 1961 AND 1962, AND SURVIVAL 1961-62, BY SEEDBED, CUT-OVER AND SCARIFIED CONDITIONS

Seedbed type*	Area 1 (near Hudson Bay)				Area 2 (near Prince Albert)			
	No./acre (Thousands)			Per cent 1961 germinants surviving in July 1962	No./acre (Thousands)			Percent 1961 germinants surviving in July 1962
	1961 germinants		1962 germinants		1961 germinants		1962 germinants	
	July 1961	July 1962	July 1962		July 1961	July 1962	July 1962	
L	3	1	9	33	1	0	0	0
F	75	19	34	25	**	**	**	**
H	52	18	64	35	6	6	0	100
A	109	48	82	44	27	22	0	82
B	**	**	**	**	89	67	1	75
F/L	18	9	35	50	6	2	0	33
H/L	41	20	42	50	**	**	**	**
A/L	22	13	45	51	63	55	0	87
B/L	**	**	**	**	39	31	0	80
Ld	**	**	**	**	5	5	0	100
S	0	0	0	0	0	0	0	0
Dw	73	36	17	50	2	2	0	100
M	0	0	0	0	**	**	**	**
D	0	0	0	0	0	0	0	0
FM	**	**	**	**	0	0	0	0
All	30***	12***	38***	40***	49***	37***	1***	75***

*L, F, H – organic horizons } L horizon undisturbed, the remainder exposed by
A and B – mineral horizons } the bulldozer blade of fire-line plough.

F/L – material from F horizon dumped on undisturbed litter
H/L – " " H " " " "
A/L – " " A " " " "
B/L – " " B " " " "
Ld – litter disturbed by tracks of tractor
S – slash
Dw – decayed wood
M – mixture of organic and mineral materials
D – piles of debris
FM – feather mosses
**No data
***Weighted averages

Observations have shown that erosion and burial were major factors causing seedling mortality on those areas treated with the fire-line plow. Therefore, it is recommended that wherever possible a bulldozer blade be used for scarification in preference to the fire-line plow. However, on very moist to wet areas the plow is about the only tool which can be used efficiently as it can be manoeuvered easily between stumps and around obstacles without much danger of the tractor becoming stuck.

New germinates were more abundant on the area near Hudson Bay in 1962 than on the area near Prince Albert. This is attributed to a heavier seed crop in the former area (see project MS-211, Study 2).

Plots to assess regeneration on Area 4 will be established in 1964 and on Area 5 as soon as feasible; additional areas will be added to the study until it is sufficiently replicated.

Status Continuing

Reports *Unpublished*

Jarvis, J.M. 1959. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration Saskatchewan. Canada, Dept. Northern Affairs and National Resources, For. Br., For. Res. Div.

Jarvis, J.M. 1961. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration Saskatchewan. Dept. of Forestry of Canada, For. Res. Br.

Jarvis, J.M. 1962. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration Saskatchewan, Dept. of Forestry of Canada, For. Res. Br.

Jarvis, J.M. 1963. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-2.

Kolabinski, V.S. 1964. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 64-MS-22.

Project MS-211 Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Study 2.

Classification 181.523:221.222

Investigator Present: J.M. Jarvis

Objective To study seed production and seed fall in pure white spruce stands which have been logged by clear cutting alternate 2-chain-wide strips.

Location This study is being carried out in two stands, one about 12 miles south of Hudson Bay, the other about 30 miles north of Prince Albert, Saskatchewan.

Work done This is a co-operative study with the Saskatchewan government: a series of seed traps have been maintained by the Saskatchewan government in the stand located near Prince Albert since 1960; the Department of Forestry has maintained traps in the other stand since 1961.

