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Development of Jack Pine and Scots Pine in the Spruce Woods Forest Reserve, Manitoba

by
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Sommaire en français

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ABSTRACT

Growth of jack pine and Scots pine plantations were compared 48 years after planting. Scots pine has maintained a significantly greater diameter and basal area increment than jack pine and has produced greater volumes per acre. Many trees of both species showed poor form. All trees have retained dead branches, but they were heavier on Scots pine. Scots pine has reproduced more readily than jack pine.

CONTENTS

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I.E. Bella[1]

INTRODUCTION

Jack pine (Pinus banksiana Lamb.), lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.), Scots pine (Pinus sylvestris L.), white spruce (Picea glauca (Moench) Voss), and Norway spruce (Picea abies (L.) Karst.), have been planted in the Spruce Woods Forest Reserve in Manitoba since 1904. The first plantations were established for experimental purposes by the Department of Forestry and Rural Development (then Forestry Branch, Department of Interior); those established after 1929 were part of a reforestation program conducted by the Manitoba Forest Service.

Of all the species planted, jack pine and Scots pine have shown the most promise; the other species have proved unsuitable owing to high seedling mortality (up to 100 per cent) or inferior development (Jameson 1956). This paper records development to 1964 and growth between 1952 and 1964 on six plots established in four of the better plantations. One jack pine plantation had been established in 1918; the other three plantations were established in 1916.

DESCRIPTION

The Spruce Woods Forest Reserve, an area of about 200 square miles, is located in south-central Manitoba on deltaic sands and gravels deposited where the old Assiniboine river entered Lake Agassiz in glacial and early post-glacial times. Rowe (1959) shows this area as an island of the B. 18a (Mixedwood) Forest Section within the B. 16 (Aspen-Oak) Section. Before plantations were established the reserve supported a park-like forest; large treeless areas were interspersed with scattered groups of white spruce and aspen (Populus tremuloides Michx.).

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The climate of the area is typically continental, characterized by long, cold winters and short, warm summers. The average annual temperature is 34°F; the average January and July temperatures are -3°F and 65°F. The average precipitation is 16 inches, of which 10 inches fall from May to September (Anon. 1952).

Soil parent material in the study area (Sec. 7, Twp. 10, Rge. 16, W.P.M.) varies in texture from fine to coarse sand and sites vary from dry to very dry (Jameson 1956). Soil profiles resemble the orthic black type (Anon. 1963) which develop primarily under grass. Topography is gently rolling and dune-like in places.

Trees were spaced 4 by 4 feet in furrows running in an east-west direction. Planting stock varied from 3 to 6 years of age. Jack pine was grown from local seed, the Scots pine from seed obtained in Germany. In 1947 a portion of one of the jack pine and one of the Scots pine plantations were thinned and pruned; thinning removed about 40 per cent of the basal area. In 1952 six plots, established in four plantations, showed densities of 98 (thinned portion), 111 and 151 square feet per acre for jack pine; 124 (thinned portion), 134 and 172 square feet per acre for Scots pine.

METHODS

In 1952 permanent sample plots were established in each plantation (one 1/5 and five 2/5 acre in size). Trees were measured in 1952 and again in 1964. Data collected at each measurement included: a diameter tally of all living trees (and dead trees at remeasurement in 1964) over 0.6 inch d.b.h. by 1 inch diameter classes, the height measurement of a sufficient number of trees for construction of height diameter curves, and the height measurement of at least six dominant trees per plot. A number of trees on jack pine plots were tagged and their crown class recorded.

In 1964 increment cores were extracted at breast height from sample trees in each diameter class on the Scots pine plots. Two trees per plot were felled (in the surround), their form class was calculated and data were obtained for complete stem analysis. Branch measurements were taken on the high density plots; this included the basal diameter of all

(except dwarf) branches in the whorls closest to points 5, 10, and 15 feet above ground, and the actual heights of the whorls on at least three trees in each diameter class 4 inches and above. The percentage of irregular stems (forks, crooks, etc.) was assessed by describing deformities on about 150 trees per species on the high density plots. Observations were made on natural regeneration and on damage caused by biotic and physical agents.

