EVALUATION OF SEEDBEDS FOR JACK PINE REGENERATION IN SOUTHEASTERN MANITOBA

By

H. P. Sims

INFORMATION REPORT NOR-X-87
MARCH, 1975

NORTHERN FOREST RESEARCH CENTRE
CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
5320 - 122 STREET
EDMONTON, ALBERTA
T6H 3S5

RESUME

Dans une station aride au sud-est du Manitoba, on a étudié le rendement du pin gris (**Pinus banksiana** *Lamb.) semé et planté sur des bandes scarifiées et coupées à blanc étoc. La moyenne de germination sur les bandes variait de 6 à 36%. La germination a été la plus affectée par les conditions atmosphériques ordinaires (la précipitation et la température), tandis que la mortalité était attribuée davantage aux conditions micro-climatiques. La germination était supérieure sur le versant nord et à la base de la pente à face nord dans les rigoles des couches à semis, mais la mortalité n'y était pas moindre que dans les autres couches à semis. Dans certaines couches à semis sur le versant nord on a remarqué une croissance ralentie. Les effets de la bordure du peuplement sur l'établissement et la croissance des semis étaient apparents sur une distance inférieure à 20 m.*

La chaleur, la sécheresse et la fonte comptaient parmi les principales causes de mortalité; mais, dans un bon nombre de cas on n'a pu établir les causes de mortalité étant donné que les semis avaient été enlevés par des agents non identifiés.

La station aride offre très peu pour l'ensemencement à la volée; c'est la plantation qui demeure la meilleure méthode de régénération. La survie des semis plantés s'avérait bonne à excellente tous les ans et sur tous les versants. L'étude ne suggérait aucunement une supériorité de la coupe à blanc étoc par bandes sur la coupe à blanc étoc parcellaire.

Sims, H.P. 1975. Evaluation of seedbeds for jack pine regeneration in southeastern Manitoba. Environ. Can., For. Serv., North. For. Res. Cent. Edmonton, Alta. Inf. Rep. NOR-X-87.

ABSTRACT

The performance of seeded and planted jack pine (Pinus banksiana Lamb.) *was studied on scarified and clear-cut strips on a dry site in southeastern Manitoba. Average germination on the strips ranged from 6 to 36%. General weather conditions (precipitation and temperature) had the greatest effect on germination, while mortality was more related to microclimatic conditions. Germination was better on the north exposure and base of north-facing slope and trough seedbeds, but mortality was no lower than on other seedbeds. Growth reductions were apparent on some seedbeds of the north exposure. The effect of the stand edge on establishment and growth of seedlings was apparent for a distance of less than 20 m.*

Heat and drought and damping-off are important causes of mortality; cause of mortality could not be established in a substantial number of cases because seedlings were removed by unidentified agents.

The dry site offers little promise for broadcast seeding; planting is the optimum method of regeneration. Planting survival was good to excellent for all years and exposures. There was no evidence that strip clear-cutting is superior to block clear-cutting.

CONTENTS

INTRODUCTION

Since 1960 the harvested acreage of forested land has increased annually in the prairie provinces and elsewhere. Increased reforestation costs due to inflation in recent years have led forest managers to seek less expensive alternatives to planting. Direct seeding is a possibility; however a recent symposium held at Timmins, Ontario, indicated that results of direct seeding in Canada to date have been very poor (Cayford 1974).

A study was initiated in 1962 to compare the relative performance of seeded and planted jack pine (*Pinus banksiana* Lamb.) on three scarified sites in the Sandilands Provincial Forest in southeastern Manitoba. Preliminary results (1962-1964) were inconclusive for the driest site (Sims 1970, 1972). Although productivity on this site is only fair (site index 13.9± 1.3 m: Mueller-Dombois 1964) it is one of the most common jack pine sites in southeastern Manitoba. Therefore this detailed study was undertaken in 1964 to evaluate the seedbeds created by scarification on this site for both seeding and planting.

STUDY AREA AND WEATHER CONDITIONS

The study area is located within the Rainy River (L.12) Section of the Great Lakes - St. Lawrence Forest Region (Rowe 1972). The topography is flat to gently rolling.

The dry site in the area is a fine to medium sand Mini Humo-Ferric Podzol (Anon. 1970). The organic horizon averages 2.5 - 5.0 cm over a deep, uniform sand profile. Water-table depth ranges from

2.5 to more than 3.0 m. Vegetation is sparse and dominated by ericaceous plants, primarily *Arctostaphylos uva-ursi* (L.) Spreng. Mueller-Dombois (1964) provides a more complete description of the site.