Results Results to date are summarized in Table 85

TABLE 85 WHITE SPRUCE SEED FALL

Treatment	Number seeds per acre		
	1960	1961	1962
		Stand near Prince Albert	
Uncut strips*	3,005,640	87,120	2,308,680
Cut-over strips			
south 1/3	1,350,360	43,560	1,131,560
centre 1/3	1,131,560	43,560	1,393,920
north 1/3	1,001,880	43,560	1,219,680
		Stand near Hudson Bay	
Uncut strips*	**	2,138,000	1,388,182
Cut-over strips			
south 1/3	**	2,600,000	1,018,333
centre 1/3	**	1,998,000	892,500
north 1/3	**	2,346,000	953,333

*Seed fall did not vary appreciably across strip
**No data

Comments The results of this study indicate seed has been well dispersed across the cut-over strips. Since almost as many seeds have fallen near the centre of these strips as near the edge, it would appear that strips could be made wider and still have adequate dispersal. The poor seedcrop in 1961 in the stand near Prince Albert is undoubtedly the reason why so few new germinants were found there in 1962 (see Project MS-211, Study 1).

Status Continuing.

Reports *Unpublished*

Jarvis, J.M. 1962. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br.

Jarvis, J.M. 1963. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br. Mimeo 63-MS-2.

Project MS-211 Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Study 3.

Classification 232.4:221.222:451.2:441

Investigator Present: J.M. Jarvis

Objective To study survival and development of planted white spruce seedlings set out in pure white spruce stands which had been logged by clear cutting alternate 2-chain-wide strips.

Location This study is being carried out in two stands, one about 12 miles south of Hudson Bay, the other about 30 miles north of Prince Albert, Saskatchewan.

Work done In June 1961 white spruce seedlings (2-2 stock) were slit-planted by the Saskatchewan government on cut-over scarified strips, cut-over unscarified strips, and on uncut strips. Seedling development is being studied by the Department of Forestry.

Results Results to the end of the 1963 growing season are summarized in Table 86.

TABLE 86 SURVIVAL, GROWTH, CONDITION AND BROWSING DAMAGE, WHITE SPRUCE PLANTED IN 1961

Planting site	Number planted	Per cent survival		Average ht. growth of survivors (in.)		Condition of survivors*				Per cent survivors browsed	
						1962		1963			
						Healthy	Sickly	Healthy	Sickly		
		1962	1963	1962	1963	Per cent				1962	1963
Stand near Hudson Bay											
Cut-over scarified.....	321	80	73	2.0	4.0	82	18	96	4	61	0
Cut-over unscarified ..	314	60	54	2.8	3.7	80	20	91	9	81	1
Uncut	322	50	37	0.4	1.6	60	40	83	17	98	3
Stand near Prince Albert											
Cut-over scarified	201	69	66	2.7	2.3	96	4	99	1	55	0
Cut-over unscarified ..	....	.....	.....	.....	no data		....	....	....	.....	.....
Uncut	179	61	52	1.0	0.6	77	23	91	9	92	0

*Includes browsed seedlings; if seedling had good colour and the unbrowsed shoots were not stunted, seedlings were classed as healthy; otherwise they were classed as sickly.

Comments On the area near Hudson Bay survival, growth and health of seedlings were best in the cut-over scarified strips, poorest on the uncut strips, and intermediate on the cut-over unscarified strips. On the area near Prince Albert survival growth and health of seedlings were better on the scarified strips than on the uncut strips. Rabbit browsing was severe in 1962 with the greatest occurrence being in the uncut strips.

Status Continuing.

Reports *Unpublished*

Jarvis, J.M. 1962. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br.

Jarvis, J.M. 1963. Clear cutting alternate strips and scarifying in pure white spruce stands to induce white spruce regeneration, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-2.

Project MS-216 Clear cutting alternate strips and scarifying in white spruce-trembling aspen stands to induce white spruce regeneration, Manitoba and Saskatchewan.

Classification 231.321:221.222

Investigator Present: J.M. Jarvis

Objective To determine whether cutting 2-chain-wide strips in an east-west direction in mature white spruce-trembling aspen stands, and mechanical seedbed preparation, will result in adequate regeneration.

Location Study areas to date are located in the Riding Mountain National Park in Manitoba and about 50 miles southwest of Lac la Ronge in Saskatchewan.