Height/diameter curves were fitted for each plot by the method of least squares using semi-logarithmic functions ($H = a + b \log D$). Since covariance analysis showed no significant difference between these curves (Steel and Torrie 1960, p. 319) a common curve was used in the preparation of local volume tables for all plots.

Total and merchantable cubic-foot and board-foot volumes were obtained using local volume tables prepared from Form-Class Volume Tables (Anon. 1948). Scots pine volume tables were not available so red pine tables were used.

Diameter increment of jack pine between 1952 and 1964 was determined from measurements of tagged trees; for Scots pine it was determined from increment core data according to the method described by Smithers (1949). Relationships of diameter increment (Y) over d.b.h. (X) were compared by covariance analyses (Steel and Torrie 1960). When testing for differences between species, data were pooled by species.

Analysis of variance was employed to evaluate differences in height growth between species and sample plots, based on the heights of the randomly selected dominant trees.

RESULTS

Results (Table 1) show that the over-all growth of Scots pine is better than that of jack pine at 48 years. Detailed plot data for 1952 and 1964 are given in the Appendix.

Diameter and Height

Scots pine has maintained a greater diameter increment than jack pine (Figure 1). Regression lines relating diameter increment to d.b.h. show no significant difference between slopes, but the difference

TABLE 1. STAND AND TREE STATISTICS, 1952 AND 1964.

Basis permanent sample plots.
(per acre)

Species		Scots pine			Jack pine		
Plot[1] (Plantation[2])		M.D. (8-16)	H.D. (12-16)	T. (12-16)	M.D. (20-18)	H.D. (7-16)	T. (7-16)
Number of trees	1952	855	1387	715	760	1720	885
	1964	730	1107	703	695	1207	867
Mortality for the period		125	280	12	65	513	18
Basal area	1952	134.0	171.7	124.2	111.5	151.0	98.5
(sq. ft.)	1964	173.5	210.2	175.5	144.2	162.5	137.0
Increment, Net		39.5	38.5	51.3	32.7	11.5	39.5
Gross		46.2	51.1	52.5	35.1	29.7	40.3
Mortality		6.7	12.6	1.2	2.4	18.2	0.8
Volume[3], Total	1952	2205	2708	2279	1700	2325	1338
(cu. ft.)	1964	3916	4579	3950	3298	3396	2940
Mortality	1952-1964	115	211	24	20	284	14
Increment, Net		1711	1871	1671	1598	1071	1602
Gross		1826	2082	1695	1618	1355	1616
Merchantable (cu. ft.)	1964	2946	3175	3015	2455	1894	1885
Board foot	1964	7851	6017	7262	3790	155	155
Average diameter	1952	5.4	4.8	5.6	5.2	4.0	4.5
(from mean B.A.)	1964	6.6	6.2	6.8	6.2	5.0	5.4
Average height	1952	34.0	32.0	39.0	32.0	31.0	27.0
(from H/D curve)	1964	48.7	47.5	49.3	47.5	43.2	44.7
Average height of Dominant Trees	1964	51.0	52.4	51.5	54.5	51.5	49.8

[1]M.D. Medium Density
H.D. High Density
T. Thinned

[2]Plantation number and year of planting (e.g., 8-16; plantation number 8, year of planting 1916). For additional information see Jameson's (1956) paper.

[3]Volume - Total: stump and top included, bark excluded.
Merchantable: stump 1.5 feet, top diameter 4 inches.
Board foot: stump 1.5 feet, log length 16.3 feet, ¼" International log rule.

of 0.27 inches between adjusted means is significant at the 0.01 level.

The greater diameter increment of Scots pine is depicted also in the stand tables since that species has more trees in larger diameter classes than jack pine (Appendix, Tables 1 and 2).

Thinning resulted in a significant (0.01 level) increase in the diameter growth rate of jack pine (Figure 2). Stimulation was observed on trees of all sizes but was greatest on the largest trees. No significant response in diameter increment could be established for Scots pine.

