

EARLY SURVIVAL AND GROWTH OF PLANTED AND SEEDED WHITE SPRUCE AS AFFECTED
BY SEEDBED TYPES OCCURRING ON SCALPED STRIPS PREPARED IN ASPEN STANDS,
MANITOBA

Project MS-227

by

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INTRODUCTION

In 1962 a project was begun to study the effect of three seedbed types--mineral soil, mixed mineral soil and humus, and humus--occurring on scalped strips prepared in aspen stands, on early survival and growth of seeded and planted white spruce (Picea glauca (Moench) Voss). In 1962 and 1963, plots were established on bulldozed strips in a dense young aspen stand in the Interlake Area and in a moderately dense, mature aspen stand in the Whiteshell Provincial Park. A description of these areas and early results are contained in an establishment report (Waldron, 1964). In 1964 and 1965 plots were established on bulldozed strips in a dense, 16-year-old aspen stand in the Interlake Area and in a dense mature aspen stand in the Whiteshell Provincial Park. For the Interlake Areas a jack pine (Pinus banksiana Lamb.) study was carried out in conjunction with the white spruce study.

Mineral soil and humus seedbeds were generally readily available following the mechanical preparation of the scalped strips using a bulldozer and blade. However, the mixed mineral soil and humus seedbeds had to be prepared using either, shovels and grub hoes, or a garden-type power tiller, and were usually 1/4000-acre in size.

METHODS AND RESULTS

White Spruce

(A) Interlake Area - Mantago Lake

(i) Seeding 1964

In March, 1964 scalped strips were prepared in a dense young aspen stand near Mantago Lake in Section 20, Township 26, Range 3, W.P.M.

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On May 12, 1964, thirty 1/8000-acre circular regeneration quadrats were established on dry to moderately moist (M.R. 2-4) sites, thirty on fresh to moderately moist (M.R. 3-4) sites, and thirty on moist to very moist (M.R. 5-6) sites. The quadrats were set out in equal numbers on selectively chosen mineral soil, mixed mineral soil and humus, and humus seedbeds. Grub hoes and shovels were used to mix the mixed seedbeds. Three hundred white spruce seed treated with Arasan, Endrin, and aluminum flakes were sown on each quadrat. Seed viability before treatment was 57.6 per cent. Soil moisture conditions would appear to have been good with over an inch and a half of rain reported in the first 10 days of May at the nearest weather station (Gimli). Although the rest of the month had almost no rain (0.02 inches at Gimli), rainfall in June was higher than normal and at 4 inches would appear to be sufficient for germination on good sites.

All quadrats were examined in late July and late August of 1964 for seedlings. In the spring of 1965 all seedlings were characterized as to conditions, whether it was healthy, sick, missing, or dead, and evident agent of damage such as frost heaving, burying under hardwood leaves, and trampling.

On the dry to moderately moist site, a sandy soil, 1964 observed germination was highest for the mineral soil seedbed and almost the same for the humus and mixed seedbeds (Table 1). However, more than a third of the mineral soil seedbed germination took place on the one quadrat considered to have a moisture regime of 4, and half of the germination on the humus seedbed did not occur until the summer of 1965 while most of the germination on mineral soil seedbeds occurred the first summer. Survival of the first year observed germination was about 90 per cent for mineral and mixed seedbeds at the end of the summer while the humus seedbed was a little less than 80 per cent (Table 2). Seedling mortality during the first winter was severest on the mineral soil seedbeds (42 per cent) followed closely by its mixed seedbeds (41 per cent). Mortality of seedlings, in the same period, on the humus seedbeds was only 23 per cent. Survival at the end of the third summer was almost the same for the humus and mixed seedbeds (25 per cent). Survival after the third summer on the mineral soil seedbeds was much better (48 per cent) than on the other seedbeds. Almost all the seedlings on all three seedbeds on the dry (M.R. 2) site had perished by the end of the third summer. The condition of the seedlings after the first winter is shown in Table 3. On the dry to moderately moist site (M.R. 2, 3, 4) most of the frost heaving occurred on the mixed seedbed where almost 20 per cent were frost heaved. There was little difference in mortality of the seedlings on the three seedbeds, however the seedlings on the mixed seedbed were in the poorest condition with the largest percentage frost heaved, sick, and missing, and with the smallest percentage healthy (26 per cent). About a third of the seedlings on the mineral soil and humus seedbeds were under leaves while only 15 per cent of the seedlings on the mixed seedbed were in the same situation.

On the fresh to moderately moist (M.R. 3-4) site, a clay soil, 1964 germination was almost the same for mineral soil and mixed seedbeds while germination on humus seedbeds trailed. However germination in 1965 on humus seedbeds was almost equal to first year germination probably indicating a moist deficiency on the humus seedbeds. On this site survival was equally

TABLE I
PER CENT STOCKING AND GERMINATION PER QUADRAT

Seedbed Type	Moisture Regime	Basis: No. of 1/8000 Acre Quadrats	Per cent Stocking Autumn 1964	Average Total 1964 Germination per Quadrat Autumn 1964	Average Total 1965 Germination per Quadrat Autumn 1965
Mineral Soil	2,3,4*	10	90.0	10.1	0.3
Humus	2,3,4	10	70.0	2.8	2.8
Mixed	2,3,4	10	80.0	2.9	1.4
All	2,3,4	30	80.0	5.3	1.5
Mineral Soil	3,4	10	100.0	9.8	3.0
Humus	3,4	10	100.0	6.0	5.2
Mixed	3,4	10	100.0	9.7	3.5
All	3,4	10	100.0	8.5	3.9
Mineral Soil	5,6	10	100.0	27.5	1.8
Humus	5,6	10	90.0	12.1	1.4
Mixed	5,6	10	100.0	35.4	2.4
All	5,6	30	96.7	25.0	1.9

* One third of the mineral soil germination was concentrated on the one Moisture Regime 4 quadrat.

TABLE 2
PER CENT SURVIVAL OF FIRST YEAR GERMINATION

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre Quadrats	Total First Year Germination	Per cent Survival			
				Autumn 1964	Spring 1965	Autumn 1965	Autumn 1966
Mineral Soil	2,3,4*	10	101	90.1	52.5	50.5	47.5
Humus	2,3,4*	10	28	78.6	60.7	39.3	25.0
Mixed	2,3,4*	10	29	93.1	55.2	31.0	24.1
All	2,3,4*	30	158	88.6	54.4	44.9	39.2
Mineral Soil	3,4	10	98	86.7	51.0	32.6	24.5
Humus	3,4	10	60	71.7	36.7	43.3	38.3
Mixed	3,4	10	97	87.6	44.3	41.2	27.8
All	3,4	30	255	83.5	45.1	38.4	29.0
Mineral Soil	5,6	10	275	96.4	80.7	76.4	53.1
Humus	5,6	10	121	78.5	64.5	62.8	57.8
Mixed	5,6	10	354	93.5	70.3	67.8	50.3
All	5,6	30	750	92.1	73.2	70.1	52.5
All	2,3,4,5,6	90	1163	89.8	64.5	59.8	45.6

* Survival is largely confined to the fresh and moderately moist sites.

TABLE 3

CONDITION OF SEEDLINGS AFTER FIRST WINTER

Seedbed Type	Moisture Regime	No. of Living Seedlings Autumn 1964	Per cent Condition															
			Healthy				Sick				Missing		Dead					
			H	UL*	FH	O	S	UL	FH	O	M	UL	D	UL	FH	O		
Mineral Soil	2,3,4	91	37.3	18.7			2.2			5.5	17.6	17.6		1.1				
Humus	2,3,4	22	59.1	18.2						4.5	13.6	4.6						
Mixed	2,3,4	27	26.0		11.1		18.5		3.7	11.1	14.8	11.1		3.7				
All	2,3,4	140	38.6	15.0	2.2		5.0		0.7	6.4	16.4	14.3		1.4				
Mineral Soil	3,4	85	41.2	4.7	12.9					7.0	11.8	22.4						
Humus	3,4	43	51.2							2.3	39.5	7.0						
Mixed	3,4	85	37.7	4.7	8.2					4.7	30.6	14.1						
All	3,4	213	41.8	3.8	8.4					5.1	24.9	16.0						
Mineral Soil	5,6	270	74.8	6.3	3.0					2.2	13.0	0.7						
Humus	5,6	96	78.1	2.1	1.0		1.0			4.2	7.3	6.3						
Mixed	5,6	332	65.4	7.8	1.5		0.6			1.5	21.1	1.8		0.3				
All	5,6	698	70.8	6.4	2.0		0.4			2.1	16.0	2.0		0.1				
All	2,3,4,5,6	1051	60.6	7.0	3.3		1.0		0.1	3.3	17.9	6.5		0.3				

* UL - Under leaves. FH - Frost heaved. O - Others.

low for mineral soil and mixed seedbeds after three summers (about 25 per cent), while 38 per cent of the first year germinants on the humus seedbeds were still living. Again humus seedbeds showed a much larger rate of mortality (28 per cent) during the first summer than the other seedbeds (13 per cent). The highest percentage (51 per cent) of healthy seedlings were found on the humus seedbeds in the spring of 1965 while mortality was severest (22 per cent) on the mineral soil seedbed. Frost heaving of seedlings was found on only the mineral soil and mixed seedbeds. Leaf cover affected more than twice as many (37 per cent) seedlings on the humus and mixed seedbeds as on the mineral soil seedbeds.

On the moist to very moist (M.R. 5-6) site, a clay soil, germination in the first summer was much greater than on the drier sites, with an average of 25 germinants per quadrat for all seedbeds as against 5 and 8 germinants on the dry and fresh sites. Less than 10 per cent of the germination occurred in the second summer on this site. Best germination was found on the mixed seedbed (35 germinants per quadrat) followed by the mineral soil and then humus seedbed.

An average of 173 viable seeds were sown and 81 germinants were found on the best mixed seedbed. As in the drier sites mortality was severest on humus seedbeds during the first summer. Survival after three summers was over 50 per cent for all seedbeds with the humus seedbed being the best (58 per cent). Seedling condition in the spring of 1965 was better on the moist to very moist site than on the drier sites. The humus seedbed had the highest percentage healthy (78 per cent) and mixed seedbed the lowest (65 per cent). Average mortality on this site was only 2 per cent during the first winter. Fewer seedlings on the humus seedbed were covered by leaves, probably because of the existence of heavy grass cover on this seedbed, as well as the very open nature of the hardwood stand on this site.

