Drinkwater-

Forest Research Branch

REPRODUCTION AND RESIDUAL STAND DEVELOPMENT FOLLOWING CUTTING IN RED PINE-JACK PINE STANDS IN MANITOBA

by
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Sommaire en français

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Reproduction and Residual Stand Development Following Cutting in Red Pine-Jack Pine Stands in Manitoba[1]

by

J. H. Cayford[2]

INTRODUCTION

The natural range of red pine[3] extends into southeastern Manitoba. Although it is usually associated with jack pine in scattered stands, occasional pure patches occur. Early records state that red pine was once more abundant in the region than at present, but repeated fires and logging have nearly eliminated it. In 1928 Lonergan wrote, "During the early days of settlement there was considerable red pine in the district but lumbermen logged it off from government land and the settlers did the same thing on the homesteads, a few scattered homesteaders kept a small patch of red pine for shade trees around their buildings..."

Observations in southeastern Manitoba indicate that, on suitable sites, red pine is a superior tree to jack pine; it (red pine) has better form, is larger in diameter at maturity, and produces higher quality lumber. It is desirable, therefore, that red pine be favoured in forest management. In Ontario and in the Lake States, experience has indicated that red pine responds well to management, is long-lived, and has a good growth rate; and in Manitoba, it is relatively free from insect and disease damage.

In order to study the means of obtaining an increased representation of red pine in the regeneration following cutting, and to determine the growth and mortality of residual trees, the present study was initiated in southeastern Manitoba in 1954.

DESCRIPTION OF EXPERIMENTAL AREA BEFORE TREATMENT

Forest Description

Two stands located in the Sandilands Forest Reserve, approximately 100 miles southeast of Winnipeg, were selected for the experiment. They are situated within the Rainy River Section (L. 12) of the Great Lakes–St. Lawrence Forest Region (Rowe 1959).

The stands were composed of 50- to 70-year-old red and jack pine, in variable proportions (Figure 1). A few scattered trembling aspen, white birch, and white spruce were also present.

Stocking averaged 293 pine trees per acre, of which 250 were four inches or greater; basal area was 108 square feet, total volume 2,604 cubic feet, and merchantable volume 10,710 board feet. Red pine constituted the following percentages in the stands: by number of trees, 28 per cent; basal area, 40 per cent; total cubic-foot volume, 42 per cent; and total board-foot volume, 47 per cent. Stand statistics before treatment are shown in Appendix II.

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[3] For a list of botanical names of plant species mentioned in text, *see* Appendix I.

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Figure 1. A view of a red pine-jack pine stand in 1954 before cutting

Figure 2. A clump of red pine advance growth in a small opening in a red pine-jack pine stand in 1954. The seedlings are 20- to 25-years old and are approximately 6 feet in height

Dominant heights averaged 62 and 63 feet at 59 years for red pine and jack pine, respectively. Site indices at age 50 years were 55 for red pine, and 56 for jack pine (Gevorkiantz 1956, 1957).

The stands were 38 per cent stocked on a milliacre basis with either red or jack pine advance growth[1] (Table 1). These stems generally occurred in small openings (Figure 2).

TABLE 1. OCCURRENCE IN 1954 AND EFFECT OF LOGGING ON PINE ADVANCE GROWTH

Species	Before logging—1954		After logging—1955	
	Per cent stocking	Number per acre	Per cent stocking	Number per acre
Red pine	28	250	20	219
Jack pine	22	440	15	312
Both species	38	690	28	531

Stocking based on 320 milliacre quadrats; number per acre on 32 milliacre quadrats.

Topography and Soils

The experimental area is located immediately west of the Campbell Beach, one of the strand lines of postglacial Lake Agassiz and is between 1,100 and 1,150 feet above sea level. The topography is flat to very gently undulating.

Soils are predominantly sandy podzols characterized by a light-grey illuviated horizon and a weakly defined illuviated horizon, somewhat darkened in colour. They are well drained, non-calcareous, and nearly stone-free; prevailing textures are fine-to-medium sand and loamy sand.

Calcareous grey-wooded soils occur on a small portion of the experimental area. These soils have developed on coarse sand and gravel overlying till and are characterized by a clay-enriched illuviated horizon.

Soil moisture regimes were classified as dry to moderately fresh; drainage as rapid to very rapid; and local climate, as normal for the region.

Minor Vegetation

Herbs, grasses, feather mosses, and ferns were abundant. Shrub density was variable, ranging from very light to heavy, depending upon the crown closure of the overstorey. Some of the more abundant species included rough mountain-rice, Schreber's moss, bracken fern, false lily-of-the-valley, wintergreen, bearberry, wild strawberry, low-bush blueberry, everlasting, twinflower, wood anemone, beaked hazel, bush honeysuckle, rose, raspberry, and prairie willow.