No significant differences were found in the height growth of dominant trees between the two species and various densities (Table 1).

Basal Area

Table 1 shows that Scots pine, even on the plots which had a higher original basal area, attained greater net basal area increment between 1952 and 1964 than jack pine. Comparing total basal area yield of the two species at the age of 48 years, it is seen that Scots pine out-produced jack pine by about 25 per cent.

Thinning increased periodic net basal area increment and reduced mortality to a negligible amount for both species. The thinned jack pine plot and Scots pine plot with basal area of about 98 and 124 square feet per acre, produced net basal area increment of approximately 40 and 51 square feet per acre in 12 years; these are increases of 240 and of 30 per cent more than attained on the adjacent high density plots which had original basal areas of 151 and 172 square feet.

Volume

Periodic net total cubic foot volume increment showed a trend similar to that of periodic net basal area increment. Although Scots pine had higher values than jack pine the difference between the two species was less pronounced than that shown by the basal area statistics. This might be the manifestation of inherent errors in the method of estimating volume, or of slight differences in height growth between the two species under consideration. It is for these reasons that Spurr (1952) claims assessment of growth studies should be based always on basal area growth.

Total and merchantable cubic foot volume production of Scots pine has averaged 4,150 and 3,050 cubic feet per acre and jack pine 3,200

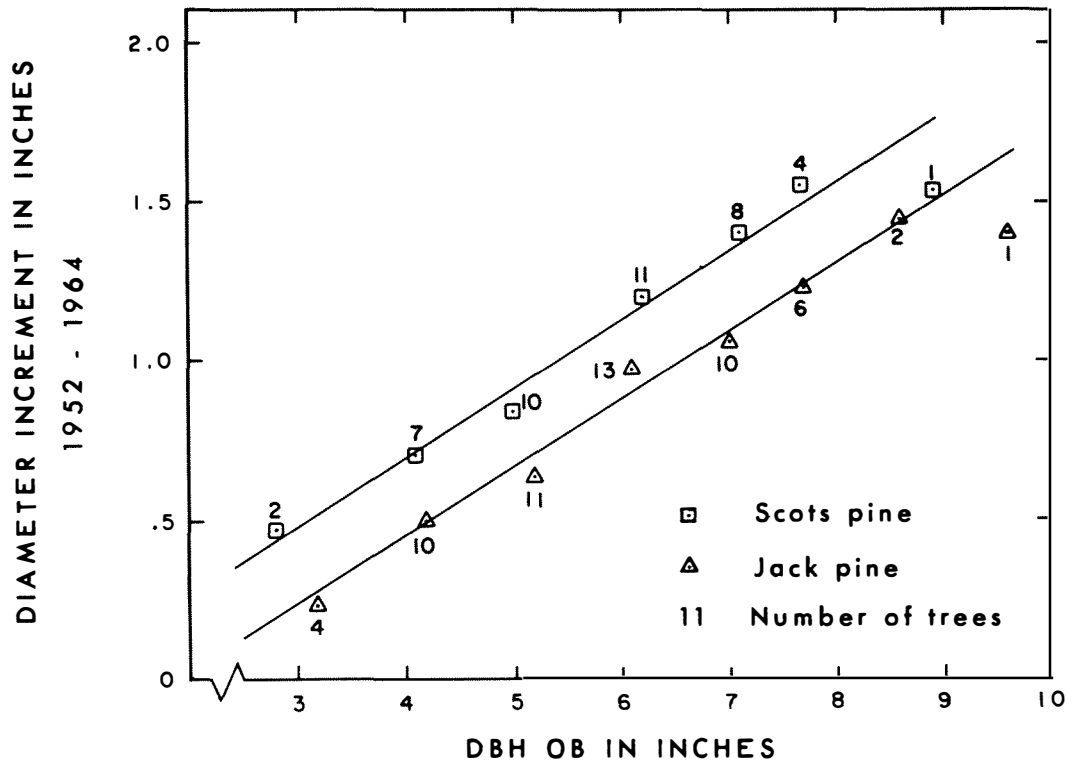


Figure 1. Diameter increment over d.b.h. (outside bark) 1964 of Scots pine and jack pine sample trees (data pooled by species).