(ii) Planting 1964

In the spring of 1964 a total of 60 white spruce transplants were set out on a moderately fresh to fresh (M.R. 2-3) site, 60 on a moderately moist (M.R. 4) site, and 60 on a moist to very moist (M.R. 5-6) site. In addition, 40 transplants were set out on a moist to very moist (M.R. 5-6) site which had been furrowed with a Middlebuster fireline plough, transplants being paired, one in the furrow and one on the ridge created by the upturned furrow slice. On the dry to fresh site, moderately moist site, and moist to very moist site, equal numbers of transplants were set out on selectively chosen mineral soil, humus, and mixed mineral soil and humus seedbeds, the mixed seedbed being prepared using grub hoes and shovels. On the furrowed site twenty transplants were set out, both, in the furrow and on the ridge. A description of the planting stock is shown in Table 4.

Planting was carried out on May 12, a cool day (high at Gimli was 52°F), and soil moisture was excellent due to heavy rains during early May.

Heights of all transplants were recorded on May 14 and condition and damage were noted on November 17, 1964, May 14, 1965, and August 25, 1966 when heights were again measured.

Survival has been generally excellent on all sites. Only the mixed seedbed on the moist to very moist site and the furrows on the very moist site have had severe mortality. Mortality on the furrowed very moist site can probably be attributed to flooding (Table 5).

Most of the mortality on the mixed seedbed on the moist to very moist site occurred soon after planting. Possibly, on this site the looser soil was not compacted around the roots sufficiently at planting. Average height growth after three summers was best on humus seedbeds for all sites. Poorest growth took place in the furrows on the wet site. Excessive moisture would appear to be effecting the performance of the transplants on the disturbed seedbeds on wet sites.

TABLE 4
PLANTING STOCK MEASUREMENTS

Species	# of transplants sampled	Average root length (in.)	Average height (in.)	Average root weight ¹ (gm.)	Average top weight ¹ (gm.)	Root/shoot ratio (by weight)
wS	25	11.0	5.1	1.56	3.29	0.47

¹

Oven dried at 105°C for 48 hours.

(iii) Seeding 1965

In the spring of 1965, scalped strips were prepared in a dense young aspen stand near Mantago Lake in Sec. 20, Twp. 26, Rge. 3, W.P.M. On May 2 and 3, thirty 1/8000-acre circular regeneration quadrats were established on a fresh (M.R. 3) site and thirty on a wet (M.R. 6) site. The quadrats were set out in equal numbers on selectively chosen mineral soil, humus, and mixed mineral soil-humus seedbeds. A garden-type power tiller was used to prepare the mixed seedbeds. One hundred and twenty-five white spruce seeds pelleted with Arasan, Endrin, and aluminum flakes, and testing 57.6 per cent viable, were sown on each quadrat on May 5.

Moisture conditions at the time of seeding were excellent however rainfall during late May and June was light and insufficient for good germination on fresh sites.

TABLE 5

SURVIVAL AND HEIGHT GROWTH OF TRANSPLANTS

Seedbed Type	Moisture Regime	Transplant							
		#	Average Height (in.)			Per cent Survival			
			at Planting	Autumn 1966	Increment	Spring 1964	Autumn 1964	Spring 1965	Autumn 1966
Mineral Soil	3	20	6.9	14.3	7.4	100.0	100.0	100.0	100.0
Humus	2	5	6.0	10.8	4.8	100.0	100.0	100.0	100.0
Humus	3	15	6.9	16.2	9.3	100.0	93.3	93.3	93.3
Mixed	3	20	6.9	15.0	8.1	100.0	100.0	100.0	100.0
All	3	60	6.8	14.7	7.9	100.0	98.3	98.3	98.3
Mineral Soil	4	20	6.3	15.8	9.5	100.0	100.0	100.0	100.0
Humus	4	20	6.8	14.7	7.9	100.0	100.0	100.0	100.0
Mixed	4	20	6.7	16.4	9.7	100.0	100.0	100.0	100.0
All	4	60	6.6	15.6	9.0	100.0	100.0	100.0	100.0
Mineral Soil	5	15	6.9	14.3	7.4	100.0	86.7	93.3	93.3
Humus	5	10	6.1	15.9	9.8	100.0	100.0	100.0	100.0
Mixed	5	15	6.8	13.8	7.0	100.0	80.0	73.3	73.3
All	5	40	6.6	14.6	8.0	100.0	87.5	87.5	87.5
Mineral Soil	6	5	8.1	14.3	6.2	100.0	80.0	80.0	80.0
Humus	6	10	6.8	15.9	9.1	100.0	100.0	100.0	100.0
Mixed	6	5	6.2	11.6	5.4	100.0	40.0	40.0	40.0
All	6	20	7.0	15.0	8.0	100.0	80.0	80.0	80.0
Furrow Ridge	5	5	6.8	12.0	5.2	100.0	100.0	100.0	100.0
Furrow Ridge	5	5	7.7	13.5	5.8	100.0	100.0	100.0	100.0
Furrow Ridge	6	15	6.1	7.0	0.9	100.0	86.7	86.7	86.7
Furrow Ridge	6	15	6.3	11.0	4.7	100.0	93.3	93.3	93.3
All	2,3,4,5,6	220	6.7	14.4	7.7	100.0	90.4	90.4	90.3

All quadrats were examined on August 20, 1965, June 14 and August 23, 1966.

First year observed germination on the fresh site was best on the mineral soil and poorest on the humus seedbeds (Table 6). Germination in the second year was lowest on the mineral soil seedbed and highest on the mixed seedbed. Survival, on this site, was very poor. For all seedbeds together, a fifth of the observed first year germination died before the first autumn examination, and by spring three-quarters of the seedlings were dead or missing (Table 7). At the end of the second summer only 17 per cent of the first year observed germination was found to be living. At this time, the mineral soil seedbed had the best survival (22 per cent) and the mixed seedbed the worst (10 per cent). Seedling condition in the spring of 1966 (Table 8) shows a large percentage (51 per cent) of the seedlings were dead or missing on the fresh site when compared to the very moist site (27 per cent) or the previous year's seeding (10 per cent) (Table 3). It would appear that the heavy mortality was confined largely to drought-prone seedbeds and thus was caused by drought conditions. Considerable mortality on the fresh site had already occurred by the first examination in the third week of August. Almost no rain fell in the last week of July and first 10 days of August (Ashern and Hodgson). Following this were several days with high daily high temperatures (upper eighties). Perhaps compounding this condition was a possible increase in solar radiation reaching the ground due to a defoliating effect of an aerial spraying on August 5, carried out to reduce vegetative competition on plantations of other experimental projects surrounding these plots (quadrats were protected with newspapers during spraying). The next spring the mineral soil seedbed had the highest percentage of healthy seedlings (35 per cent--Table 8) but had the most seedlings effected by leaves (18 per cent) and along with the mixed seedbed had the most frost heaving (27 per cent). The mixed seedbed had no seedlings under leaves and the humus seedbed had 9 per cent of its seedlings under leaves. Subsequent survival in the autumn of seedlings on the fresh site, considered sick in the spring was nil. All the missing seedlings were either dead or still missing in the autumn. Fourteen per cent of the seedlings missing under leaves were found living in the autumn while none of the healthy seedlings under leaves died. Eighty-five per cent of the healthy seedlings survived the summer, however only 55 per cent of the healthy frost-heaved seedlings were found alive in the autumn.

On the very moist site (M.R. 6) first year observed germination (Table 6) was best on the humus seedbed (44 seedlings per quadrat). The best quadrat had 66 established germinants the first year as opposed to a laboratory germination average of 72 germinants. Very little germination occurred the second year on the mineral soil and humus seedbeds. The mixed seedbed had the poorest germination the first year (8.9 seedlings per quadrat) and the most second year germination (1.9 seedlings per quadrat). Survival of the first year germinants (Table 7) was poorest on the mixed seedbed after two summers (40 per cent), best on the humus seedbed (68 per cent), and intermediate on the mineral soil seedbed (62 per cent). It would appear that the mixed seedbed on this open site was, along with the humus seedbed, not as subject to flooding as the mineral soil, but, on the other hand, not as shaded, with its own vegetation, as the humus, as well as probably being better drained

TABLE 6
PER CENT STOCKING AND GERMINATION PER QUADRAT

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre Quadrats	Per cent Stocking Autumn 1965	Average Total 1965 Germination per Quadrat Autumn 1965	Average Total 1966 Germination per Quadrat Autumn 1966
Mineral Soil	3	10	100.0	10.7	2.0
Humus	3	10	100.0	9.0	3.2
Mixed	3	10	100.0	9.8	3.6
All	3	30	100.0	9.8	2.9
Mineral Soil	6	10	100.0	18.3	0.6
Humus	6	10	100.0	44.4	0.6
Mixed	6	10	100.0	8.9	1.9
All	6	30	100.0	23.9	1.0
All	3,6	60	100.0	16.8	2.0

TABLE 7
PER CENT SURVIVAL OF FIRST YEAR GERMINATION

Seedbed Type	Moisture Regime	Basis: No. of 1/8000 Acre Quadrats	Total First Year Germination	Per cent Survival		
				Autumn 1965	Spring 1966	Autumn 1966
Mineral Soil	3	10	107	82.2	34.6	22.4
Humus	3	10	90	85.6	23.3	17.8
Mixed	3	10	98	73.5	25.0	10.2
All	3	30	295	80.3	25.8	16.9
Mineral Soil	6	10	183	97.3	82.5	62.3
Humus	6	10	444	99.1	77.7	68.5
Mixed	6	10	89	93.2	57.3	43.8
All	6	30	716	97.9	76.4	63.8
All	3,6	60	1011	92.8	61.6	50.1

TABLE 8

CONDITION OF SEEDLINGS AFTER FIRST WINTER

Seedbed Type	Moisture Regime	No. of Living Seedlings Autumn 1965	Per cent Condition															
			Healthy				Sick				Missing		Dead					
			H	UL*	FH	O FHUL	S	UL	FH	O	M	UL	D	UL	FH	O FHUL		
Mineral Soil	3	88	20.5	3.4	9.1	2.3	3.4		3.4		26.1	9.1	9.1	2.3	10.2	1.1		
Humus	3	78	17.9	1.3	2.6		1.3	2.6	1.3		32.0	2.6	26.9	2.6	8.9			
Mixed	3	72	9.7		11.1				4.2		50.0		11.1		13.9			
All	3	238	16.4	1.7	7.6	0.8	1.7	0.9	2.9		35.3	4.2	15.5	1.7	10.9	0.4		
Mineral Soil	6	185	43.3	0.5	27.6		2.7		10.8		7.0		6.5	0.5	1.1			
Humus	6	444	63.3	2.0	7.4		3.6	0.5	1.8		4.5		15.3	0.2	1.4			
Mixed	6	86	19.8		34.9	1.2		1.1	3.5		16.3	2.3	7.0		13.9			
All	6	715	52.9	1.4	16.0	0.1	2.9	0.4	4.3		6.6	0.3	12.0	0.3	2.8			
All	3,6	953	43.8	1.5	13.9	0.3	2.6	0.5	4.0		13.7	1.3	12.9	0.6	4.8	0.1		

* UL - Under leaves, FH - Frost heaved, O - FHUL - Frost heaved under leaves.