Weather conditions in 1964 were severe, but not uncommon for the area. Precipitation was 60% above normal for the growing season (about 40 cm) but lengthy dry periods occurred and mean weekly maximum temperatures reached the 30-35°C range twice during the summer. During 1965 precipitation was almost 80% above normal over the growing season and was more evenly distributed than in 1964. Mean weekly maximum temperatures ranged between 25 and 30°C over most of the summer. During 1966 precipitation was normal and evenly distributed over the growing season; temperatures were again in the 25-30°C range.

EXPERIMENTAL METHODS

The study was conducted over a 5-year period beginning in 1964. Each fall for 3 years one area was scarified with a tractor-drawn Rome middlebuster plow and logged during the winter months, creating a 40-m wide clear-cut strip oriented in an east-west direction.

The scarification treatment creates a flat-bottomed furrow, approximately 75 cm wide and 7.5-10 cm deep with an overturned sod ridge on each side. Five distinct seedbeds result: ridge (R), trough (T), undisturbed (U), base of north-facing slope (BNF), and base of south-facing slope (BSF) (Fig. 1).

The clear-cut strip was divided into three longitudinal sections: north (N), middle (M), and south (S) exposures, with three plots located in each. The area containing the plots was enclosed by stock fence to

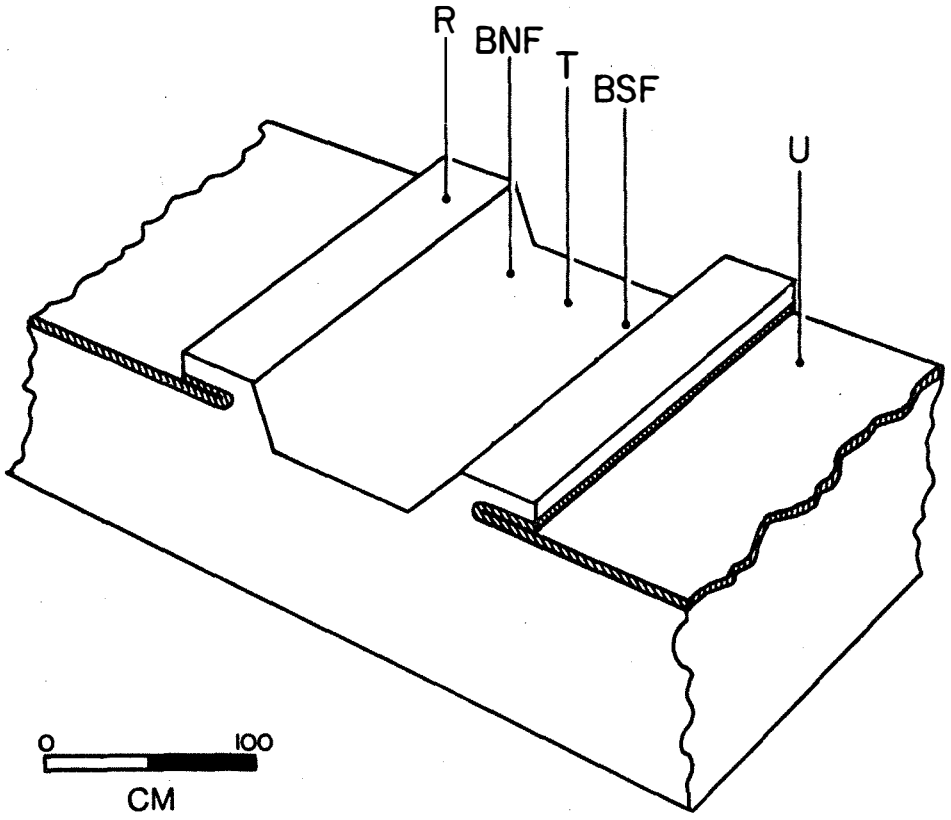

Figure 1. Furrow created by scarification showing five kinds of seedbed: (U) undisturbed, (T) trough, (BNF) base of north-facing slope, (BSF) base of south-facing slope, and (R) ridge.

prevent damage by mammals to seedlings and instruments. Slash and cones were removed from the plots to prevent seeding from natural sources. Each plot contained fifteen 30-cm-square seedspots, three on each of the five seedbeds. Seedspots were broadcast-sown by hand in the spring with 50 seeds each from local seed source. Seeds were treated with a combination of fungicide and rodent repellent (Arasan-Endrin-aluminum flakes). In the first year after seeding, weekly records of germination and mortality were maintained; during peak periods they were increased to a daily schedule. Mortality was classified according to cause whenever positive identification was possible, and was tallied in the spring and fall of the second and third years after seeding.