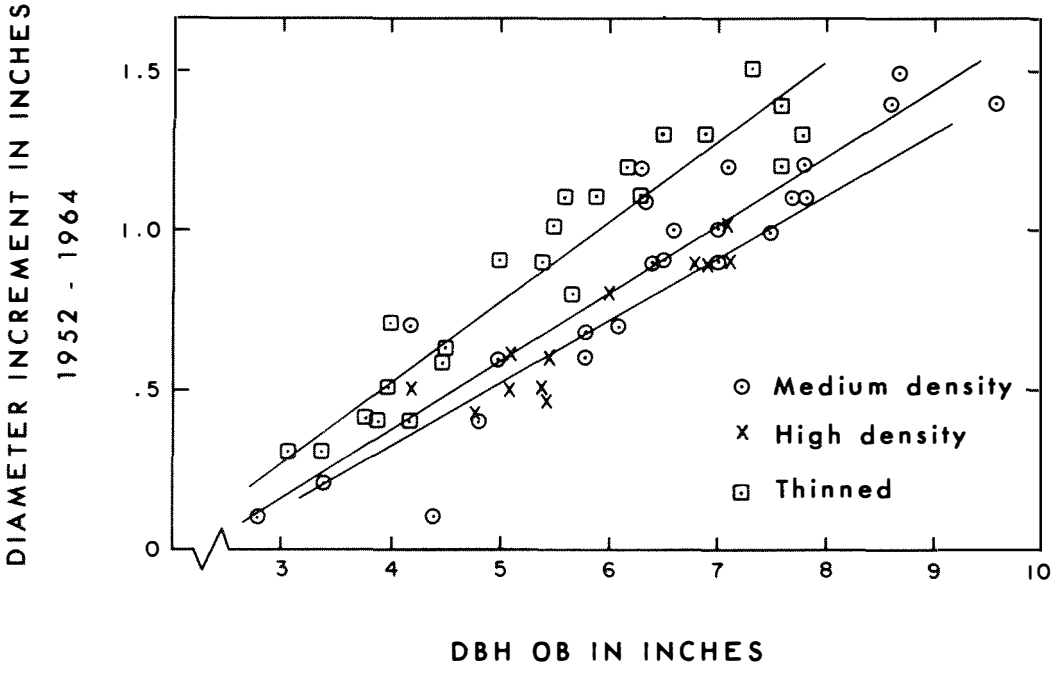


Figure 2. Diameter increment over d.b.h. (outside bark) 1964 of jack pine sample trees on three permanent sample plots.

TABLE 2. TOTAL VOLUME OF THE ONE HUNDRED LARGEST TREES FOR THE TWO SPECIES.
(cubic feet per acre)

Species	Scots pine			Jack pine		
Plots[1]	M.D.	H.D.	T.	M.D.	H.D.	T.
Volume in 1952	567	468	538	478	370	251
Volume in 1964	1120	949	1007	1061	585	566
Increase	553	481	469	583	215	315
Per cent increase	98	103	87	122	58	126

[1] M.D. Medium Density
H.D. High Density
T. Thinned

and 2,100 cubic feet per acre. These are differences of about 30 and 45 per cent in favour of Scots pine.

Scots pine produced board foot volumes averaging 7,000 board feet per acre, but only one of the three jack pine plots had trees large enough (7.6 inches and over) to contain appreciable board foot volumes and it produced only about 3,800 board feet per acre (Table 1).

The effect of thinning on the total volume increment of the 100 largest trees per acre on each plot is shown in Table 2. Thinning had no effect on the growth rate of large Scots pine, but had a significant effect on that of large jack pine. The rate of increase on the thinned and medium density jack pine plots (since 1952) was twice that of the high density plot.

Stem Taper, Branchiness and Tree Form, Regeneration

Stem analysis and form class determination showed variation in stem taper, but no consistent trends were revealed for different densities or for species. Thick bark at the base of the stem gave the appearance of greater taper for Scots pine.