TABLE 9

SUBSEQUENT SURVIVAL OF SPRING CONDITION CLASSES

Seedbed Type	Moisture Regime		No. of Seedlings and Per cent Survival									
			Healthy				Sick				Missing	
			H	UL*	FH	O FHUL	S	UL	FH	O	M	UL
Mineral Soil	3	#	18	3	8	2	3		3		23	8
		%	77.8	100.0	62.5	50.0	0.0				0.0	14.3
Humus	3	#	14	1	2		1	2	1		25	2
		%	92.8	100.0	50.0		0.0	0.0	0.0		0.0	0.0
Mixed	3	#	7		8				3		36	
		%	85.7		50.0				100.0		0.0	
All	3	#	39	4	18	2	4	2	7		84	10
		%	84.6	100.0	55.6	50.0	0.0	0.0	0.0		0.0	10.0
Mineral Soil	6	#	80	1	51		5		20		13	
		%	88.8	100.0	76.5		40.0		15.0		0.0	
Humus	6	#	281	9	33		16	2	8		20	
		%	93.2	87.5	84.8		31.2	50.0	25.0		15.0	
Mixed	6	#	17		30	1		1	3		14	2
		%	88.2		70.0	100.0		0.0	0.0		0.0	0.0
All	6	#	378	10	114	1	21	3	31		47	2
		%	92.1	90.0	77.2	100.0	33.3	33.3	16.1		6.4	0.0
All	3,6	#	417	14	132	3	25	5	38		131	12
		%	91.4	92.8	74.2	66.7	28.0	20.0	13.2		2.3	9.1

* UL - Under leaves, FH - Frost heaved, FHUL - Frost heaved under leaves.

because of the looseness of the soil. About 70 per cent of the first year germinants on the humus and mineral soil seedbeds were in healthy condition the next spring whereas 56 per cent of the seedlings on the mixed seedbed were in the same condition. Forty per cent of the mineral soil seedlings had been frost-heaved the first winter as had 53 per cent of the mixed seedbed's seedlings. Leaf-cover was not an important factor on this site (2 per cent of the seedlings covered by leaves), while mortality of frost-heaved seedlings was only serious on the mixed seedbed (14 per cent). Subsequent survival in the autumn (Table 9) indicates that less than a quarter of healthy frost-heaved seedlings in the spring, died or were missing on the very moist site. Subsequent survival was generally poorer on the fresh site when compared to the very moist site.

(iv) Planting 1965

In the spring of 1965 a total of 60 white spruce transplants were set out on a fresh (M.R. 3) site and 60 on a very moist (M.R. 6) site. On both sites equal numbers of transplants were set out on selectively chosen mineral soil, humus, and mixed mineral soil and humus seedbeds, the mixed seedbed being prepared using a garden-type power tiller. A description of the planting stock is shown in Table 10.

Planting was carried out on May 5, a warm day (high at Hodgson was 66°F). Soil moisture condition was probably less than ideal with about 1/3 inch of rain from April 22 to May 5, however about 1/3 inch of rain fell the evening of May 5 and morning of May 6.

TABLE 10
PLANTING STOCK MEASUREMENTS

Species	# of transplants sampled	Average root length (in.)	Average height (in.)	Average root weight ¹ (gm.)	Average top weight ¹ (gm.)	Root/shoot ratio (by weight)
wS	25	11.4	6.0	0.82	2.35	0.35

¹ Oven dried at 105°C for 48 hours.

All plantations were examined May 13, when planting height was recorded, October 18, 1965, May 9 and August 25, 1966.

Survival on the fresh site was excellent on all seedbeds (Table 11). Transplants on the humus seedbeds had no mortality and best average height growth (5.4 inches) at the end of two summers. Survival has been only fair on the very moist site with most of the mortality occurring in the first summer. Best survival was on mineral soil (65 per cent) while best height growth was on the humus seedbed (3.9 inches). The mixed seedbed transplants had the poorest performance in both categories.

(B) Whiteshell Provincial Park - West Hawk Lake

(i) Seeding 1964

In the autumn of 1963 scalped strips were prepared in a dense mature aspen stand on fresh to very moist (M.R. 3-6), clay loam textured soils in Section 14, Twp. 10, Rge. 16, E.P.M. near West Hawk Lake. On May 20, 1964, thirty 1/8000-acre circular regeneration quadrats were established on a fresh site and thirty on a very moist site. Since mineral soil exposure was complete on the strips, humus seedbeds were prepared on undisturbed ground between the strips while the mixed seedbeds were prepared by returning humus material, to the strip, to be mixed. Grub hoes and shovels were used to mix the seedbed. The quadrats were set out in equal numbers on selectively chosen mineral soil, mixed mineral soil and humus, and humus seedbeds. Three hundred white spruce seed treated with Arasan, Endrin, and aluminum flakes were sown on each quadrat. Seed viability before treatment was 57.6 per cent.

Considerable rain fell in the first three weeks of May (2.1 inches at Rennie) and soil moisture conditions at the time of sowing was good. No rain fell the last week of May and first week of June, however rainfall was about normal for June and July (6.9 inches at Rennie).

All quadrats were examined on Sept. 22, 1964, July 14 and Sept. 22, 1965, and Sept. 9, 1966.

First year observed germination on the fresh site was highest on the mineral soil seedbed (25 per quadrat--Table 12) followed closely by the mixed seedbed. Germination was comparatively poor on the humus seedbed the first summer however more seed germinated during the second summer than during the first summer, probably indicating inadequate moisture conditions for germination on this seedbed. Best survival (66 per cent) on this site after three summers (Table 13) has been on the humus seedbed while poorest survival was on the mixed seedbed. Frost-heaving the first winter (Table 14) effected about a third of the seedlings on the mineral soil seedbed while leaves covered about a third of the seedlings on the humus and mixed seedbeds. Very few seedlings were frost-heaved on the humus (6 per cent). The mixed seedbed had the fewest healthy seedlings (61 per cent) and considerable frost-heaving (19 per cent).

On the very moist site first year observed germination was excellent on the humus seedbeds (69 seedlings per quadrat--Table 12). The best quadrat had 95 germinants from an average of 173 viable seeds.

TABLE II
SURVIVAL AND HEIGHT GROWTH OF TRANSPLANTS

Seedbed Type	Moisture Regime	Transplant								
		#	Average Height (in.)				Per cent Survival			
			at Planting	Spring 1966	Autumn 1966	Increment	Spring 1965	Autumn 1965	Spring 1966	Autumn 1966
Mineral Soil	3	20	7.1	8.7	11.7	4.6	100.0	95.0	95.0	95.0
Humus	3	20	7.7	9.7	13.1	5.4	100.0	100.0	100.0	100.0
Mixed	3	20	9.4	11.7	13.9	4.5	100.0	90.0	90.0	90.0
All	3	60	8.0	10.0	12.7	4.7	100.0	95.0	95.0	95.0
Mineral Soil	6	20	7.6	9.4	10.0	2.4	100.0	65.0	65.0	65.0
Humus	6	20	8.0	10.6	11.9	3.9	100.0	55.0	55.0	55.0
Mixed	6	20	8.9	10.1	11.1	2.2	100.0	60.0	50.0	45.0
All	6	60	8.2	10.0	10.9	2.7	100.0	60.0	56.7	53.3
All	3,6	120	8.0	10.0	12.1	4.1	100.0	77.5	75.8	74.2

TABLE I2
PER CENT STOCKING AND GERMINATION PER QUADRAT

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre Quadrats	Per cent Stocking Autumn 1964	Average Total 1964 Germination per Quadrat Autumn 1964	Average Total 1965 Germination per Quadrat Autumn 1965
Mineral Soil	3	10	100.0	25.2	5.6
Humus	3	10	80.0	5.3	9.1
Mixed	3	10	100.0	21.8	5.6
All	3	30	93.3	17.4	6.8
Mineral Soil	6	10	90.0	16.9	0.1
Humus	6	10	100.0	69.4	5.4
Mixed	6	10	100.0	33.8	0.5
All	6	30	96.7	40.0	2.0
All	3,6	60	95.0	28.7	4.4

TABLE I3
PER CENT SURVIVAL OF FIRST YEAR GERMINATION

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre Quadrats	Total First Year Germination	Per cent Survival			
				Autumn 1964	Spring 1965	Autumn 1965	Autumn 1966
Mineral Soil	3	10	252	100.0	78.6	71.4	49.6
Humus	3	10	53	98.1	77.3	73.6	66.0
Mixed	3	10	218	98.6	66.5	63.3	43.1
All	3	30	523	99.2	73.4	68.3	48.6
Mineral Soil	6	10	169	95.3	30.2	14.2	1.2
Humus	6	10	694	94.7	72.2	70.7	52.0
Mixed	6	10	338	97.9	59.2	57.1	33.1
All	6	30	1201	95.7	62.6	59.0	39.6
All	3,6	60	1724	96.8	65.9	61.8	42.3

Comparatively poor germination took place on the mineral soil and mixed seedbeds which were located on a scarified strip unlike the humus seedbed. In this locality the terrain is hilly and bedrock is close to the surface. Most of the bulldozed strips ran downhill and acted as miniature watersheds for surface water. At the bottom of the hills the bulldozer generally dug deep through, a heavy humus layer and into a rich silty clay loam, then pushed this material into a high mound at the end of the strip. This procedure caused considerable flooding of the strips on the moist sites. In addition the crown cover of the mature stand reduced evaporation on this site. Thus almost all its seedlings on the mineral soil seedbed that managed to germinate had died by the end of the third summer (Table 13). The mixed seedbed, being higher off the floor of the strip due to the addition of humus, was not as badly flooded. Germination was good while survival was poor (33 per cent). Survival of the seedlings on the humus, although better than on the other seedbeds, is misleading in this case. Seedlings on the humus seedbed generally have very thin and weak stems, poor coloured needles (yellowish-green), and were under intense competition from grasses. Condition of the mineral soil seedlings in the second spring was poor, 50 per cent was frost-heaved and 46 per cent were missing. Seedlings on the mixed seedbed were in much better condition with over 50 per cent still healthy, however about 25 per cent of them were frost-heaved, 20 per cent were under leaves, and 21 per cent were missing. Observations at the time of examination indicated considerable washing of the plots by water perhaps removing the seedlings or burying them under the loose soil. Seedlings on the humus seedbed were healthiest (75 per cent) although more seedlings were under leaves (20 per cent) than on the other seedbeds.