Injurious Agencies

The stands were relatively free from serious insect or disease attack. A few of the larger trees of both species had red heart, or red stain, probably caused by *Fomes pini* (Thore) Lloyd (Figure 3). Much of the jack pine advance growth (but not the red pine) was deformed as a result of browsing by deer (*Odocoileus virginianus borealis* (Miller)). Fire scars were common, the result of surface fires which occurred around 1905, 1920 and 1930.

[1] All stems less than 6.5 feet in height were considered as advance growth.

Figure 3. The butt end of an 18-inch red pine showing red heart.

EXPERIMENTAL METHODS

In each stand, two five-acre blocks, each 5 chains by 10 chains, were selected for treatment. The blocks were divided into three segments consisting of two strips each, 1 chain by 10 chains, and an intervening area 3 chains by 10 chains. The one-chain-wide strips, which were oriented in either north-south or northeast-southwest directions, were clear cut to a minimum diameter of 3.5 inches; on the remainder of each block, all jack pine and all malformed red pine were similarly cut (Figure 4).

Logging was the responsibility of the Manitoba Forest Service. It commenced in August 1954 and continued until the end of March 1955. Trees either were bucked into log lengths and skidded with a wheeled tractor and sloop, or were skidded by tractor in tree lengths. Jack pine pulpwood was cut under permit; trees were cut into 8-foot bolts, piled, and hauled by truck. Both red pine and jack pine slash was piled and burned during the logging operation.

Scale returns provided by the Manitoba Forest Service showed that a volume of 32,400 cubic feet of pine was removed from the four blocks. On the clear cut strips, 2,082 cubic feet per acre were removed and on the partial cut, 1,312 cubic feet per acre were removed. The total cut consisted of 200 cords of jack pine, 46,220 board feet of jack pine, and 30,780 board feet of red pine.

Examinations of advance growth and regeneration were made annually from 1955 to 1959. During each examination, 320 permanent milliacre quadrats, 80 per block, were recorded as stocked or not stocked with red pine advance growth, jack pine advance growth, red pine regeneration, jack pine regeneration, and cotyledonous seedlings (either red or jack pine). A complete tally by species and classes was made on every tenth quadrat. General information concerning seedbeds, slash, and minor vegetation was recorded for each quadrat.

In the partially cut area of each block, a transect of 10 permanent one-tenth-acre plots was established in late June of 1955. The diameter and height of each living tree was measured. Plots were remeasured in late September of 1960.

Figure 4. A partially cut area photographed in 1955 following the removal of jack pine and malformed red pine. The lumber in the foreground was cut from the experimental area. (Photo by R.A. Haig.)

REPRODUCTION

The piling and burning of slash destroyed much of the jack pine seed. The cutting of all jack pine trees in the 4-inch diameter class and larger removed jack pine as a seed source from the experimental area. Most jack pine regeneration resulted from germination of seed in 1955, the year after logging, and it was most common around the peripheries of burned slash piles. In the partial cut areas and also adjacent to the clear cut strips, a source of red pine seed has been present in standing trees. Germination has occurred following each red pine seed year.

In 1959, five years after logging, the cut-over areas were 54 per cent stocked either with red or jack pine regeneration or with advance growth (Table 2). Total number of stems per acre was 1,478. Approximately 70 per cent of the reproduction originated after logging and over 65 per cent of it was red pine. Most red pine regeneration originated either in 1955 or in 1958. In 1959, the 1955 seedlings were approximately 1 to 2 feet in height, and the 1958 seedlings, 2 to 3 inches.

TABLE 2. RED AND JACK PINE REPRODUCTION IN 1959

Species	Per cent stocking			No. of stems per acre		
	Advance growth	Regeneration	Adv. gr. and regen.	Advance growth	Regeneration	Adv. gr. and regen.
Red pine	16	30	41	234	750	984
Jack pine	12	20	29	244	250	494
Both species	23	40	54	478	1,000	1,478
Basis: no. of milliacre quadrats	320	320	320	320	32	320 and 32

Stocking both with regeneration and with advance growth has shown annual variations in the five years after logging (Figure 5). Advance growth stocking declined slightly between 1955 and 1959. The most noticeable drop was between 1955 and 1956, a result of mortality of seedlings damaged during logging. In 1959 it was observed that root rot caused by *Armillaria mellea* (Vahl ex Fr.) Quél. had resulted in a small amount of mortality of red pine advance growth.