TABLE 3. AVERAGE BRANCH DIAMETER, DEAD BRANCHES.

(inches)

Species	Scots pine			Jack pine		
Height above ground	5'	10'	15'	5'	10'	15'
D.b.h. 4"	0.46	0.42	0.48	0.40	0.36	0.45
D.b.h. 5"	0.55	0.61	0.69	0.46	0.46	0.48
D.b.h. 6"	0.65	0.71	0.74	0.53	0.61	0.52
D.b.h. 7"	0.53	0.77	0.92			
D.b.h. 8"	0.74	0.83	1.18			
D.b.h. 9"	0.66	0.67	1.03			

Table 3 shows average branch diameter for various size classes at three different heights above ground. For both species, branch size increased directly with d.b.h., at least up to 8 inches. Branch diameter of Scots pine also increased with height, but the data for jack pine showed no such trends. The average branch diameter for the same d.b.h. and height above ground was considerably greater for Scots pine than for jack pine. Observations indicated no difference between species in the number of dead branches that remained on the trees (Figures 3-5). No live branches occurred below 15 feet.

Irregularities in form were found on about 25 per cent of the trees sampled; the incidence of poor form was roughly the same for both species. Forks and crooks were the most prevalent types of irregularity; they occurred mostly in the upper part of the crown.

Good cone production was observed for both species and excellent Scots pine regeneration has become established in stand openings and around the edges of plantations in the last 10 years. Jack pine regeneration is absent.

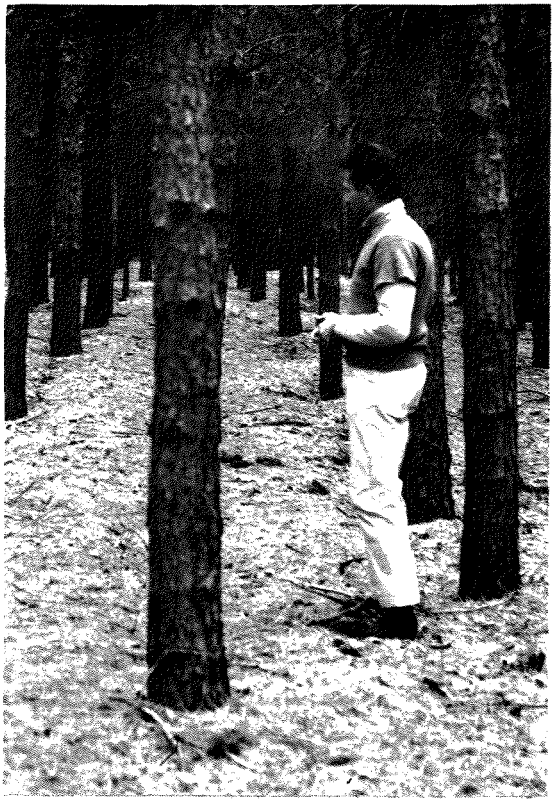
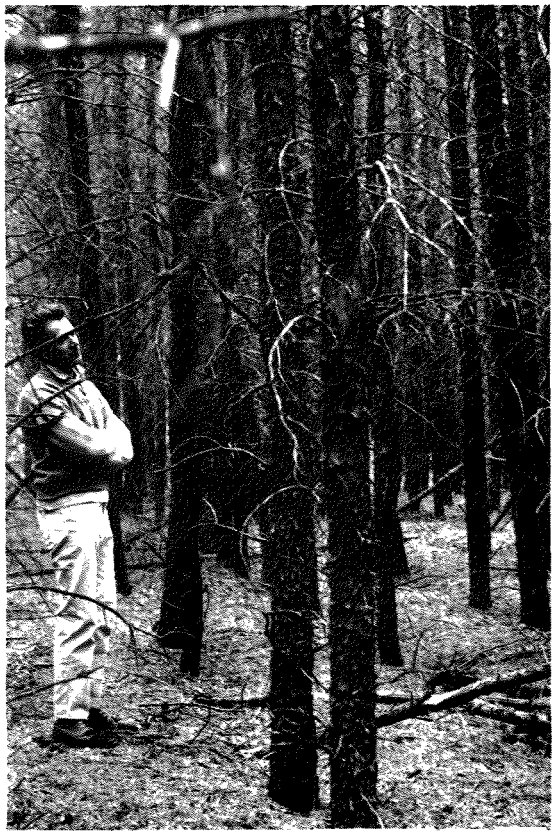
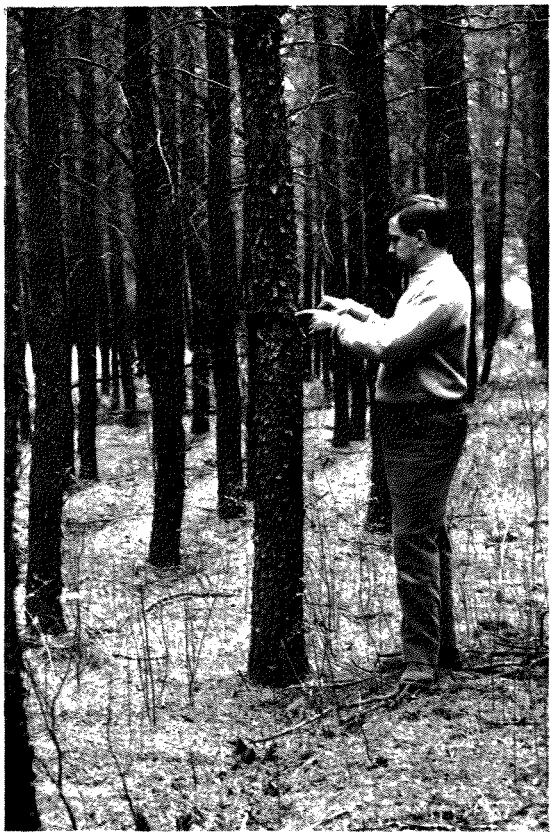