Future survival and growth may be affected by the herbicide spraying of the bulldozed strips carried out in late August of 1965.

(ii) Planting 1964

In the spring of 1964 a total of sixty white spruce transplants were set out on a fresh (M.R. 3) site, twenty on a moderately moist site (M.R. 4), and sixty on a very moist (M.R. 6) site. On the fresh and very moist sites equal numbers of transplants were set out on selectively chosen mineral soil, humus, and mixed mineral soil and humus seedbeds, while the twenty transplants on the moderately moist site were all on mineral soil seedbeds. Mixed seedbeds were prepared using grub-hoe and shovels while the humus seedbeds were prepared in the undisturbed portion of the stand between strips. A description of the planting stock is shown in Table 15.

Planting was carried out on May 20 and 21 in hot, wet weather (Rennie had 78°F and 93°F daily highs and 0.7 inches of rain). Soil moisture condition was good with over an inch of rain in the first three weeks of May.

All plantations were examined on May 21 and Sept. 22, 1964, May 25, 1965, May 16 and Sept. 9, 1966.

TABLE II

CONDITION OF SEEDLINGS AFTER FIRST WINTER

Seedbed Type	Moisture Regime	No. of Living Seedlings Autumn 1964	Per cent Condition													
			Healthy				Sick				Missing		Dead			
			H	UL*	FH	O FHUL	S	UL	FH	O	M	UL	D	UL	FH	O
Mineral Soil	3	252	42.5	6.3	26.5	0.4	0.8		2.4		4.4	7.1	3.6		6.0	
Humus	3	54	51.9	3.7			1.8	1.8			3.7	13.0	5.6		1.8	Deer stepped on.
Mixed	3	215	37.2	7.5	16.3		4.2	2.8			5.1	19.5	2.3	1.4	2.8	0.9
All	3	521	41.3	7.9	19.9	0.2	2.3	1.3	1.2		4.6	12.8	3.3	0.6	4.2	0.4
Mineral Soil	6	161	2.5	0.6	7.5		0.6		20.5		45.4	0.6	0.6		21.7	
Humus	6	653	65.7	8.3	1.2		1.4	0.2			10.0	11.6	0.9	0.7		
Mixed	6	331	30.5	3.9	16.0	2.4	3.0		4.6		20.6	13.9	0.6	0.6	3.9	
All	6	1145	46.6	5.9	6.4	0.7	1.7	0.1	4.2		18.0	10.8	0.8	0.6	4.2	
All	3,6	1666	45.0	6.5	10.6	0.5	1.9	0.5	3.2		13.8	11.4	1.6	0.7	4.2	0.1

* UL - Under leaves, FH - Frost heaved, O - FHUL - Frost heaved under leaves.

TABLE 15
PLANTING STOCK MEASUREMENTS

# of transplants sampled	Average root length (in.)	Average height (in.)	Average root weight ¹ (gms.)	Average top weight ¹ (gms.)	Root/shoot ratio (by weight)
25	5.0	5.5	0.22	1.29	0.17

¹

Oven dried at 105°C for 48 hours.

Survival on the fresh site was good on all seedbeds with almost all the mortality confined to the first summer (Table 16). The mixed seedbed had the best survival (95 per cent) and the greatest height growth in the first three summers (7.9 inches). Smallest height growth took place on transplants on the mineral soil seedbeds (4.8 inches). Some effect may be expected from a hand-spraying, with herbicide, of the competing vegetation on the strips in late August of 1965. Survival was poor (45 per cent) on the moderately moist site which was located on a slope. Much of the mortality is due to a combination of frost-heaving and transplant root exposure caused by rapid run-off as explained in the section on seeding (1/3 uprooted in spring of 1966). Very poor survival of the transplants on the disturbed seedbed on the very moist site would appear to be the result of severe flooding on the bulldozed strips. Survival has been excellent on the humus seedbed, however height growth has been much less than on the fresh site (3.7 versus 7.6 inches). This result seems to be due to severe grass competition on the very moist site.

Future survival and growth may be affected by the herbicide spraying of the bulldozed strips carried out in late August of 1965.

(iii) Seeding 1965

In the autumn of 1963 scalped strips were prepared in a dense mature aspen stand on fresh to very moist (M.R. 3-6) clay loam textured soils in Section 14, Twp. 10, Rge. 16, E.P.M. near West Hawk Lake. On May 25, 1965 thirty 1/8000-acre circular regeneration quadrats were established on a fresh site and thirty on a very moist site. Since mineral soil exposure was complete on the strips, humus seedbeds were prepared on undisturbed ground between the strips while mixed seedbeds were prepared by returning humus material to the strip to be mixed using a garden-type power tiller.

TABLE 16

SURVIVAL AND HEIGHT GROWTH OF TRANSPLANTS

Seedbed Type	Moisture Regime	Transplant							
		#	Average Height (in.)			Per cent Survival			
			at Planting	Autumn 1966	Increment	Autumn 1964	Spring 1965	Spring 1966	Autumn 1966
Mineral Soil	3	20	6.3	11.1	4.8	85.0	85.0	85.0	85.0
Humus	3	20	5.8	13.4	7.6	80.0	80.0	80.0	80.0
Mixed	3	20	6.1	14.0	7.9	100.0	95.0	95.0	95.0
All	3	60	6.0	12.8	6.8	88.3	86.7	86.7	86.7
Mineral Soil	4	20	5.8	7.8	2.0	80.0	75.0	70.0	45.0
Mineral Soil	6	20	5.5	10.0	4.5	25.0	10.0	10.0	5.0
Humus	6	20	6.0	9.7	3.7	100.0	100.0	100.0	100.0
Mixed	6	20	6.0	10.3	4.3	55.0	30.0	10.0	5.0
All	6	60	5.8	9.7	3.9	60.0	46.7	40.0	36.7
All	3,4,6	140	5.9	11.5	5.6	75.0	67.9	64.3	59.3

The quadrats were set out in equal numbers on selectively chosen mineral soil, mixed mineral soil and humus, and humus seedbeds. One hundred and twenty-five white spruce seeds treated with Arasan, Endrin, and aluminum flakes were sown on each quadrat. Seed viability was 57.6 per cent.

Soil moisture conditions at the time of sowing were good. Rainfall was adequate and well distributed throughout May, June and July (11 inches at Rennie).

All quadrats were examined on September 20, 1965, May 17 and September 7, 1966.

First year observed germination on the fresh (M.R. 3) sites was highest on the humus seedbed (25 germinants per quadrat (Table 17)). The best quadrat had 32 germinants from an average of 72 viable seeds.

Germination was poorest on the mineral soil seedbed and intermediate on the mixed seedbed (6 and 10 germinants per quadrat). Second year observed germination averaged 2 germinants per quadrat with little difference between seedbeds. Germination results in 1965 reversed the results in 1964 where germination was much greater on the disturbed seedbeds than on the humus seedbeds. Differences in survival of the three seedbeds at the end of the second summer were small (Table 18). The mixed seedbed had the best survival (72 per cent) while the mineral soil seedbed had the poorest (62 per cent). Most of the mortality of the observed germination took place in the second summer. Per cent condition in the first spring after seeding as shown in Table 19 indicates that on the fresh site, severest frost-heaving occurred on the mixed seedbed (52 per cent) while most covering of seedlings by leaves occurred on the humus seedbed (39 per cent). There was very little overwinter mortality (4 per cent) and most germinants were considered healthy (94 per cent). Subsequent survival (Table 20) of frost-heaved germinants on this site was about 75 per cent while almost 50 per cent of the germinants covered by leaves in the spring died that summer. Mortality related to leaf covering was higher on the humus seedbed than on the disturbed seedbeds (52 to 19 per cent). This was probably due to a heavier leaf cover produced by a good growth of hazel on the humus.

On the very moist (M.R. 6) site first year observed germination was very poor on the mineral soil and mixed seedbed. This is attributed, principally, to flooding as described in the section on seeding the preceding year. Good germination (21 germinants per quadrat) occurred on the humus seedbed. Best quadrat had 46 germinants from an average of 72 viable seeds in laboratory tests. No new germinants were found in the second summer. Of the germinants that established themselves on the mineral soil and mixed seedbed, none remained on the mineral soil while only 12 per cent remained on the mixed seedbed at the end of the second summer. Survival at that time, was almost as poor on the humus seedbed (21 per cent). Visual observations indicated heavy grass and some herb competition on this seedbed. Table 19 indicates the generally poorer condition of seedlings on the very moist site when compared to the fresh site (87 to 91 healthy) while Table 20 shows poor subsequent survival of

TABLE I7
PER CENT STOCKING AND GERMINATION PER QUADRAT

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre Quadrats	Per cent Stocking Autumn 1965	Average Total 1965 Germination per Quadrat 1965	Average Total 1966 Germination per Quadrat 1966
Mineral Soil	3	10	90.0	5.5	1.6
Humus	3	10	100.0	25.3	2.2
Mixed	3	10	100.0	10.0	2.1
All	3	30	96.7	13.6	2.0
Mineral Soil	6	10	20.0*	1.1	0.0
Humus	6	10	100.0	20.8	0.0
Mixed	6	10	60.0	1.7	0.0
All	6	30	60.0	7.9	0.0
All	3,6	60	78.3	10.7	1.0

* Ten germinants were on one quadrat.