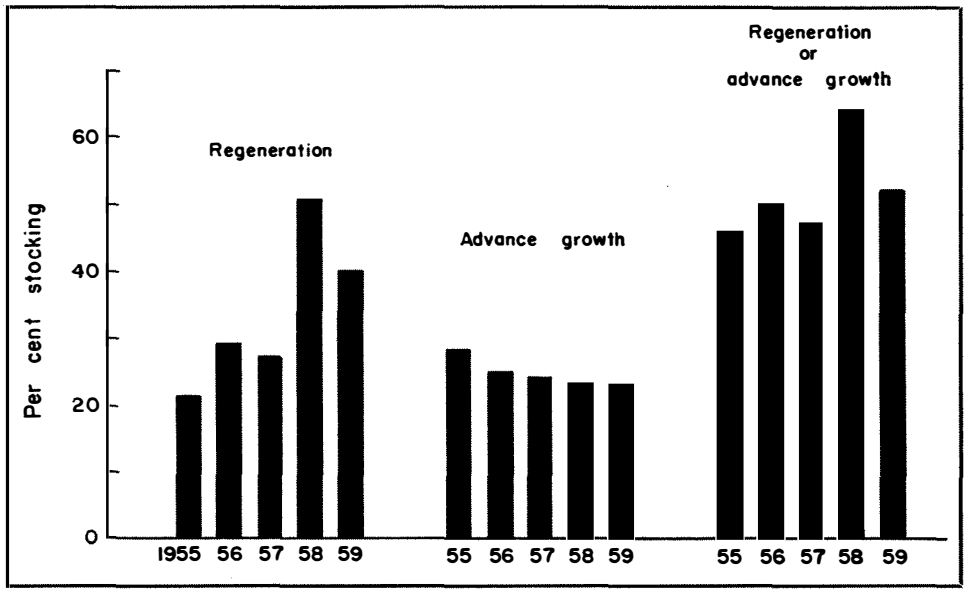

Figure 5. Annual stocking with red pine or jack pine regeneration and advance growth

Stocking with regeneration has tended to increase after logging, but has fluctuated in accordance with variations in the red pine cone crop. For instance, the nil-to-light cone crops in 1956 and 1958 were reflected by small decreases in stocking between 1956 and 1957, and between 1958 and 1959.

It seems probable that the future stands will contain a larger number of red pine than the original, and also that the percentage-representation of red pine will be increased from its original 28 per cent. There is also good reason to believe that reasonably well-stocked stands will develop. According to Candy's (1951) stocking standards, the area in 1959 was moderately stocked with reproduction. Horton and Bedell (1960) have reported that approximately 1,500 established seedlings per acre are considered reasonable for stocking of red pine at later stages in stand development. In young red pine plantations in Ontario, it was found that a wide range of spacing, from 700 to 1,700 trees per acre, produced close to maximum volume growth for the period 15 to 25 years from planting (Stiell and Bickerstaff 1959). Eyre and LeBarron (1944) have reported that at 20 years of age, from 800 to 1,500 jack pine trees per acre is close to ideal stocking, while from 400 to 800 trees at the same age is intermediate stocking. Thus, it would appear that the 1,500 seedlings present in 1959 should be considered as acceptable stocking.

SOME FACTORS THAT AFFECTED REPRODUCTION

Logging

Some mortality of advance growth occurred while logging took place. It was mainly caused by skidding, which resulted in breakage of seedlings; in

addition, a small number were killed by burning of slash piles. Stocking of pine advance growth was reduced from 38 per cent in 1954 to 28 per cent in 1955 (Table 1); a small percentage of damaged seedlings died after 1955.

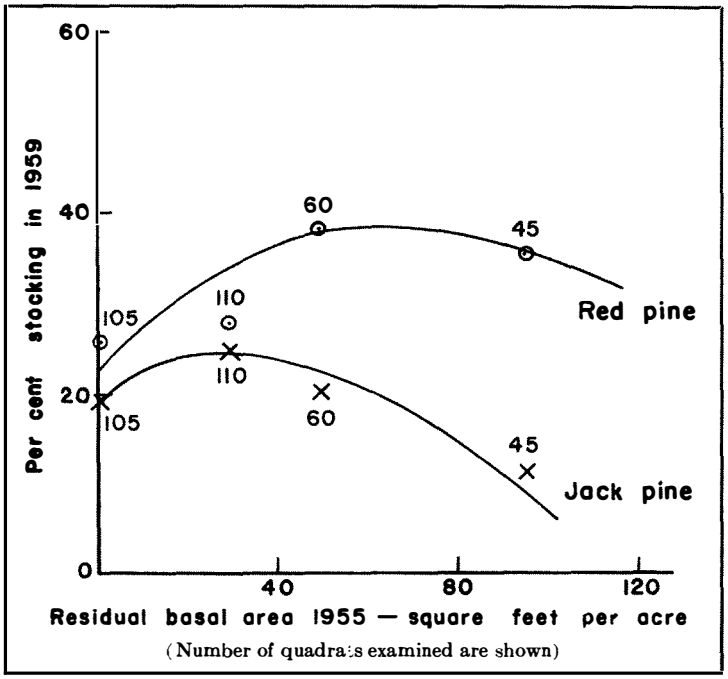

Figure 6. Relationship between regeneration stocking in 1959 and 1955 residual basal area