Each plot was also planted to twenty-five 2-0 transplants, five on each seedbed type. Height of each seedling was measured at time of planting. Mortality of the planted stock was tallied in the fall of the first year and in the spring and fall of the second and third years. Height growth of all seeded and planted stock was measured at the end of each growing season. At the end of the third year all surviving seedlings were harvested and oven-dry weights measured.

Precipitation was measured by means of a Cassella recording siphon rain gauge situated in the centre of the study area and supplemented by three Beal-type rain gauges, one on each exposure.

Air temperature was recorded by a thermograph situated at a height of 1.4 m in a birdhouse shelter and by a shielded thermocouple and recorder.

Germination data were analyzed by analysis of variance, and individual seedbed and exposure comparisons by Duncan's multiple range test (Duncan 1956). Analysis of mortality and growth data was limited by missing values (where germination did not occur), and therefore individual seedbed and exposure comparisons were made using Student's t-tests. Planting data were analyzed by analysis of variance and Duncan's multiple range test. In all analyses percentages were transformed to arcsin$\sqrt{\text{percentage}}$.

RESULTS AND DISCUSSION

SEEDING

Seeding Establishment

Germination and mortality by seedbed, exposure, and year are presented in Tables 1 and 2. Germination was generally inadequate on all but the BNF and T seedbeds and was poor even on these during some years (cf Sims 1970). Mortality was generally high and variable on all seedbeds.

Averaging all seedbeds, germination was significantly higher on the N exposure in 2 of 3 years. However, this advantage was prevalent over the five seedbeds only in 1966 and the good results on the N exposure tended to inflate the results for the site as a whole. The stand edge effect was less than 20 m, since the clear-cut strip was 40 m wide and the poorest results were generally recorded on the M exposure.

The combined effect of germination and mortality on individual seedbeds, in terms of seedling establishment potential, is presented in Table 3. Seedlings surviving through the year of germination were

TABLE 1. PERCENTAGE GERMINATION BY SEEDBED TYPE, EXPOSURE, AND YEAR OF SOWING ON A DRY SITE IN SOUTHEASTERN MANITOBA.

		Percentage germination					
Year	Exposure	R	U	T	BNF	BSF	All seedbeds
1964[1]	N	4b[2]	9ab	11ab	14a	14a	10
	M	3a	10a	6a	7a	3a	6
	S	3cd	0d	12ab	18a	5bc	8
	Average	3b	6ab	10ab	13a	7ab	8
1965[1]	N	15c	23c	A 43a	25b	25b	A 26
	M	1b	11a	B 9a	15a	14a	B 10
	S	7a	2b	B 11a	15a	11a	B 9
	Average	8c	12bc	21a	19ab	17ab	15
1966[3]	N	A 25b	11c	A 45a	A 50a	A 47a	A 36
	M	B 0b	2b	B 9a	B 14a	B 8a	B 6
	S	B 2b	2b	B 13a	B 13a	B 4b	B 7
	Average	9b	5b	22a	26a	20a	16

[1]Based on seed viability of 95.4% at time of sowing.

[2]Figures in rows followed by the same lower case letter are not significantly different at the 5% level. Figures in columns (within years) overtopped by the same upper case letter or no letter are not significantly different at the 5% level.

[3]Based on seed viability of 90.9% at time of sowing.

essentially established; subsequent mortality was low and occurred mainly during the second year. Results were generally best on the BNF and T seedbeds and N exposure for all years of the study.

Factors affecting seedling establishment are presented in Table 4. Mortality attributed to each factor varied considerably among exposures and seedbeds over the 3-year study period. Mortality attributed to "other" causes could have been caused by any of the three major factors, since most seedlings in this category were missing and may have been broken off, washed or blown away, or removed by insects and rodents.

General weather conditions (precipitation and temperature) had most effect on germination. Mortality was apparently more related to microclimatic conditions, since heat and drought mortality was not drastically lower on the N exposure or on the BNF and T seedbeds (Table 4). These seedbeds provided better conditions for germination but apparently had as many small niches of unfavorable microclimate as other seedbeds. Surface temperatures on these seedbeds, though averaging lower than on R, U and BSF, reached lethal maxima periodically throughout the growing season (Sims, unpubl. rep.).