Work done This is a co-operative project; so far two areas have been established. On the area at the Riding Mountain, seedbeds were made with a bulldozer blade in the fall of 1961; logging was done during the winter of 1961-62. On the area near Lac la Ronge seedbeds were made with the Saskatchewan fire-line plow; logging had been done during the winter of 1960-61.

Randomly located permanent milliacre quadrats have been established on both areas to assess regeneration. At the Riding Mountain permanent transects (2 feet wide) have also been established to study seedling survival and development on specific seedbeds.

Results Results are summarized in Tables 87 and 88

TABLE 87 STOCKING TO WHITE SPRUCE ONE YEAR AFTER SCARIFICATION

Location	Scarifying equipment	Per cent quadrats stocked*		
		Cut and scarified	Cut not scarified	Not cut not scarified
Area 1 (Riding Mountain)	Bulldozer blade ...	69	1	2
Area 2 (near Lac la Ronge)	Saskatchewan fire-line plough..	68	5	2

*Basis 200 quadrats in each condition on each area.

Comments Results show that white spruce regeneration is much more abundant on scarified areas than on unscarified areas. At the Riding Mountain all seedbeds made by the bulldozer blade, except piles of debris, appeared to be suitable germinating media.

Status Continuing.

Reports *Unpublished*

Jarvis, J.M. 1962. Clear cutting alternate strips and scarifying in white spruce-aspen stands to induce white spruce regeneration, Manitoba and Saskatchewan. Dept. of Canada, For. Res. Br.

Kolabinski, V.S. 1963. Clear cutting alternate strips and scarifying in white spruce-aspen stands to induce white spruce regeneration, Manitoba and Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-16.

Kolabinski, V.S. 1964. Clear cutting alternate strips and scarifying in white spruce-aspen stands to induce white spruce regeneration, Manitoba and Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 64-MS-15.

TABLE 88 NUMBER OF WHITE SPRUCE SEEDLINGS PER ACRE BY SITE AND SEEDBED TYPE, SCARIFIED AREAS, ONE YEAR AFTER TREATMENT, RIDING MOUNTAIN

Seedbed* type	Number per acre (thousands)**		
	Fresh site	Moderately moist site	Moist site
L	1	0	16
F	15	5	13
H	10	59	18
A	9	85	14
B	20	–	19
B/L	26	–	17
A/L	–	17	23
H/L	8	16	33
F/L	5	0	–
L/B	0	0	–
S/H	30	160	–
S/B	19	–	10
S/A	–	32	–
LD	5	10	42
A1	0	–	–
S	0	3	–
D	0	3	–
Br	0	–	–
Ch	–	4	–
As	–	0	–
M	5	–	5
Dw	0	0	0

– Seedbed not encountered.

* Seedbed types defined as follows:

L,F,H, - organic horizons } L horizon undisturbed, the remainder exposed
A,B - mineral horizons } by the bulldozer blade.
B/L -material from B horizon deposited on undisturbed litter.
A/L - " " A " " " " "
H/L - " " H " " " " "
F/L - " " F " " " " "
L/B - litter deposited on B horizon
S/H - light slash and needle deposited on H horizon.
S/A - " " " " " A "
S/B - " " " " " B "
L/D - litter disturbed by action of tractor.
A1 - alluvium deposit.
Br - charcoal and ash resulting from the burning of slash.
Ch - charcoal resulting from the burning of slash.
As - ash resulting from the burning of slash.
M - mixture of organic and mineral materials.
S - light slash and needles.
D - debris including organic matter and mineral soil pushed up in piles by the bulldozer.
Dw - decayed wood.

**Figures showing numbers of seedlings per acre opposite various seedbed types are in effect efficiency ratings for the types; figures for types were obtained by multiplying the number of seedlings actually tallied in that type by 43,560, then dividing by the actual area of that type on the plots.

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

Classification 181.525

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

Objective To determine the effect of depth and position of needles and aspen leaves on the germination of white spruce seed.