TABLE I8

PER CENT SURVIVAL OF FIRST YEAR GERMINATION

Seedbed Type	Moisture Regime	Basis: No. of I/8000	Total First Year Germination	Per cent Survival		
				Autumn 1965	Spring 1966	Autumn 1966
Mineral Soil	3	10	55	92.7	89.1	61.8
Humus	3	10	253	99.2	93.3	66.7
Mixed	3	10	100	92.0	91.0	72.0
All	3	30	408	96.6	92.2	67.3
Mineral Soil	6	10	11	90.9	90.9	0.0
Humus	6	10	208	99.5	78.8	21.2
Mixed	6	10	17	82.4	76.5	11.8
All	6	30	236	97.9	79.2	19.5
All	3,6	60	644	97.0	87.5	49.8

TABLE 19

CONDITION OF SEEDLINGS AFTER FIRST WINTER

Seedbed Type	Moisture Regime	No. of Living Seedlings Autumn 1965	Per cent Condition															
			Healthy				Sick				Missing		Dead					
			H	UL*	FH	O	S	UL	FH	O	M	UL	D	UL	FH	O		
Mineral Soil	3	51	56.9	17.6	13.7	2.0		3.9	2.0		2.0		1.9					
Humus	3	253	45.4	34.0	10.7	3.1	0.8				0.4	2.0	3.2		0.4			
Mixed	3	94	34.1	12.8	48.9	2.1	1.0								1.1			
All	3	398	44.2	26.9	20.1	2.8	0.8	0.5	0.2		0.5	1.2	2.3		0.5			
Mineral Soil	6	11			72.7				18.2		9.1							
Humus	6	207	39.6	10.1	18.4	4.4	1.4	1.0	4.3		3.9	5.3	7.2		4.4			
Mixed	6	14	21.4		28.6	7.1			21.4				14.3	7.2				
All	6	232	36.6	9.1	21.6	4.3	1.3	0.9	6.0		3.9	4.7	7.3	0.4	3.9			
All	3,6	630	41.4	20.3	20.6	3.3	1.0	0.6	2.4		1.8	2.5	4.1	0.2	1.8			

* UL - Under leaves. FH - Frost heaved. O - FHUL - Frost heaved under leaves.

TABLE 20

SUBSEQUENT SURVIVAL OF SPRING CONDITION CLASSES

Seedbed Type	Moisture		No. of Seedlings and Per cent Survival									
	Regime		Healthy				Sick				Missing	
			H	UL*	FH	O HFUL	S	UL	FH	O	M	UL
Mineral Soil	3	#	29	9	7	I		2	I		I	
		%	86.2	77.8	42.8	0.0		0.0	0.0		0.0	
Humus	3	#	115	86	27	8	2				I	5
		%	88.7	47.7	85.2	25.0	50.0				0.0	0.0
Mixed	3	#	32	12	46	2	I					
		%	84.4	83.3	78.3	50.0	0.0					
All	3	#	176	107	80	11	3	2	I		2	5
		%	87.5	54.2	77.5	27.3	33.3	0.0	0.0		0.0	0.0
Mineral Soil	6	#			8				2		I	
		%			0.0				0.0		0.0	
Humus	6	#	82	21	38	9	3	2	9		8	11
		%	51.2	38.1	26.3	0.0	0.0	0.0	11.1		0.0	0.0
Mixed	6	#	3		4	I			3			
		%	0.0		50.0	100.0			0.0			
All	6	#	85	21	50	10	3	2	14		9	11
		%	49.4	38.1	26.0	10.0	0.0	0.0	17.1		0.0	0.0
All	3,6	#	261	128	130	21	6	4	15		11	16
		%	75.1	51.6	56.9	19.0	16.7	0.0	6.7		0.0	0.0

* UL - Under leaves, FH - Frost heaved, HFUL - Frost heaved under leaves.

healthy seedlings that had not been frost-heaved or covered with leaves (51 per cent) in the spring, and thus pointed to other factors causing the heavy mortality. For both sites together, fifty-five per cent of all frost-heaved seedlings either were dead in the spring or were dead or missing in the autumn. In the same period 59 per cent mortality was recorded for seedlings covered by leaves in the spring.

Future survival and growth may be affected by the herbicide spraying of the bulldozed strips or the very moist site carried out in late August 1965.

(iv) Planting 1965

In the spring of 1965 a total of sixty white spruce transplants were set out on a fresh (M.R. 3) site and sixty on a very moist (M.R. 6) site. On both sites equal numbers of transplants were set out on selectively chosen mineral soil, humus, and mixed mineral soil and humus seedbeds. Mixed seedbeds were prepared by returning humus material to the bulldozed strip, and there, mixed with mineral soil using a garden-type power tiller. Humus seedbeds were prepared in the undisturbed portion of the stand between strips. A description of the planting stock is in Table 10.

Soil moisture conditions at the time of planting, May 28, were good and the day was cool (high 55° Rennie). Rainfall was adequate and well distributed throughout May, June, and July (11 inches at Rennie).

Planting stock for the area was the same as that used more than 3 weeks earlier on the Interlake. Consequently seedlings had been transported to the Interlake, heeled in, taken up and transported to the Winnipeg laboratory, stored in a cold room for almost 3 weeks at 44°F, then were transported to West Hawk Lake and planted. At planting, trees were not dormant, buds were flushing and root growth was apparent.

All plantations were examined May 28, October 4, 1965, May 20 and September 9, 1966.

Survival (Table 22) on the fresh site was only fair (62 per cent) at the end of the second summer. Most of the mortality occurred in the first summer and would appear to be the result of the poor planting stock. Survival was best on the mineral soil seedbed and poorest on the mixed seedbed and intermediate on the humus seedbed. Best average height growth was on the humus seedbed and poorest average height growth at the end of the second growing season was 2 inches occurring on both the mineral soil and mixed seedbeds.

Survival after two summers was poor on the very moist site. Only a third of the transplants were alive at that time. Best survival (45 per cent) was on the mixed seedbed while poorest (25 per cent) was on the mineral soil seedbed. Poor survival is mainly attributed to a combination of poor planting stock and prevailing flood conditions described under 1964 seeding. The good survival of the transplants on the humus seedbed in the autumn of the first year is misleading since almost a third of the living seedlings were sick at that time. The superior average height growth

TABLE 22

SURVIVAL AND HEIGHT GROWTH OF TRANSPLANTS

Seedbed Type	Moisture Regime	Tranplant								
		#	Average Height (in.)				Per cent Survival			
			at Planting	Spring 1966	Autumn 1966	Increment	Spring 1965	Autumn 1965	Spring 1966	Autumn 1966
Mineral Soil	3	20	8.9	10.2	10.9	2.0	100.0	85.0	85.0	80.0
Humus	3	20	8.2	9.4	11.2	3.0	100.0	65.0	60.0	55.0
Mixed	3	20	8.1	8.0	10.1	2.0	100.0	60.0	50.0	50.0
All	3	60	8.4	9.4	10.8	2.4	100.0	70.0	65.0	61.7
Mineral Soil	6	20	7.8	11.4	13.2	5.4	100.0	40.0	30.0	25.0
Humus	6	20	8.1	10.2	12.7	4.6	100.0	85.0	40.0	30.0
Mixed	6	20	7.6	10.8	10.7	3.1	100.0	45.0	45.0	45.0
All	6	60	7.8	10.7	12.0	4.2	100.0	56.7	38.3	33.3
All	3,6	120	8.1	9.9	11.2	3.1	100.0	63.3	51.7	47.5

on this site when compared to the fresh site may be partially ascribed to a tendency for taller transplants to survive and, in the case of the disturbed seedbeds, to the extension of the aerial portion of the trees by frost-heaving.

Future survival and growth may be affected by the herbicide spraying of the bulldozed strips on the very moist site carried out in late August of 1965.

JACK PINE

(A) Interlake Area - Mantago Lake

(i) Seeding 1964

In March, 1964 scalped strips were prepared in a dense young aspen stand near Mantago Lake in Section 20, Township 26, Range 3, W.P.M. On May 12, 1964, twenty 1/8000-acre circular regeneration quadrats were established on a very dry (M.R. 0) site, twenty on a dry (M.R. 1) site, thirty on a moderately fresh to moderately moist (M.R. 2-3-4) site. The quadrats were set out in equal numbers on selectively chosen mineral soil and humus soil seedbeds, on the very dry and dry sites. On the moderately fresh to moderately moist sites quadrats were set out in equal numbers on selectively chosen mineral soil, humus soil, and mixed humus and mineral soil in conjunction with quadrats seeded to white spruce. Grub hoes and shovels were used to mix the mixed seedbeds. Fifty jack pine seed treated with Arasan, Endrin, and aluminum flakes were sown on each quadrat. Seed viability after treatment was 96.5 per cent. Seeding was carried out on May 12 on moderately fresh to moderately moist sites and on May 14 on the very dry to dry sites.

Soil moisture conditions would appear to have been good with over an inch and a half of rain reported in the first 10 days of May at the nearest weather station (Gimli). Although the rest of the month had almost no rain (0.02 inches at Gimli), rainfall in June was higher than normal and at 4 inches would appear to be sufficient for germination on good sites. All quadrats were examined in July 27, August 24, 1964, May 11, August 23, 1965 and August 22, 1966.

Observed germination (Table 23) on the very dry to dry site was a very small percentage of the possible seed sown. Best germination occurred on mineral soil seedbed on the dry site (2.5 per quadrat or 5 per cent of viable seed) while no germination was observed on the mineral soil seedbed on the very dry site (almost no tree cover on the very dry site). Germination on the humus seedbed was the same for both sites at 1.1 seedling per quadrat. Although the quadrats were examined in mid-summer and late summer few dead germinants were found during the first growing season. Survival overwinter was excellent with only the mineral soil seedbed on the dry site having any mortality (28 per cent). Considerable mortality occurred during the second summer on the dry site and seedling survival was poor during the next year. At the end of the third summer, seedlings on the humus seedbed had better survival than those on the mineral soil seedbed. Overwinter condition (Table 24) indicates little covering of seedlings by leaves and no frost-heaving on these sites located on a sand and gravel ridge.