Density of Residual Stand

Optimum residual basal area for early establishment of red pine regeneration appeared to be between 50 and 90 square-feet per acre, but basal area as high as 120 square feet did not appear to hinder it seriously (Figure 6). However, as the residual stands are only 3 chains in width and are bounded by one-chain-wide clear cut strips, it is possible that the relationship of regeneration to residual stand density as found, might vary from that which would occur if the residual stands extended over broad areas. In the Lake States, Ralston (1950) found that five years after cutting, red pine regeneration was better under a light to moderate overstorey (50 to 80 square feet) than under a heavier overstorey (120 to 160 square feet). He found that although thousands of seedlings per acre germinated under the densest stand, only relatively few survived after five growing seasons. Another study in the Lake States indicated that red pine-white pine stands older than 120 years shoud be reduced below 90 square feet per acre if red pine regeneration was to be favoured (Conover 1953). On dry, sandy sites on the Sandilands Forest Reserve, red pine survival has been very low on open, exposed areas (Cayford 1959).

Even though most jack pine regeneration occurred around the peripheries of burned slash piles, its establishment appeared to be related, to a certain degree, with residual basal area. Approximately 30 square feet per acre appeared to be optimum for early establishment (Figure 6); jack pine seedlings were scarce beneath a dense, red pine overstorey. Other investigators have found that partial shade creates conditions which aid germination of jack pine and is also beneficial for seedling survival (Anon. 1939, Fraser and Farrar 1953, Jameson 1961).

Seedbeds

Before logging, the prevalent seedbed type was litter consisting of pine needles and leaves of shrubs, herbs, grasses, and deciduous trees. During skidding of red pine in the fall of 1954, mineral soil was exposed and litter disturbed and reduced in thickness on small portions of the cut-over area. Piling and burning of slash created patches of burned mineral-soil seedbed.

Observations in 1955 indicated that pine seedlings were most commonly located on seedbeds that had been disturbed during logging. Mineral soil, burned slash piles, and pine litter were the most favourable seedbeds (Table 3). Litter was only favourable as a seedbed where it had been disturbed during logging or where its thickness did not exceed one inch; greater accumulations were unfavourable. Nearly 90 per cent of the seedlings occurred on the afore-mentioned seedbeds which covered only 45 per cent of the area. Accumulations of slash, feather mosses, and herbaceous, grass and shrub litter were unfavourable seedbeds. Only 10 per cent of seedlings occurred on these seedbeds which covered 55 per cent of the area.

Seedlings that originated in 1958 were generally found on litter seedbeds. Usually these were on areas where the original litter had been removed or disturbed during logging; and consequently the litter formed only a thin layer, consisting generally of an accumulation of only four years of needlefall.

The two pine species varied somewhat in their seedbed requirements for germination. Red pine germination occurred on litter up to about one inch in depth, whereas jack pine germination was not observed where litter depth was greater than approximately one-quarter inch.

TABLE 3. OCCURRENCE OF SEEDBEDS AND PINE SEEDLINGS ON CUT-OVER AREAS

Seedbed type	Per cent occurrence of 1955 seedlings	Per cent occurrence of seedbed (1956)	Ratio: seedlings/seedbed
Mineral soil	40.0	4	10.0
Burned slash piles	4.3	1	4.3
Pine litter	43.0	40	1.1
Slash	1.4	5	0.3
Herbaceous litter	7.1	31	0.2
Grass litter	1.4	9	0.2
Shrub litter	0	4	0
Feather moss	0	6	0
Sawdust	1.4	<0.5	—
Unclassified	1.4	<0.5	—

Jack pine seedlings, most commonly observed around the edges of slash fires, were absent in the centres because of seed destruction. Similar observations made in Saskatchewan have been reported by Jameson (1961). In the centres of the slash-burned areas, numerous 1958 and 1960 red pine germinates were observed. However, red pine germinates of earlier origin than 1958 were not observed. For a few years following burning, either red pine seed did not germinate or seedlings did not survive on the slash-burned areas. By 1958, when the areas were covered with a thin layer of red pine needles, the reaction was probably less alkaline than originally, and conditions were more favourable for germination and survival of red pine seedlings.[1]

[1] In the same locale, the author has observed poor survival of 2-1 red pine seedlings planted on areas where slash piles had been burnt shortly before planting.