Figure 3. (left) A 48-year-old Scots pine plantation, thinned and pruned in 1947, average d.b.h. 6.8 inches in 1964. The branch stubs being covered over with new growth.

Figure 4. (bottom left) Medium density jack pine plantation, age 48 years, average d.b.h. 5.0 inches. Although self pruning is very slow, the branches are not as heavy as those on Scots pine.

Figure 5. (bottom right) A 48-year-old jack pine plantation thinned and pruned in 1947, average d.b.h. 5.4 inches in 1964.





DISCUSSION

The present results show that Scots pine has grown and developed better than jack pine. Diameter, basal area and volume growth were significantly greater and total basal area and cubic-foot volume production was about 25 per cent higher.

Height growth was similar for both species; this is in agreement with the results reported by McLeod (1956) on 18-year-height growth of Scots pine and jack pine plantations in the Acadia Forest Experiment Station.

Using height/age relationship as index height, it would appear that the jack pine plots fall just about half way between jack pine Quality Class I and II as determined by Kabzems and Kirby (1956) in Saskatchewan. However, when average diameter, number of trees per acre, basal area and total volume production are considered, these plantations surpass Quality Class I. Average values for total basal area and volume production are about 30 per cent higher than those for Quality Class I in Saskatchewan at age 48. This difference has been attributed to a greater number of trees per acre in conjunction with regular stem distribution within the plantations.

Thinning results indicated that young jack pine and Scots pine respond favourably to release with higher net increment as a result of lower mortality. Similar results have been reported by other investigators (Smithers 1954, 1957; Cayford 1961). Thinning had a stimulating effect on the diameter increment of jack pine but no significant response could be noted for Scots pine. Two factors may have been responsible for the fact that Scots pine showed no significant increase as a result of thinning: (1) it is possible that due to its fast growth the available growing space in the thinned Scots pine plantations had been reoccupied by 1952, thus the effect of thinning has disappeared; (2) wide variation in diameter increment of Scots pine trees has masked the effect of thinning. This variation has been attributed to a jack pine budworm (Choristoneura pinus, Freeman) infestation in the late 1950's. Observations revealed (McDowall et al. 1957) that some trees were damaged much more than others.