Location Winnipeg, Manitoba.

Work done The experiment was carried out using small pots containing a clay soil set out in the greenhouse during the winter of 1961. Nine treatments involving two depths of needles, two thicknesses of aspen leaves, two methods of seeding white spruce, and a control were tested using white spruce seed. Details of treatments were as follows:

1. Control (mineral soil) — — no litter added.
2. 1/8" – 1/4" layer of spruce needles applied after seeding.
3. 3/8" – 1/2" layer of spruce needles applied after seeding.
4. 1/8" – 1/2" layer of spruce needles applied before seeding.
5. 3/8" – 1/2" layer of spruce needles applied before seeding.
6. Three-leaf thickness of aspen leaves applied after seeding.
7. Six-leaf thickness of aspen leaves applied after seeding.
8. Three-leaf thickness of aspen leaves applied before seeding.
9. Six-leaf thickness of aspen leaves applied before seeding.

Periodic watering of the plots was carried out during the eight weeks germination period.

Results Results to date are given in Table 89.

TABLE 89 EFFECT OF LITTER ON THE GERMINATION OF WHITE SPRUCE SEED

Treatment	Depth of litter	Germination of white spruce seed (per cent)	
		Litter applied after seeding	Litter applied before seeding
Control (mineral soil)	No litter added	7.2	
Spruce needles over mineral soil	1/8" – 1/4"	9.0	0.5
	3/8" – 1/2"	4.0	0.7
Aspen leaves over mineral soil	3–leaf thickness	31.0	13.0
	6–leaf thickness	10.7	10.2

Comments Statistical analysis showed that 3-leaf thicknesses of aspen leaves applied either before or after seeding resulted in significantly higher number of germinates than where no litter was applied. The three-leaf thicknesses applied after seeding resulted in the largest number of germinates. The application of six-leaf thickness of aspen leaves was neither beneficial or detrimental. The application of needles after seeding was not particularly beneficial but when applied before seeding was detrimental to white spruce germination.

MS-223

Status Closed

Reports *Unpublished*

Waldron, R.M. 1963. Factors affecting natural white spruce regeneration on artificially prepared seedbeds at the Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-30.

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(2):229-231.

Project MS-224	Improvement cutting in 60- to 100-year-old white spruce-aspen stands to increase white spruce volume production.
Classification	243
Investigator	Present: G.A. Steneker
Objective	To demonstrate that merchantable yield of white spruce can be increased by improvement cuttings.
Location	About 50 miles northwest of Big River, and about 10 miles south of Meadow Lake, Saskatchewan.
Work done	Two mixedwood stands, about 95 years of age, were selected along the Doré Lake road, northwest of Big River. (Twp. 60-10-23 and Twp. 62-10-26). Another about 70 years of age, was selected south of Meadow Lake (Twp. 58-17-17). In 1961 and 1962 a portion of each stand was marked for selective cutting. A number of permanent sample plots was established in the marked and unmarked portions of each stand. At time of marking information on stand structure and composition was obtained from all sample plots.
Work proposed	After completion of cutting of marked material by provincial agencies, planned for the winter of 1962-63, sample plots will be established permanently, tallied, and remeasured at 10-year intervals until rotation age of white spruce (120 years).
Results	Nil to date.
Status	Continuing.
Reports	*Unpublished*

Steneker, G.A. 1962. Improvement cutting in 60- to 100-year-old white spruce-aspen stands to increase white spruce volume production, Saskatchewan. Dept. of Forestry of Canada, For. Res. Br., Mimeo 62-MS-6.

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

Classification 226:232.21:232.33:232.4

Investigator Present: R.M. Waldron

Objective To test the hypothesis that aspen stands can be converted to mixed coniferous-deciduous stands by planting and seeding on scalped strips spaced at approximately regular intervals.

Location Various localities in Manitoba.