Red Pine Cone Crop

Stocking with first-year seedlings in any one year was closely related to the red pine cone crop of the preceding year (Figure 7). With the exception of 1955, when a considerable number of jack pine cotyledonous seedlings were observed, virtually all first-year seedlings were red pine.

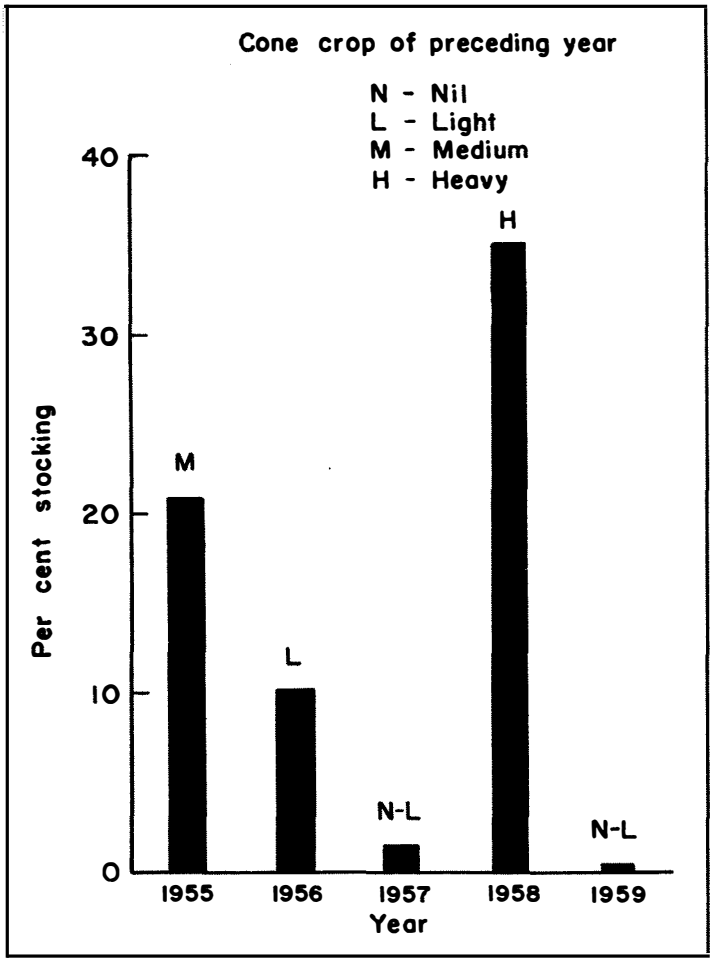

Figure 7. Yearly stocking with first-year seedlings as related to red pine cone crop of the preceding year

INCREMENT AND MORTALITY OF RESIDUAL STAND 1955-1960

Increment

Within the range of residual basal areas (0 to 190 square feet per acre) both volume and basal area increment increased with increase in residual basal area (Figure 8). Increment per acre for individual one-tenth-acre plots ranged from 0 to 808 cubic feet, 0 to 4,500 board feet, and 0 to 21 square feet of basal area.

Diameter increments of trees in the densest stands, 121 to 190 square feet per acre, were less than those of similar-sized trees growing in the more open stands; this was particularly evident for trees 10 inches in diameter or less

(Figure 9). There was also an indication that greater diameter increment occurred in the 1 to 60 square foot residual basal area class than in the 61 to 120 square foot class. Generally, the larger the tree the greater its increment.

Height increment did not appear to be related to either residual basal area or tree diameter. For the period under investigation, a large proportion of the trees grew between 3.5 and 5 feet in height.