Although Scots pine has grown faster than jack pine it has also produced much heavier branches (Figures 3-5). This characteristic of Scots pine has been noted also by other workers (Stiell 1955; Jameson 1956; McLeod 1956; MacArthur 1959). While development of heavy branches may be reduced to a certain extent by initial spacing and subsequent density control, Klebingat (1962) maintains that dry pruning is required to obtain quality Scots pine timber even at 3.5 by 3.5 feet spacing. Jack pine has developed heavy branches only in open places.

During the past 10 years excellent Scots pine regeneration has become established in stand openings. This is attributed to the fact that Scots pine cones will open under normal climatic conditions, whereas jack pine cones require excessive heat. Because of this characteristic it would appear that Scots pine could be perpetuated more easily and economically than jack pine on similar sites in the future.

SUMMARY

This report presents data on the development to 1964 of three jack pine and three Scots pine plantations set out in the Spruce Woods Forest Reserve, Manitoba, in 1916. The data were obtained from six permanent sample plots, established in the plantations in 1952.

Results have shown that good growth and full stocking can be achieved by both jack pine and Scots pine. However, Scots pine has maintained a significantly greater diameter increment and about 25 per cent higher total basal area and volume production than jack pine. No significant difference was found between dominant heights of the two species.

Thinning has resulted in higher net increment and lower mortality for both species.

Both species have retained many dead branches; those on Scots pine were larger than those on jack pine. Many trees of both species had poor form as a result of past injuries.

Scots pine has reproduced more readily than jack pine.

SOMMAIRE

Le présent rapport fournit des informations sur le développement, jusqu'en 1964, de trois plantations de pin gris et trois plantations de pin sylvestre créées en 1916 dans la Réserve forestière de Spruce Woods (Manitoba). Les informations de l'auteur proviennent de six places-échantillons permanentes qui datent de 1952.

Les chiffres obtenus démontrent que les deux essences peuvent bien pousser et atteindre à une densité optimale. Cependant, le diamètre des pins sylvestres a augmenté plus rapidement que le pin gris et il en a résulté une production courante et une surface terrière totale de 25 p. 100 plus grande. La hauteur de l'étage dominant ne différait pas significativement.

Le traitement par éclaircies produisit pour les deux espèces un accroissement plus élevé du diamètre et un taux de mortalité plus bas.

Les fûts des deux espèces ont conservé beaucoup de branches mortes; celles des pins sylvestres étaient plus grosses. Plusieurs sujets de chaque espèce étaient malformés par suite de blessures.

La régénération du pin sylvestre était meilleure que celle du pin gris.

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APPENDIX

TABLE 1. STAND AND STOCK TABLES FOR SCOTS AND JACK PINE IN 1952.
(Number of Trees and Total Cubic Foot Volume[1] Per Acre)

Species	Scots pine						Jack pine					
Plot[2]	M.D.		H.D.		T.		M.D.		H.D.		T.	
No. of trees; Volume	N.T.	V.	N.T.	V.	N.T.	V.	N.T.	V.	N.T.	V.	N.T.	V.
D.b.h. 1"									15.5	0.8	8.2	1.6
D.b.h. 2"	37.9	8.0	115.8	26.6	3.1	0.9	43.7	8.7	212.4	53.1	68.3	35.5
D.b.h. 3"	119.0	71.4	251.0	160.6	40.4	31.1	60.1	34.9	398.9	255.3	376.9	410.8
D.b.h. 4"	178.6	217.9	311.7	405.2	90.1	136.9	136.7	164.0	577.6	745.1	382.4	738.0
D.b.h. 5"	135.3	292.2	328.2	708.9	205.2	506.8	262.4	535.3	427.4	948.8	46.4	140.6
D.b.h. 6"	211.0	706.8	253.8	817.2	230.0	834.9	158.6	490.1	77.7	269.6	2.7	11.9
D.b.h. 7"	129.9	606.6	113.1	507.8	121.2	604.8	76.5	332.0	10.4	52.1		
D.b.h. 8"	21.6	133.5	13.8	81.4	24.9	163.6	16.4	94.5				
D.b.h. 9"	21.6	168.9					5.5	40.4				
Totals	855.0	2205.3	1387.5	2707.7	715.0	2279.0	760.0	1699.9	1720.0	2324.8	885.0	1338.4

[1] Volumes were obtained from Dominion Form-Class Volume Tables (Anon. 1948); for Scots pine Table 67, and for jack pine Table 28 were used (F.C. 70 and 65, respectively).