Work done The experiment was begun in 1962 and to date 13 areas have been planted and 7 areas seeded to white spruce. Scalped strips have been prepared using a bulldozer and blade in both young and mature aspen stands and in mature mixedwoods. A small number of plots have been established on each area as ''observation plots'' on which seed germination and early survival and growth of spruce seedlings and transplants are being recorded. All treated areas will be assessed as to their success or failure five years following their establishment.

Results Results so far are presented in Tables 90 and 91.

TABLE 90 SURVIVAL AND GROWTH OF PLANTED WHITE SPRUCE MANITOBA

Location	Date of planting	Average height of planting stock (in.)	Survival and height growth in the spring of 1963		Basis: number of transplants
			Per cent survival	Height growth (in.)	
Fish Road	May 1962	5.0	79	0.1	214
Pine Falls	May 1962	4.7	78	1.0	159
Porcupine Mt.	,, ,,	3.3	87	0.0	228
Madge Lake	,, ,,	5.1	95	0.0	180
Gill Meadow	,, ,,	4.2	84	0.3	161
Beaver Creek	Sept. 1962	8.7	97	0.0	122

TABLE 91 STOCKING OF SEEDED WHITE SPRUCE MANITOBA

Location	Date of sowing	Pre-treatment of seed	Viability of seed (%)	Rate of application (lbs/acre)	Stocking in the spring of 1963	
					Quadrats stocked (%)	Number of seedlings (per acre)
Porcupine Mt.	Nov. 1961	Captan 50–W*	11	1.1	0	0
Madge Lake	,, ,,	,, ,,	11	2.5	14	No data
Gill Meadow	,, ,,	,, ,,	11	1.8	0	0
Whiteshell	,, ,,	,, ,,	no data	no data	58	8,000
Whiteshell	Apr. 1962	,, ,,	no data	no data	80	22,000
Fish Road	May ,,	,, ,,	63	1.3	83	15,800
Pine Falls	Oct. ,,	,, ,,	41	1.5	33	1,800

* Fungicide

Comments Survival of white spruce transplants and the good stocking of white spruce seedlings (where seed of high viability was used) is encouraging. However more trials are needed before the treatments can be rated a success or failure. Additional areas will be set out in future years to cover as large a range of stand, soil and climatic conditions as possible.

Status Continuing

Reports Nil

Project MS-228 Shelterwood cutting and mechanical seedbed treatment in white spruce-trembling aspen stands to induce white spruce regeneration, Manitoba and Saskatchewan.

Classification 231.31:231.321:221.02

Investigator Present: J.M. Jarvis

Objective To test on an operational basis the hypothesis that uniform two-cut shelterwood logging and mechanical seedbed treatment in mixed white spruce-trembling aspen stands will result in sufficient white spruce regeneration to form potentially merchantable stands.

Location District wide.

Work done In 1962 the first of several areas was established in the Riding Mountain Research Area. Scarification was completed during the summer. Logging was done during the winter of 1963-64. Additional areas have been located near Big River and Carrot River in Saskatchewan.

Results Regeneration results as of 1963 are summarized in Table 92.

TABLE 92 STOCKING TO WHITE SPRUCE
1963

Area	Stocking	
	Per cent	Number per acre
Scarified	96	12,375
Not scarified	4	25

Comments Stocking one year after scarification is much better on the scarified areas than on the unscarified areas; the results show that scarification is essential for germination.

Status Continuing.

Reports *Unpublished*

Jarvis, J.M. 1963. Uniform shelterwood cutting and mechanical seedbed treatment in white spruce-trembling aspen stands to induce white spruce regeneration, Manitoba and Saskatchewan, progress report. Dept. of Forestry of Canada, For. Res. Br.

Project MS-229 The effect of three methods of soil treatment (prior to planting) on the survival and growth of white spruce transplants, mesic clay loams, Riding Mountain Forest Experiment Station.

Classification 232.21:232.4

Investigator Present: J.M. Jarvis

Objective To study the growth and survival of white spruce seedlings planted on mesic sites where (1) all horizons down to the B_2 had been removed with a bulldozer blade, (2) all horizons down to the B_2 had been removed with a bulldozer blade then the B_2 horizon cultivated, (3) litter humus and A horizons had been dug into and mixed with the B_2 horizon, and (4) there was no disturbance prior to planting.