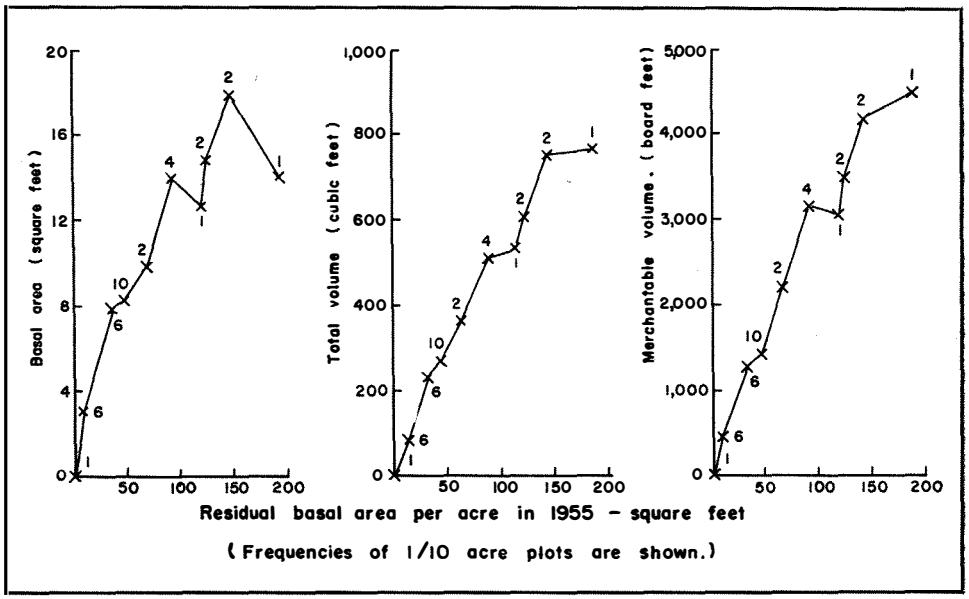

Figure 8. Increment per acre, 1955-1960

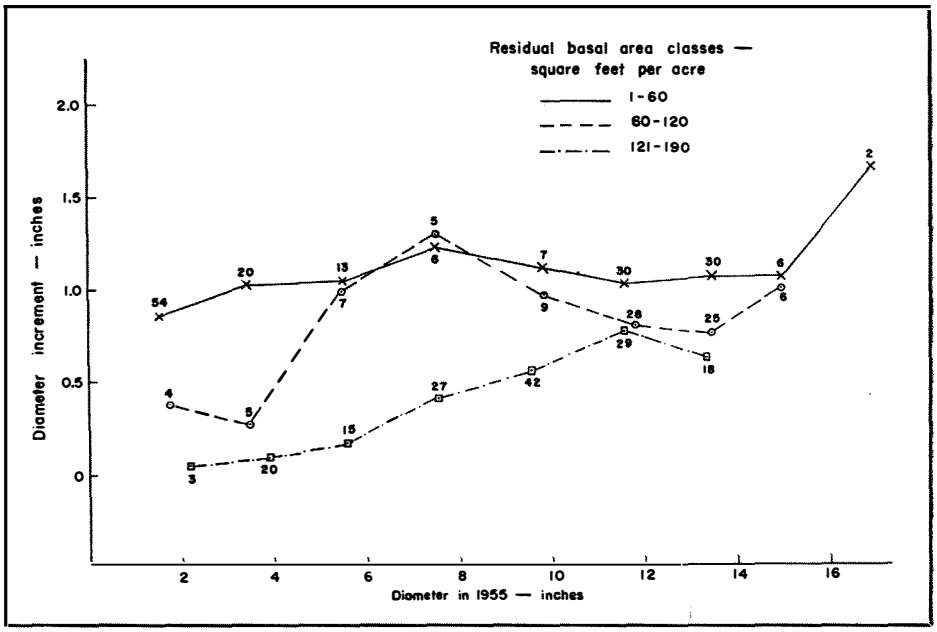

Figure 9. Diameter increment for the period 1955-1960

Mortality

Mortality of trees 1 inch and greater was light; for the period 1955 to 1960, mortality averaged 1.4 for red pine and 0.6 for jack pine per acre. Three per cent of the residual red pine and 18 per cent of the jack pine died during the period, and most of the mortality was in the 1 to 4 inch diameter classes (Table 4). These small trees, which had short crowns, were suppressed and the sudden exposures probably only hastened mortality. One small jack pine and one red pine 11 inches d.b.h. were killed by scorching during the burning of slash piles, and one small red pine died following basal damage incurred during logging. An important fact to note is that for the period after logging only 1 of 306 residual red pine larger than 4 inches died.

TABLE 4. MORTALITY OF RED AND JACK PINE 1955–1960

Diameter class in 1955 (inches)	Jack pine		Red pine	
	Number	Per cent	Number	Per cent
1	6	18.2	2	6.1
2	2	10.0	1	3.2
3	4	36.4	4	17.4
4	.....	.....	3	10.3
5–17	.....	.....	1	0.3
All diameter classes	12	17.6	11	2.6

Basis—68 jack pine and 422 red pine.

SILVICULTURAL APPLICATIONS

The results from this experiment, together with findings of other investigators, indicate that a light to moderate overstorey of between 50 and 90 square feet basal area provides the most favourable conditions for early establishment of red pine seedlings. However, as both total and merchantable volume increment increased with increases in residual basal area from 0 to 190 square feet per acre, it is evident that during the regeneration period stand density must be maintained at a lower level than that which will produce maximum volume increment.