TABLE 23

PER CENT STOCKING, AVERAGE GERMINATION PER QUADRAT, AND PER CENT SURVIVAL

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre	Per cent Stocking Autumn 1964	Average Total 1964 Germination per Quadrat Autumn 1964	Per cent Survival			
					Autumn 1964	Spring 1965	Autumn 1965	Autumn 1966
Mineral Soil	0	10	0.0	0.0	-	-	-	-
Humus	0	10	50.0	1.1	81.8	81.8	81.8	36.4
All	0	20	25.0	0.6	81.8	81.8	81.8	36.4
Mineral Soil	I	10	80.0	2.5	100.0	72.0	56.0	32.0
Humus	I	10	60.0	1.1	100.0	100.0	72.7	54.5
All	I	20	70.0	1.9	100.0	80.6	61.1	38.9
Mineral Soil	2	6	83.3	2.0	100.0	33.3	8.0	0.0
Humus	2	6	50.0	1.3	75.0	75.0	62.5	50.0
Mixed	2	5	80.0	2.0	100.0	50.0	40.0	20.0
All	2	17	70.6	1.8	93.3	50.0	30.0	20.0
Mineral Soil	3,4	4	75.0	1.5	100.0	66.7	33.3	33.3
Humus	3,4	4	75.0	4.8	94.7	63.2	57.9	15.8
Mixed	3,4	5	80.0	2.6	85.7	57.1	50.0	14.3
All	3,4	13	76.9	3.0	92.3	61.5	51.3	17.9
All	0,1,2,3,4	70	58.6	1.6	83.6	66.4	52.6	26.7

TABLE 24

CONDITION OF SEEDLINGS AFTER FIRST WINTER

Seedbed Type	Moisture Regime	No. of Living Seedlings Autumn 1964	Per cent Condition															
			Healthy				Sick				Missing		Dead					
			H	UL*	FH	O	S	UL	FH	O	M	UL	D	UL	FH	O		
Mineral Soil	0	0																
Humus	0	9	100.0															
All	0	9	100.0															
Mineral Soil	I	25	68.0	4.0							4.0	12.0	12.0					
Humus	I	11	100.0															
All	I	36	77.8	2.8							2.8	8.3	8.3					
Mineral Soil	2	11	36.4									9.1	54.5					
Humus	2	7	100.0															
Mixed	2	10	50.0								10.0	10.0	30.0					
All	2	28	57.1								3.6	7.2	32.1					
Mineral Soil	3,4	6	50.0		16.7							16.7	16.6					
Humus	3,4	18	55.6	5.6				5.5				5.5	27.8					
Mixed	3,4	12	66.7									25.0	8.3					
All	3,4	36	58.3	2.8	2.8			2.8				13.9	19.4					
All	0,1,2,3,4	109	67.9	1.8	0.9			0.9				1.8	9.2	17.5				

* - UL - Under leaves. FH - Frost heaved.

First year observed germination on the moderately fresh site, a sandy soil at the base of a ridge, was similar to that on the very dry and dry sites. Germination was a little better on both the mineral soil and mixed seedbed than on the humus seedbed (2.0 to 1.3 per quadrat). No mortality was observed the first summer on the disturbed seedbeds while 25 per cent of seedlings on the humus died in this period. Over winter there was no mortality of seedlings on the humus seedbed while two-thirds of the seedlings died on the mineral soil seedbed and half died on the mixed seedbeds. By the end of the third summer survival was the best on the humus seedbed (50 per cent) as against complete mortality of seedlings on the mineral soil seedbed and 20 per cent survival on the mixed seedbed. No frost-heaving of seedlings on this site was evident the second spring while about 10 per cent of the seedlings were covered with leaves on the mineral soil and mixed seedbeds.

First year observed germination on the fresh to moderately moist site was best on the humus seedbed, poorest on the mineral soil seedbed and intermediate on the mixed seedbed. Observed germination was much less than germination minus summer mortality recorded on similar sites and seedbeds in southeastern Manitoba (Bruce and Walker, 1967). On the fresh to moderately moist site mortality of the seedlings was most severe during the first winter and between the second and third autumn. At the end of the third summer survival was best on the mineral soil seedbed, however this result is based on an observed germination of only 6 seedlings. Overwinter condition shown in Table 24 indicates some frost-heaving on the mineral soil seedbeds, the least leaf covering of seedlings (11 per cent) on the humus seedbed, and the most on the mixed seedbed on this site.

Some mortality may be due to an aerial herbicide treatment carried out in early August of 1965 on plantations surrounding these seed spots although no damage was noted in the examination that September.

(ii) Planting 1964

In the spring of 1964 a total of 15 jack pine transplants were set out on a moderately fresh (M.R. 2) site and 45 on a fresh (M.R. 3) site. Equal numbers of transplants were set out on selectively chosen mineral soil, humus, and mixed mineral soil and humus seedbeds, the mixed seedbeds being prepared using grub hoes and shovels. A description of the planting stock is shown in Table 25.

Planting was carried out on May 12, a cool day (high at Gimli was 52°F) and soil moisture was excellent due to heavy rains during early May.

Heights of all transplants were recorded on May 14 and condition and damage were noted on November 17, 1964, May 14, 1965, and August 25, 1966 when heights were again measured.

Transplant survival (Table 26) has been fair to excellent to the end of the third summer. Best survival was on the humus seedbed (90 per cent) while fair survival (62 per cent) occurred on the disturbed seedbeds. Mortality is attributed, partly to severe browsing by deer as 98 per cent of the living seedlings in the second spring had been browsed during the first year. Some later mortality may be due to an aerial herbicide treatment carried out in early August of 1965 on white spruce plantations surrounding this site.

Average height growth after three summers was best on mixed seedbeds, poorest on humus seedbeds, and intermediate on mineral soil seedbeds. Some of the difference in height growth on the three seedbeds may be due to a different intensity of browsing for each of them.

(iii) Seeding 1965

In the spring of 1965, twenty 1/8000-acre circular regeneration quadrats were established on a very dry (M.R. 0) site, twenty on a dry (M.R. 1) site, and thirty on a fresh (M.R. 3) site. The quadrats were set out in equal numbers on selectively chosen mineral soil and humus seedbeds on the dry and very dry sites and on mineral soil, humus, and mixed mineral soil-humus seedbeds on the fresh site. A garden-type power tiller was used to prepare the mixed seedbeds. Fifty jack pine seeds pelleted with Arasan, Endrin, and aluminum flakes, and testing 89 per cent viable, were sown on each quadrat on May 5.

TABLE 25

PLANTING STOCK MEASUREMENTS

# of transplants sampled	Average root length (in.)	Average height (in.)	Average root weight ¹ (gms.)	Average top weight ¹ (gms.)	Root/shoot ratio (by weight)
25	7.9	4.6	0.53	2.03	0.26

¹

Oven dried at 105°C for 48 hours.

Moisture conditions at the time of seeding were excellent however rainfall during late May and June was light and insufficient for good germination.

All quadrats were examined on August 20, 1965, June 14 and August 23, 1966.

TABLE 26

SURVIVAL AND HEIGHT GROWTH OF TRANSPLANTS

Seedbed Type	Moisture Regime	Transplant							
		#	Average Height (in.)			Per cent Survival			
			at Planting	Autumn 1966	Increment	Spring 1964	Autumn 1964	Spring 1965	Autumn 1966
Mineral Soil	2	5	8.7	11.1	2.4	100.0	80.0	80.0	80.0
Humus	2	5	6.4	8.4	2.0	100.0	80.0	80.0	80.0
Mixed	2	5	8.0	15.4	7.4	100.0	100.0	100.0	100.0
All	2	15	7.7	11.9	4.2	100.0	86.7	80.0	86.7
Mineral Soil	3	15	7.1	12.8	5.7	100.0	100.0	93.3	60.0
Humus	3	15	7.8	11.0	3.2	100.0	100.0	100.0	93.3
Mixed	3	15	6.5	14.4	7.9	100.0	86.7	86.7	60.0
All	3	45	7.1	12.5	5.4	100.0	95.6	93.3	71.1
All	2,3	60	7.3	12.3	5.0	100.0	93.3	90.0	75.0

First year observed germination (Table 27) was poor for all seedbeds on all sites when compared to viable seed sown (4 germinants from average of 44 viable seeds). Best germination occurred on the humus seedbed on the dry site (5.5 germinants per quadrat) and the mixed seedbed on the fresh site (5.2 germinants per quadrat) while poorest germination was on the mineral soil seedbed on the fresh site (2.6 germinants per quadrat).

Survival of first year germination was generally poor for all seedbeds on all sites. Considerable mortality had already taken place by the first autumn examination. This mortality would appear to have been caused by a combination of drought and high temperatures in late July and early August. Survival was better on the fresh site than on the dry site which was better than on the very dry site (93-65-54 per cent). Mortality of the seedlings was severe over winter, especially on the fresh site where only 13 per cent of the germinants had survived to the spring. Survival during the second summer was good and in the autumn best survival was on the dry site (30 per cent) and poorest on the fresh site (9 per cent) while the very dry site was intermediate (23 per cent). There was little difference at this point between different seedbeds on the same site as per cent survival was based on very few seedlings.

Overwinter condition as shown in Table 28 indicates considerable mortality (21 per cent) associated with frost-heaving. This was more severe on the disturbed seedbeds than on the humus seedbeds on all sites. Mortality, unassociated with frost-heaving or leaf cover of seedlings in the spring was heavy (36 per cent); greater on the humus than on the disturbed seedbeds and greater on the fresh than on the dry and very dry sites. Possibly this was a continuing effect of the previous summer's drought. Subsequent survival of healthy seedlings in the spring (Table 29) indicates that best survival in the second summer occurred on the mineral soil seedbed and poorest survival on the humus seedbed.

Results to date and in the future may be effected by an aerial herbicide treatment carried out in early August of 1965 to reduce vegetative competition on surrounding plantations (quadrats were protected with newspapers during spraying).

(iv) Planting 1965

In the spring of 1965 a total of 60 jack pine transplants were set out on a fresh (M.R. 3) site. Equal numbers of transplants were set out on selectively chosen mineral soil, humus, and mixed mineral soil and humus seedbeds, the mixed seedbed being prepared using a garden-type power tiller. A description of the planting stock is shown in Table 30.