Damping-off losses on the N exposure were as high or higher than on other exposures (Table 4). Damping-off was not restricted on any of the mineral soil seedbeds under conditions of temperature and moisture favorable for germination. In 1965 and 1966, warm moist years, damping-off accounted for approximately 50% of mortality. It was generally low on the warm, dry R seedbed of M and S exposures and was reduced by dry conditions on other seedbeds (cf Table 4, 1964).

TABLE 2. FIRST-YEAR MORTALITY BY SEEDBED TYPE, EXPOSURE, AND YEAR OF SOWING ON A DRY SITE IN SOUTHEASTERN MANITOBA.

		Percentage mortality[1]					
Year	Exposure	R	U	T	BNF	BSF	All seedbeds
		B			AB		
	N	83b[2]	49ab	50ab	50a	43a	50
		A			A		
	M	50b	88c	38ab	24a	36abc	53
1964					B		
	S	54[3]	-[3]	57a	57a	81a	60
	Average	65bc	69c	50ab	49a	50abc	54
	N	29ab	23ab	32a	49b	34a	34
	M	33a	50a	18a	20a	39a	32
1965							
	S	19a	60[3]	15a	23a	34a	25
	Average	26ab	34ab	27a	34ab	35b	32
		B		A			
	N	12a	20ab	15ab	24b	14ab	17
				AB			
	M	-[3]	33a	51a	39a	44a	43
1966		A		B			
	S	0a	44bc	45c	23b	62bc	36
	Average	11a	25b	25b	26b	21b	23

[1]Based on number of seedlings germinated.

[2]Figures in rows followed by the same lower case letter are not significantly different at the 5% level. Figures in columns (within years), except "all seedbeds", overtopped by the same upper case letter, or no letter (except those noted in '3'), are not significantly different at the 5% level.

[3]Insufficient data for comparisons.

TABLE 3. SEEDS PER SEEDLING RATIO FOR 3-YEAR-OLD JACK PINE.

Seeding year	Exposure	R	T	U	BNF	BSF	Average
1964	N	214	21	24	20	17	25
	M	86	54	86	33	72	58
	S	214	19	>429	16	107	38
	Average	143	25	56	21	37	36
1965	N	11	3	6	10	7	6
	M	86	14	20	8	12	15
	S	19	11	214	9	15	15
	Average	19	7	14	9	10	10
1966	N	8	4	20	8	4	7
	M	>409	34	409	13	41	38
	S	136	26	>409	11	136	35
	Average	24	10	61	10	12	15

TABLE 4. DISTRIBUTION BY CAUSE OF FIRST YEAR MORTALITY (PERCENTAGE OF TOTAL MORTALITY).

	1964				1965				1966			
	Exposure				Exposure				Exposure			
Seedbed	N	M	S	Average	N	M	S	Average	N	M	S	Average
R												
Heat & drought	13	29	17	18	6	50	33	15	17	0	0	17
Damping off	20	43	17	25	83	0	33	65	50	0	0	50
Animal	27	0	50	25	0	50	17	8	17	0	0	17
Other	40	29	16	32	11	0	17	12	17	0	0	17
U												
Heat & drought	26	40	-	36	13	17	33	17	33	0	0	20
Damping off	10	3	-	5	30	25	0	24	22	50	50	33
Animal	47	32	-	38	4	12	0	7	22	0	50	27
Other	16	24	-	21	52	46	67	51	22	50	0	20
T												
Heat & drought	44	10	10	22	17	43	14	19	33	0	4	14
Damping off	9	50	10	16	66	28	58	62	52	63	54	56
Animal	4	10	20	13	8	0	0	7	7	37	29	23
Other	43	30	60	49	8	28	28	12	7	0	12	7
BNF												
Heat & drought	39	14	18	25	6	0	33	10	26	0	0	16
Damping off	26	28	13	19	58	46	13	48	41	55	75	49
Animal	6	43	25	19	0	15	0	2	6	36	25	17
Other	29	14	44	36	36	39	53	40	26	9	0	18
BSF												
Heat & drought	8	25	41	21	8	20	6	12	11	0	0	6
Damping off	23	50	24	26	58	48	13	45	63	43	40	53
Animal	50	25	18	36	6	16	0	8	15	57	60	35
Other	19	0	18	17	28	16	81	35	11	0	0	6
All seedbeds												
Heat & drought	27	31	20	25	10	18	22	14	24	0	2	13
Damping off	19	20	14	17	60	37	20	48	48	55	56	51
Animal	25	26	24	25	4	14	2	6	10	40	36	24
Other	29	23	43	32	25	31	56	32	18	5	6	12