It is suggested that red pine stands in Manitoba be harvested under a two-cut shelterwood method. This system has particular application in localities where thinning products cannot be readily marketed (Eyre and Zehngraff 1948). Because of the occurrence of red heart in some of the trees older than 70 years, a rotation of between 80 and 90 years is recommended.

In pure patches of red pine, the least vigorous trees should be removed during the first cut. This should be made between 65 and 80 years and the basal area reduced to between 50 and 90 square feet per acre. The final cut should be made when reproduction is well established. Woolsey and Chapman (1914) considered that the interval between cuts should be less than 7 years if seedling-suppression was to be avoided, but Horton and Bedell (1960) thought that sufficient seed may not have fallen during that short a period.

In stands of red and jack pine, the first cut should be made at an earlier age (60 to 70 years) than in pure red pine stands, because of the lower rotation age of jack pine. In this cut, jack pine and the poorer red pine should be removed; the residual basal area should not be less than 50 square feet per acre, which may necessitate the leaving of some jack pine. As in pure red pine stands, the final cut should be made when reproduction is well established. If red pine regeneration is to be favoured over jack pine, slash should be piled and burned during the first cut.

Preparation of mineral-soil seedbeds on portions of the cut-over area should increase the abundance of regeneration. A disturbed seedbed needed for regeneration can be provided for by logging when the ground is not snow-covered, or by mechanical treatment. The former is preferable in areas where considerable advance growth in present, whereas the latter might be most useful where advance growth is sparse or lacking. Scarification would be most beneficial if carried out during the summer of a seed year.

In stands where tall shrubs form a dense cover, silvicide treatment to reduce their density should increase regeneration stocking.

SUMMARY

In 1954, an experiment was begun in two red pine-jack pine stands in southeastern Manitoba. The purpose of the experiment was to study the means of obtaining an increased representation of red pine in the regeneration following cutting, and to determine the growth and mortality of residual trees. Four five-acre blocks, each 5 chains by 10 chains, were selected for treatment. Two one-chain-wide strips were clear cut while on the intervening three-chain-wide area all jack pine and all malformed red pine were removed.

Logging commenced in August 1954 and continued until the end of March 1955. Advance growth and regeneration were examined annually from 1955 to 1959. Growth plots, which were established in 1955, were remeasured in 1960.

Results of the experiment for the first five-year period after logging are as follows:

1. In 1959, cut-over areas were 54 per cent stocked with either red or jack pine regeneration or advance growth. There were 1,478 stems per acre. Seventy per cent of the reproduction originated after logging, and over 65 per cent of it was red pine.

2. Logging damage reduced advance growth from 38 per cent in 1954 to 28 per cent in 1955. Mortality was caused by skidding and by burning of slash piles.

3. Stocking with both red and jack pine regeneration varied with residual basal area. Approximately 30 square feet per acre appeared optimum for early establishment of jack pine and between 50 and 90 square feet for red pine.

4. Regeneration was most commonly present on patches of mineral soil and on areas where litter was reduced in thickness during logging. Unfavourable seedbeds were accumulations of slash, feather mosses, and herbaceous, grass and shrub litter.

5. The increment of basal area and of volume increased as residual basal area increased within the range from 0 to 190 square feet per acre. Diameter increment was inversely related and height increment unrelated to residual stand density.

Some suggestions for managing pure and mixed red pine stands in Manitoba are made. A two-cut shelterwood method is advocated with ground preparation in certain circumstances.

SOMMAIRE

En 1954, on entreprenait une expérience dans deux peuplements de pin rouge et de pin gris dans le sud-est du Manitoba. Le but de l'expérience était d'étudier les moyens d'obtenir un accroissement de la proportion de pin rouge dans la régénération consécutive à la coupe et de déterminer la croissance et la mortalité chez les arbres résiduels. On a choisi pour traitement quatre blocs de cinq acres, de cinq (5) chaînes sur dix (10) chacun. On a coupé à blanc deux bandes d'une largeur d'une chaîne chacune, alors que dans les bandes intermédiaires de trois chaînes de largeur on a enlevé tous les pins gris et tous les pins rouges difformes.

Entreprise au mois d'août 1954, la coupe s'est poursuivie jusqu'à la fin de mars 1955. Les semis préexistants et la régénération ont été examinés tous les ans, de 1955 à 1959. Les places d'étude de croissance établies en 1955 ont fait l'objet de nouveaux mesurages en 1960. Voici quels ont été les résultats de l'expérience pour la première période de cinq ans qui a suivi l'exploitation:

1. En 1959, les aires bûchées étaient peuplées dans une proportion de 54 p. 100 soit d'une régénération soit de semis préexistants de pin rouge ou de pin gris. On dénombrait 1,478 tiges à l'acre. Soixante-dix pour cent de la régénération ont surgi après la coupe et plus de 65 p. 100 des sujets étaient des pins rouges.