Planting was carried out on May 5, a warm day (high at Hodgson was 66°F). Soil moisture condition was probably less than ideal with about one third of an inch of rain from April 22 to May 5, however about one third of an inch of rain fell the evening of May 5 and morning of May 6.

TABLE 27

PER CENT STOCKING, AVERAGE GERMINATION PER QUADRAT, AND PER CENT SURVIVAL

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Acre	Per cent Stocking Autumn 1965	Average Total 1965 Germination per Quadrat Autumn 1965	Per cent Survival		
					Autumn 1965	Spring 1966	Autumn 1966
Mineral Soil	0	10	80.0	4.8	50.0	22.9	20.8
Humus	0	10	80.0	3.5	60.0	31.4	25.7
All	0	20	80.0	4.2	54.2	26.5	22.9
Mineral Soil	I	10	90.0	3.6	77.8	36.1	33.3
Humus	I	10	100.0	5.5	56.4	29.1	27.3
All	I	20	95.0	4.6	64.8	31.9	29.7
Mineral Soil	3	10	70.0	2.6	84.7	3.8	3.8
Humus	3	10	90.0	3.3	93.9	18.2	12.1
Mixed	3	10	90.0	5.2	96.2	13.5	9.6
All	3	30	83.3	3.7	92.8	12.6	9.0
All	0, I, 3	70	85.7	4.1	72.6	22.8	19.6

TABLE 28

CONDITION OF SEEDLINGS AFTER FIRST WINTER

Seedbed Type	Moisture Regime	No. of Living Seedlings Autumn 1965	Per cent Condition															
			Healthy				Sick				Missing		Dead					
			H	UL*	FH	O	S	UL	FH	O	M	UL	D	UL	FH	O		
Mineral Soil	0	24	41.7		4.2						4.1		25.0		25.0			
Humus	0	21	42.9										38.1		19.0			
All	0	45	42.3		2.2						2.2		31.1		22.2			
Mineral Soil	I	28	39.3				3.6				3.6		17.8	14.3	21.4			
Humus	I	31	51.6								3.2		29.1		16.1			
All	I	59	45.8				1.7				3.4		23.7	6.8	18.6			
Mineral Soil	3	22	4.6								22.7		45.4	4.6	22.7			
Humus	3	31	16.1								9.7		58.1		16.1			
Mixed	3	50	12.0				2.0				20.0	4.0	38.0		24.0			
All	3	103	11.6				1.0				17.5	1.9	45.6	1.0	21.4			
All	0,I,3	207	28.0		0.5		1.0				10.1	1.0	36.2	2.4	20.8			

* UL - Under leaves. FH - Frost heaved.

TABLE 29

SUBSEQUENT SURVIVAL OF SPRING CONDITION CLASSES

Seedbed Type	Moisture Regime		No. of Seedlings and Per cent Survival											
			Healthy				Sick				Missing			
			H	UL	FH	O	S	UL	FH	O	M	UL		
Mineral Soil	0	#	10		I								I	
		%	90.0		100.0								0.0	
Humus	0	#	9											
		%	77.8											
All	0	#	19		I								I	
		%	84.2		100.0								0.0	
Mineral Soil	I	#	11					I					I	
		%	100.0					0.0					0.0	
Humus	I	#	16										I	
		%	93.8										0.0	
All	I	#	27					I					2	
		%	96.3					0.0					0.0	
Mineral Soil	3	#	1										5	
		%	100.0										0.0	
Humus	3	#	5										3	
		%	60.0										0.0	
Mixed	3	#	6					I					10	2
		%	83.3					0.0					0.0	0.0
All	3	#	12					I					18	2
		%	75.0					0.0					0.0	0.0
All	0,I,3	#	58		I			2					21	2
		%	87.9		100.0			0.0					0.0	0.0

* UL - Under leaves. FH - Frost heaved.

Survival of the transplants (Table 31) has been generally good with mineral soil seedbed, the best (95 per cent) and the mixed seedbed poorest (80 per cent). Average height growth to the end of the second summer has been best (7.7 inches) on the mixed seedbed, poorest on the humus seedbed and intermediate on the mineral soil seedbed.

Average height growth and survival may have been effected by an aerial herbicide spraying carried out in early August of 1965. In the autumn of 1965 a third of the transplants were found to be sick, principally loss of needles and some dead buds, due primarily to the herbicide.

TABLE 30
PLANTING STOCK MEASUREMENTS

# of transplants sampled	Average root length (in.)	Average height (in.)	Average root weight ¹ (gms.)	Average top weight ¹ (gms.)	Root/shoot ratio (by weight)
25	9.1	3.3	0.43	1.15	0.37

¹

Oven dried at 105°C for 48 hours.

In this plantation deer browsing during the first winter appeared to be selective, while only 20 per cent of the transplants on the humus were browsed, 45 per cent were on the mixed seedbed, and 70 per cent were on the mineral soil seedbed.

FIFTH YEAR ASSESSMENT OF 1962 SEEDING

All seed used in 1962 was pelleted with Captan 50-W, a fungicide. Subsequent research (Waldron and Cayford 1964) indicated that while Captan 50-W reduced damping-off, it also caused abnormal rooting which prevented the normal establishment of a large proportion of the germinants. Thus while viability was improved by Captan 50-W in the laboratory, apparent germination based on observations made in early summer and again in autumn would be reduced.

TABLE 3I

SURVIVAL AND HEIGHT GROWTH OF TRANSPLANTS

Seedbed Type	Moisture Regime	Transplant							
		#	Average Height (in.)			Per cent Survival			
			at Planting	Autumn 1966	Increment	Spring 1965	Autumn 1965	Spring 1966	Autumn 1966
Mineral Soil	3	20	5.9	11.3	5.6	100.0	95.0	95.0	95.0
Humus	3	20	5.7	9.6	3.9	100.0	95.0	90.0	90.0
Mixed	3	20	5.3	13.0	7.7	100.0	85.0	80.0	80.0
All	3	60	5.6	11.2	5.6	100.0	91.7	88.3	88.3

TABLE 32

FIFTH YEAR ASSESSMENT OF DIRECT SEEDING

Seedbed Type	Moisture Regime	Basis: No. of I/8000 quadrats	Per cent Stocking to First Year Germination Autumn 1966	First Year Germination per quadrat		Other Living Germination Autumn 1966	Average Height of Tallest per Quadrat (in.)	Per cent Survival Of First Year Germination				
				Living Autumn 1966	Germination per Quadrat Autumn 1966			1962 Autumn	1963 Spring	1963 Autumn	1964 Autumn	1966 Autumn
Mineral Soil	3,4	10	90.0	10.0	4.8	0.5	3.1	92.0	75.0	60.0	54.0	48.0
Humus	3,4	10	90.0	13.8	9.2	0.8	6.4	76.8	69.6	68.8	68.1	66.7
Mixed	3,4	10	80.0	9.5	6.4	1.3	7.1	84.2	74.7	71.5	70.5	67.4
All	3,4	30	86.7	11.1	6.8	0.9	5.5	83.5	72.7	67.0	64.6	61.3
Mineral Soil	5,6	10	-	-	-	-	-	-	-	-	-	-
Humus	5,6	10	-	-	-	-	-	-	-	-	-	-
Mixed	5,6	10	-	-	-	-	-	-	-	-	-	-
All	5,6	30	-	-	-	-	-	-	-	-	-	-

ROAD CONSTRUCTION

WHITE SPRUCE

(A) Interlake - Fish Road

(i) Seeding 1962

In the spring of 1962, sixty 1/8000-acre regeneration quadrats were established and sown with 200 white spruce seeds each (Waldron 1964). The seed was pelleted with Captan 50-W and tested 63 per cent viable. The next winter thirty quadrats on the moist to very moist site were destroyed by road construction and in early August of 1965 an aerial herbicide treatment was carried out over these plots in releasing adjacent plantations. Observation indicated a good leaf kill of the aspen stand, with some mortality, and a good kill of herbs and brush such as willow.

A seeding assessment was carried out August 15, 1966 and results are summarized in Table 32. Best germination occurred on the humus seedbed, poorest on the mineral soil seedbed, and intermediate germination occurred on the mixed seedbed for the fresh site. About two thirds of the germinants survived through five summers on both the humus and the mixed seedbeds while slightly less than 50 per cent survival was recorded on the mineral soil seedbed. Average height growth over the five summers was poor on the mineral soil seedbed (3 inches) and best growth (7 inches) occurred on the mixed seedbeds. Average height growth on the humus seedbeds was 6 inches. The good survival and growth of seedlings on the humus seedbeds is perhaps due to poorly developed ground vegetation under the dense young aspen stand with the further assistance of the herbicide treatment.

To supplement the data from the seeding experiment, sixty 1/8000-acre regeneration quadrats were subjectively located on scalped strips that had been seeded in the spring of 1962 with white spruce at the rate of 1.3 pounds of Captan 50-W pelleted seed per acre. Seed viability was 63 per cent. Fifty quadrats were located on a fresh to moderately moist (M.R. 3-4) site and ten on a moist to very moist (M.R. 5-6) site (Waldron 1964). These plots were included in the aerial herbicide spraying of 1965.

A seeding assessment was carried out August 15, 1966 and results are summarized in Table 33. Best observed germination, stocking, survival and average height growth were found on the humus seedbeds for the fresh site. Germination was poor on the moist to very moist site, however, of the seedlings that did germinate all were dead by the end of the second summer on the mineral soil seedbed while survival was 25 per cent on the humus seedbed at the end of five summers.

(B) Whiteshell Provincial Park - Nutinik

(i) Seeding 1962

In the spring of 1962, thirty 1/8000-acre regeneration quadrats were established on a fresh to moderately moist (M.R. 3-4) site and ten on a very moist (M.R. 6) site (Waldron, 1964). Three hundred white spruce seeds pelleted with Captan 50-W and testing 10 per cent viable, were sown on each quadrat. A herbicide spraying of vegetation on the bulldozed strips on which the plots were situated, was carried out in early August of 1963.