Growth

Height growth and oven-dry weights of seedlings on exposures and seedbeds are shown in Tables 5 and 6 respectively. Missing data, the result of mortality or no germination, precluded comparisons with R and U seedbed figures in several instances. There were no significant differences among seedbeds of the M and S exposures and very few on the N exposure. Comparisons of seedbeds across exposures indicated significantly reduced growth on the N exposure. However, there were no significant comparisons in 1964 (R and U not tested) and comparisons involving BNF were the only ones significant in both 1965 and 1966.

The advantage of the N exposure in germinant survival was offset by growth reductions. Seedlings established in 1965 and 1966 on the N exposure had lower 3-year height growth and oven-dry weight than on either the M or S exposures (Tables 5 and 6).

PLANTED STOCK

Survival

Three growing seasons after planting there were no significant differences in planting survival among years or exposures. Seedbeds differed significantly, however, with U and R averaging 74% and 75% survival respectively and BNF, BSF, and T averaging 93%, 93%, and 95% respectively. There were no significant interactions between years, seedbeds, and exposures (Table 7).

Over 80% of the mortality (79 of 94 seedlings) occurred during the growing season, and primarily during the first growing season

TABLE 5. THREE-YEAR HEIGHT GROWTH (CM) BY SEEDBED TYPE, EXPOSURE, AND YEAR OF SOWING ON A DRY SITE IN SOUTHEASTERN MANITOBA.

Year of seeding	Exposure	Seedbed R	U	T	BNF	BSF
	N	18.8[1]	18.8[1]	19.0a[2]	17.5a	17.5a
1964	M	13.7a	18.8a	19.3a	15.2a	19.0a
	S	17.3[1]	- [1]	19.0a	25.1a	14.7a
	N	B 10.2ab	5.3b	B 9.9a	B 8.9ab	14.2ab
1965	M	A 24.9a	16.0a	AB 18.5a	A 27.7a	24.6a
	S	AB 20.3a	6.8[1]	A 22.1a	A 25.4a	17.8a
	N	14.2a	12.7a	B 6.4b	B 4.6c	B 8.1ab
1966	M	-[1]	-[1]	A 17.5a	A 25.6a	A 22.1a
	S	23.4a	-[1]	AB 16.5a	A 24.4a	A 17.3a

[1]Insufficient data for comparisons.

[2]Figures in rows followed by the same lower-case letter are not significantly different at the 5% level. Figures in columns (within years) overtopped by the same upper case letter or no letter are not significantly different at the 5% level.

TABLE 6. OVER-DRY WEIGHT (G) OF 3-YEAR-OLD SEEDED JACK PINE ON PREPARED SEEDBEDS ON A DRY SITE IN SOUTHEASTERN MANITOBA.

Year of seeding	Exposure	Seedbed R	U	T	BNF	BSF
	N	2.6[1]	1.4[1]	2.8a[2]	1.7a	1.6a
1964	M	1.6a	0.8a	1.9a	3.0a	2.1a
	S	1.6[1]	-[1]	2.1a	3.0a	1.6a
	N	0.9ab	0.1b	B 0.5a	B 0.7ab	1.4ab
1965	M	10.5a	2.1a	AB 2.9a	A 5.0a	4.7a
	S	4.0a	0.6[1]	A 2.9a	A 3.6a	1.5a
	N	1.8a	1.3abc	0.4b	B 0.2c	B 0.4b
1966	M	-[1]	-[1]	3.6a	AB 4.9a	A 4.0a
	S	3.7a	-[1]	3.2a	A 5.2a	AB 4.4a

[1]Insufficient data for comparisons.

[2]Figures in rows followed by the same lower-case letters are not significantly different at the 5% level. Figures in columns (within years) overtopped by the same upper-case letter, or no letter, are not significantely different at the 5% level.

after planting (53% or 42 of 79 seedlings). Considerable mortality (35%) occurred in the third growing season, mainly during an extreme drought (1967) and the following year.