2. Les dommages attribuables à la coupe ont réduit les semis préexistants; de 38 p. 100 qu'ils étaient en 1954 ils sont tombés à 28 p. 100 en 1955. Ce sont le débusquage et le brûlage des abattis qui ont causé la mortalité.

3. Les peuplements jeunes de pin rouge et de pin gris ont varié selon la surface terrière résiduelle. Environ 30 pieds carrés à l'acre semblaient réaliser les conditions optimales pour l'établissement précoce du pin gris et entre 50 et 90 pieds carrés pour celui du pin rouge.

4. La régénération se trouvait le plus souvent dans des aires de sol minéral à nu et dans certains endroits où l'épaisseur de la litière avait été réduite au cours de la coupe. Les accumulations d'abattis, les mousses plumeuses, ainsi que la litière d'herbacées, de graminées et d'arbrisseaux, ont constitué des terrains de germination peu favorables à la régénération.

5. L'accroissement de la surface terrière et du volume s'est fait dans la mesure où la surface terrière résiduelle a augmenté de 0 à 190 pieds carrés à l'acre. La croissance en diamètre était en raison inverse de la densité du peuplement résiduel et la croissance en hauteur n'était pas proportionnelle à cette densité.

L'auteur fait certaines propositions relatives à l'aménagement des peuplements purs et des peuplements mêlés de pin rouge au Manitoba. Il préconise, comme méthode, deux coupes progressives, en plus de la préparation du sol dans certaines circonstances.

APPENDIX I

COMMON AND BOTANICAL NAMES OF PLANT SPECIES MENTIONED IN TEXT

Anemone, wood	*Anemone quinquefolia* L.
Aspen, trembling	*Populus tremuloides* Michx.
Bearberry	*Arctostaphylos uva-ursi* (L.) Spreng.
Birch, white	*Betula papyrifera* Marsh.
Blueberry, low-bush	*Vaccinium angustifolium* Ait.
Everlasting	*Antennaria campestris* Rydb.
Fern, bracken	*Pteridium aquilinum* (L.) Kuhn
Hazel, beaked	*Corylus cornuta* Marsh.
Honeysuckle, bush	*Diervilla lonicera* Mill.
Lily-of-the-valley, false	*Maianthemum canadense* Desf.
Moss, Schreber's	*Calliergonella schreberi* (BSG.) Grout
Mountain-rice, rough	*Oryzopsis asperifolia* Michx.
Pine, jack	*Pinus banksiana* Lamb.
Pine, red	*Pinus resinosa* Ait.
Pine, white	*Pinus strobus* L.
Raspberry	*Rubus idaeus* L.
Rose	*Rosa acicularis* Lindl.
Spruce, white	*Picea glauca* (Moench) Voss
Strawberry, wild	*Fragaria virginiana* Duchesne
Twinflower	*Linnaea borealis* L.
Willow, prairie	*Salix humilis* Marsh.
Wintergreen	*Gaultheria procumbens* L.

APPENDIX II

STAND STATISTICS BEFORE TREATMENT

STAND STATISTICS IN 1954 — RED AND JACK PINE

D.b.h. (inches)	Number of Trees		
	Red pine	Jack pine	Red and Jack pine
1	7.5	13.1	20.6
2	5.7	8.2	13.9
3	4.4	4.1	8.5
4	4.4	11.0	15.4
5	3.6	19.6	23.2
6	3.2	30.4	33.6
7	3.2	33.4	36.6
8	3.9	31.6	35.5
9	4.6	23.9	28.5
10	5.6	16.6	22.2
11	6.4	10.2	16.6
12	8.9	4.9	13.8
13	7.5	3.0	10.5
14	6.6	0.6	7.2
15	3.8	0.2	4.0
16	1.6	0.1	1.7
17	0.8		0.8
18	0.3		0.3
19	0.2		0.2
20	0.1		0.1
1–3	17.6	25.4	43.0
4+	64.7	185.5	250.2
Total	82.3	210.9	293.2
Basal area (sq. ft.)	43.6	64.0	107.6
Total vol. (cu. ft.)	1,091*	1,513**	2,604
Merch. vol. (bd. ft.)	5,020†	5,690††	10,710

* From Table 67 (Anon. 1948) ** From Table 28 (Anon. 1948) † From Table 89 (Anon. 1948). International ¼ log rule, stump height 1.5 feet, top diameter 4 inches. †† From Table 89 (Brown and Gevorkiantz 1934). International ¼ log rule, stump height 1.0 foot, top diameter 5 inches.

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