Location Riding Mountain National Park.

Work done The experiment utilizes a split-split-plot design consisting of 10 blocks, each with 4 plots. During the summer of 1962 the blocks each 40 ft. x 32 ft. were established; each block was divided into 4 plots each 16 ft. x 16 ft. Treatments bulldozing, no bulldozing, and sub treatments spading and no spading were applied randomly. Nine white spruce seedlings were planted on each plot in the spring of 1963. Periodically throughout the growing season all competing vegetation on the plots was clipped. The whole experiment will be replicated three times to account for variations in weather conditions.

Results Results are not yet available.

Status Continuing

Reports *Unpublished*

Jarvis, J.M. 1963. The effect of scalping and cultivating (prior to planting) on the survival and growth of white spruce, mesic clay loams, Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo 63-MS-4

Project MS-239 Creating seedbeds by burning slash piles and scorching with a torch, Riding Mountain Forest Experimental Area.

Classification 232.213:232.33

Investigator Present: J.M. Jarvis

Objective

(1) To determine whether a variety of seedbed conditions ranging from "burned to mineral soil" (the most extreme) to "only litter burned off" (the least extreme) can be made by (a) burning different size slash piles and (b) burning small patches of the forest floor with a propane torch.

(2) Providing a variety of seedbeds can be made, to study similarities and differences between them.

(3) Providing a variety of seedbeds can be made, to study germination and survival of white spruce, black spruce, jack pine and balsam fir on each condition.

Location Riding Mountain Forest Experimental Area.

Work done In late May and early June of 1963 thirteen slash piles were made. Two of the piles were 40 feet in diameter and varied from 6 feet in height at the centre to 6 inches at the edge. A third pile also 40 feet in diameter varied from 3 feet in height at the centre to 6 inches at the edge. The other ten piles were 10 feet in diameter; two of these piles were each 5 feet, 4 feet, 3 feet, 2 feet, and 1 foot high at the centre. Burning was carried out in late August on a day when the fire hazard was moderate. At the time the moisture content of the slash in the piles was about 14 per cent; that of the underlying organic horizons varied from about 134 to 178 per cent. Burning with the torch was not attempted because of inclement weather conditions, if possible tests will be carried out in 1964.

Results All piles burned fiercely with an intense heat and all of the slash in each pile was totally consumed. Very little of the organic horizons beneath the slash piles was consumed. Generally only the L horizon was burned; in a few places where a large branch smouldered for some time all horizons down to mineral soil were consumed. However the extent of such areas was small and correlations with size of slash piles were not evident.

Comments The seedbeds created were not considered to be suitable for spruce regeneration. Had the moisture content of the organic horizons been less at the time of burning better seedbeds might have been made. Further studies are planned to follow the moisture content of the organic horizons beneath slash piles in relation to weather and to determine whether a propane torch can be used to make a variety of seedbed conditions.

Status Continuing.

Reports *Unpublished*

Jarvis, J.M. 1964. Creating seedbeds by burning slash piles and scorching with a torch, Riding Mountain Forest Experimental Area. Dept. of Forestry of Canada, For. Res. Br., Mimeo 64-MS-1.

APPENDIX I

Glossary of Terms

1. Site .... The complex of physical and biological factors for an area which determine what forest or other vegetation it may carry (Bri. Comm. For. Term. 1953).
2. Site dry .... Lack of soil moisture for part of the growing season.
3. Site fresh ...... Adequate soil moisture for optimum development of mesophytic plants throughout the growing season.
4. Site moist...... Excess of soil moisture during the early part of the growing season.
5. Site very moist . Excess of soil moisture during most of the growing season.
6. Site wet .... Excess of soil moisture throughout the entire growing season.
7. Site mesic ..... Includes a range of sites from somewhat fresh through fresh to somewhat moist.

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