Winter kill occurred primarily on 1966 planting on the N exposure during the second winter. No specific reason was apparent.

TABLE 7. PERCENTAGE SURVIVAL OF JACK PINE 3 YEARS AFTER PLANTING ON A PREPARED DRY SITE IN SOUTHEASTERN MANITOBA (AVERAGE OF THREE PLANTING YEARS).

	Seedbed					
Exposure	R	U	T	BNF	BSF	Average
N	73	71	93	89	93	84
M	78	69	91	96	96	86
S	73	82	100	96	89	88
Average	75	74	95	93	93	86

Growth

There were no significant differences among seedbeds and exposures in height of planting stock at time of planting. Years differed significantly, attributable to differences in planting stock size, but did not result in any significant interactions.

Height growth differences among seedbeds and exposures after 3 years were not significant. Oven-dry weight was significantly less on the N exposure than on the M exposure; values were intermediate on the S exposure but did not differ significantly from either of the other exposures. Between-year variation was significant for

both parameters but there were no significant year-treatment interactions (Table 8).

The results suggest a moisture stress on seedlings on the N and S exposures as a result of competition from the stand (there was no precipitation gradient across the strip). The growth deficit of the N exposure was probably increased by shading and reduced temperatures of the rooting media (snow was seen to lie on the N exposure for up to 3 weeks after disappearing from the M and S exposures).

CONCLUSIONS

Including the preliminary studies on a similar site begun in 1962, a 7-year record of observations of regeneration success and weather conditions is available. During that period weather conditions on the study area ranged from dry to very wet and conditions for regeneration ranged from severe to excellent. Based on the results of these studies, the following conclusions can be drawn:

(1) The dry jack pine sites in southeastern Manitoba offer little promise for regeneration by broadcast seeding.

(2) Planting is the optimum method of regenerating dry site areas; planting survival was 75% or better on all seedbeds.

(3) There is no evidence, in terms of growth and survival, to support east-west strip clear-cutting as opposed to block clear-cutting. The stand edge effect apparently extends less than 20 m into the opening and has as much or more detrimental effect in terms of growth reductions as it has beneficial effect on survival.

TABLE 8. THREE-YEAR HEIGHT GROWTH (CM) AND OVEN-DRY-WEIGHT (G) BY SEEDBED TYPE AND EXPOSURE OF 3-YEAR-OLD JACK PINE PLANTED ON A PREPARED DRY SITE IN SOUTHEASTERN MANITOBA (AVERAGE OF THREE PLANTING YEARS).

	Seedbed					
Exposure	R	U	T	BNF	BSF	Average
			Growth (cm)			
N	43.7	41.1	39.9	39.9	49.0	42.9
M	46.0	51.3	50.3	56.6	55.6	53.1
S	44.4	52.8	50.3	53.8	49.5	50.3
Average	44.4	48.0	48.0	50.3	51.6	48.5
			Oven-dry weight (g)			
N	32.9	26.8	18.3	20.1	31.5	25.6
M	49.4	50.9	51.4	60.9	63.2	55.7
S	45.4	49.5	43.8	46.5	40.3	45.0
Average	42.8	42.7	37.9	43.0	45.4	42.3

After this study was initiated the Manitoba Department of Mines, Resources and Environmental Management began using shark-finned barrel scarifiers almost exclusively in their site preparation program. This treatment creates seedbeds very similar to those created by the Rome middlebuster plow, except it disturbs the surface soil of the mineral soil seedbeds more, creating a slight mulch condition which probably lasts for at least a part of the first year. This would result in more severe moisture and temperature conditions for seeding, but would have little effect on planted stock.

REFERENCES

Anon. 1970. The system of soil classification for Canada. Can. Dep. Agric.

Cayford, J.H., Ed. 1974. Direct seeding symposium, Timmins, Ontario. September 11-13, 1973. Environ. Can., For. Serv. Publ. 1339.

Duncan, D.B. 1956. Multiple range and multiple F tests. Biometrics, 11:1-42.

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

Rowe, J.S. 1972. Forest regions of Canada. Environ. Can., Can. For. Serv. Publ. 1300.

Sims, H.P. 1970. Germination and survival of jack pine on three prepared cutover sites. Can. Dep. Fish. For., For. Serv. Publ. 1283.

_____1972. Jack pine in southeastern Manitoba; a compendium of research, 1967-1970. II. Survival and growth of jack pine on prepared seedbeds. Environ. Can., For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-50B.