[2] M.D. Medium Density
H.D. High Density
T. Thinned

TABLE 2. STAND AND STOCK TABLES FOR SCOTS AND JACK PINE IN 1964.
(Number of Trees; Total Cubic Foot[1], Merchantable Cubic Foot[2] and Board Foot[3] Volumes Per Acre)

Species	Scots pine												Jack pine											
Plot[4]	M.D.				H.D.				T.				M.D.				H.D.				T.			
No. of trees; Volume	N.T.	T.V.	M.V.	B.V.	N.T.	T.V.	M.V.	B.V.	N.T.	T.V.	M.V.	B.V.	N.T.	T.V.	M.V.	B.V.	N.T.	T.V.	M.V.	B.V.	N.T.	T.V.	M.V.	B.V.
D.b.h. 1"																								
D.b.h. 2"	10.0	2.9			15.0	4.3							5.0	1.4			2.5	0.7			2.5	0.7		
D.b.h. 3"	20.0	16.2			102.5	83.0			10.0	8.1			50.0	40.0			130.0	104.0			27.5	22.0		
D.b.h. 4"	80.0	129.6			190.0	307.8			50.0	81.0			70.0	114.1			320.0	521.6			140.0	228.2		
D.b.h. 5"	145.0	397.3	250.8		210.0	575.4	363.3		100.0	274.0	173.0		120.0	336.0	195.6		427.5	1197.0	696.8		305.0	854.0	497.1	
D.b.h. 6"	120.0	502.8	349.2		235.0	984.6	683.8		157.5	659.9	458.3		200.0	868.0	642.0		255.0	1106.7	818.5		330.0	1432.2	1059.3	
D.b.h. 7"	155.0	926.9	725.4		185.0	1106.3	865.8		185.0	1106.3	865.8		155.0	971.8	787.4		67.5	423.2	342.9		57.5	360.5	292.1	
D.b.h. 8"	110.0	902.4	735.9	3432	120.0	975.6	802.8	3744	145.0	1178.8	970.0	4524	60.0	512.4	432.6	1860	5.0	42.7	36.1	155	5.0	42.7	36.1	155
D.b.h. 9"	70.0	749.0	633.5	3129	47.5	508.3	429.9	2123	42.5	454.7	384.6	1900	20.0	224.0	193.0	900								
D.b.h. 10"	15.0	204.0	177.0	903	2.5	34.0	29.5	150	7.5	102.0	88.5	451	10.0	142.0	125.0	620								
D.b.h. 11"	5.0	85.0	74.5	387					5.0	85.0	74.5	387	5.0	88.5	79.0	410								
Totals	730.0	3916.1	2946.3	7851	1107.5	4579.3	3175.1	6017	702.5	3949.8	3014.7	7262	695.0	3298.2	2454.6	3790	1207.5	3395.9	1894.3	155	867.5	2940.3	1884.6	155

[1]Dominion Form-Class Volume Tables; Table 67 for Scots pine and Table 29 for jack pine. Stump and top included, bark excluded.

[2]Dominion Form-Class Volume Tables; Table 69 for Scots pine and Table 37 for jack pine. Stump 1.5 feet, top diameter 4 inches.

[3]Dominion Form-Class Volume Tables; Table 89 for Scots pine and Table 52 for jack pine. Stump 1.5 feet, log length 16.3 feet, ¼" International rule.

[4]M.D. Medium Density.
H.D. High Density.
T. Thinned.

N.T. Number of trees.
T.V. Total cubic foot volume.
M.V. Merchantable cubic foot volume.
B.V. Board foot volume.