TABLE 33

FIFTH YEAR ASSESSMENT OF BROADCAST SEEDING

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Quadrats	Per cent Stocking to First Year Germination Autumn 1966	First Year Germination		Average Height of Tallest per Quadrat (in.)	Per cent Survival Of First Year Germination				
				Per Quadrat	Living in Autumn 1966		Autumn 1962	Spring 1963	Autumn 1963	Autumn 1964	Autumn 1966
Mineral Soil	3,4	25(5)*	84.0	5.4	2.0	4.5	100.0	85.2	48.1	48.1	37.0
Humus	3,4	25(5)	96.0	6.0	4.8	6.3	100.0	86.7	86.7	86.7	80.0
All	3,4	50(10)	90.0	5.7	3.4	5.4	100.0	86.0	68.4	68.4	59.6
Mineral Soil	5,6	(5)	0.0	0.8	0.0	-	100.0	75.0	0.0	0.0	0.0
Humus	5,6	(5)	20.0	0.8	0.2	2.0	100.0	100.0	50.0	50.0	25.0
All	5,6	(10)	10.0	0.8	0.1	2.0	100.0	87.5	25.0	25.0	12.5

* 25 stock quadrats 5 of which are list quadrats.

TABLE 34

FIFTH YEAR ASSESSMENT OF DIRECT SEEDING

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Quadrats	Per cent Stocking to First Year Germination Autumn 1966	First Year Germination per Quadrat		Other Germination per Quadrat Living Autumn 1966	Average Height of Tallest per Quadrat (in.)	Per cent Survival of First Year Germination				
				Living Autumn 1966	Autumn 1966			Autumn 1962	Spring 1963	Autumn 1963	Autumn 1965	Autumn 1966
Mineral Soil	3,4	10	60.0	3.3	1.0	0.5	3.1	100.0	54.5	48.5	33.3	30.3
Humus	3,4	10	60.0	5.8	1.6	0.3	5.5	100.0	53.4	46.6	27.6	27.6
Mixed	3,4	10	80.0	8.3	2.3	0.3	3.8	100.0	49.4	41.0	30.1	27.7
All	3,4	30	73.3	5.8	1.6	0.4	4.1	100.0	51.7	44.2	29.9	28.2
Mineral Soil	6	5	0.0	1.2	0.0	0.0	-	83.3	0.0	0.0	0.0	0.0
Humus	6	5	20.0	1.6	0.2	0.2	1.9	100.0	50.0	50.0	25.0	12.5
All	6	10	10.0	1.4	0.1	0.1	1.9	92.8	28.6	28.6	14.3	7.1

A seeding assessment was carried out on September 1, 1966 and results are summarized in Table 34. Germination and survival of germinants was very poor on the very moist site and there was only one 1962 germinant living at the end of five summers. This result is attributed to Captan and excessive soil moisture. On the fresh to moderately moist site best germination was on the mixed seedbed and poorest on the mineral soil seedbed with the humus seedbed being intermediate. Seedling survival after five summers was essentially similar for all seedbeds (28 per cent). Best average height growth was on the humus seedbed (6 inches) while poorest average height growth was on the mineral soil seedbed (3 inches). The comparatively good results on the humus seedbeds is attributed to the absence of intense ground competition on the humus seedbeds.

To supplement the data from the seeding experiment sixty-one 1/4000-acre circular regeneration quadrats were subjectively located on scalped strips that had been seeded in the autumn of 1961 and in the spring of 1962 with white spruce at the rate of one pound of Captan 50-W pelleted seed per acre (Waldron, 1964). Seed viability was 39 per cent. These plots were included in the herbicide spraying of the bulldozed strips.

A seeding assessment was carried out on September 1, 1966 and results are summarized in Table 35. Again observed germination and early survival of seedlings on the very moist site was very poor due, principally, to Captan and excessive soil moisture. On the fresh to moderately moist site, the mineral soil seedbed had slightly better germination, survival, and height growth, but much poorer stocking than the humus seedbed. Mineral soil seedbed germination and survival was concentrated on the fresh sites. Considerable new germination was found in the autumn of 1965, a result, perhaps, of seedfall of white spruce trees near the area (an abundant cone crop was noted in 1964 for southeastern Manitoba, Waldron, 1965).

JACK PINE

(A) Interlake - Fish Road

(i) Seeding 1962

In the spring of 1962, a total of thirty 1/8000-acre circular regeneration quadrats were set out on a fresh to moderately moist site (M.R. 3-4). Fifty seeds, pelleted with Captan 50-W, with a viability of 80 per cent, were sown on each quadrat on May 2 of that year (Waldron, 1964). Observations made shortly after seeding indicated that some seeds had been eaten. In early August of 1965 an aerial herbicide treatment was carried out over these plots with results as noted under the white spruce seeding assessment.

A seeding assessment was carried out August 15, 1966 and results are summarized in Table 36. Best germination (5.0 germinants per quadrat) occurred on the mineral soil seedbed, poorest on the humus seedbed, and intermediate germination occurred on the mixed soil seedbed. Poorest

TABLE 35

FIFTH YEAR ASSESSMENT OF BROADCAST SEEDING

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Quadrats	Per cent Stocking to First Year Germination Autumn 1966	First Year Germination		Other Germination per Quadrat Living Autumn 1966	Average Height of Tallest per Quadrat (in.)	Per cent Survival of First Year Germination				
				Per Quadrat	Living Autumn 1966			Autumn 1962	Spring 1963	Autumn 1963	Autumn 1965	Autumn 1966
Mineral Soil	3,4	21	42.8	6.7	2.6	3.5	6.7	100.0	72.1	45.0	39.3	39.3
Humus	3,4	20	70.0	6.1	2.1	1.8	5.3	100.0	63.9	38.5	34.4	34.4
All	3,4	41	63.4	6.4	2.4	2.7	6.0	100.0	68.3	42.0	37.0	37.0
Mineral Soil	6	8	12.5	0.5	0.1	0.0	2.4	100.0	25.0	25.0	25.0	25.0
Humus	6	12	16.7	1.8	0.2	0.1	3.0	100.0	63.6	40.9	13.6	9.1
All	6	20	15.0	1.2	0.2	0.0	2.9	100.0	57.7	38.5	15.4	11.5

survival at 5 years occurred on the mineral soil seedbed (44 per cent) while best survival was on the humus seedbed (63 per cent). Frost-heaving would not appear to be a major cause of mortality as only 3 of 21 frost-heaved seedlings the first winter had died by the end of the second summer. Some mortality may have been caused by the herbicide treatment of 1965. Best average height growth occurred on the mineral soil seedbed (6 inches) and poorest average height growth occurred on the mixed seedbed (4 inches).

To supplement the data from the seeding experiment, twenty 1/8000-acre quadrats were subjectively located on scalped strips that had been seeded in the spring of 1962 with one pound (14.4 ounces of seed) of Captan pelleted seed per acre (Waldron, 1964). Viability of the seed was 80 per cent. Ten quadrats, five humus and five mineral soil seedbeds, were located on fresh to moderately moist sites (M.R. 3-4), the other ten on moist to very moist sites (M.R. 5-6). In early August of 1965 an aerial herbicide treatment was carried out over these plots with results as noted under the white spruce seeding assessment.

A seeding assessment was carried out August 15, 1966 and results are summarized in Table 37. On the fresh to moderately moist site, germination was slightly better on the mineral soil seedbed as was distribution of seedlings at the end of five summers. However, average height growth, at five years, was greater on the humus seedbed and seedling survival on the humus was more than twice as good as survival on the mineral soil seedbed. Some seedling mortality may have been caused by the aerial herbicide treatment of 1965.

At the end of five summers only two quadrats, on the moist to very moist site, had seedlings, one mineral soil, the other humus. Tallest seedling was on the mineral soil seedbed and best survival occurred on the mineral soil quadrat.

ASSESSMENT OF GERMINATION AND SURVIVAL TO THE END OF THE SECOND SUMMER FOR ALL AREAS

(A) WHITE SPRUCE

Germination found in the first summer after sowing as a per cent of the estimated viable seed sown is compared for all areas and years of seeding in Table 38. The rate of germination has been found to be somewhat better on the humus seedbeds than on the disturbed seedbeds for the moderately fresh to moderately moist sites. The rate of germination on this site would appear to be better in the generally more humid climate of the Whiteshell. Considerable fluctuation in the rate of germination is evident from year to year and from locality to locality, however, the widest variation would appear to occur on the humus seedbed and the smallest variation on the mineral soil seedbed.

TABLE 36

FIFTH YEAR ASSESSMENT OF DIRECT SEEDING

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Quadrats	Per cent Stocking to First Year Germination Autumn 1966	First Year Germination		Average Height of Tallest per Quadrat (in.)	Per cent Survival of First Year Germination				
				per Quadrat	Living in Autumn 1966		Autumn 1962	Spring 1963	Autumn 1963	Autumn 1964	Autumn 1966
Mineral Soil	3,4	10	90.0	5.0	2.2	5.8	90.0	84.0	72.0	64.0	44.0
Humus	3,4	10	80.0	2.7	1.7	5.0	96.2	96.2	92.7	85.2	63.0
Mixed	3,4	10	80.0	4.3	2.1	4.4	90.7	86.0	78.1	72.1	48.8
All	3,4	30	86.7	4.0	2.0	5.1	91.7	87.5	79.2	71.7	50.0

TABLE 37

FIFTH YEAR ASSESSMENT OF BROADCAST SEEDING

Seedbed Type	Moisture Regime	Basis: No. of I/8000 Quadrats	Per cent Stocking to First Year Germination Autumn 1966	First Year Germination per Quadrat	Living in Autumn 1966	Average Height of Tallest per Quadrat (in.)	Per cent Survival of First Year Germination				
							Autumn 1962	Spring 1963	Autumn 1963	Autumn 1964	Autumn 1966
							Mineral Soil	3,4	5	80.0	4.6
Humus	3,4	5	60.0	4.0	2.2	9.7	100.0	100.0	100.0	85.0	55.0
All	3,4	10	70.0	4.3	1.7	8.7	100.0	95.3	79.1	72.1	39.5
Mineral Soil	5,6	5	20.0	1.0	0.8	6.8	100.0	100.0	80.0	80.0	80.0
Humus	5,6	5	20.0	2.2	0.2	4.9	100.0	81.8	54.5	54.5	10.0
All	5,6	10	20.0	1.6	0.5	5.8	100.0	87.5	62.5	62.5	31.2

The rate of germination, on the moist to very moist site, for the humus seedbed (24 per cent) was more than double that of the disturbed seedbeds. The mixed seedbed was somewhat superior as a germination site in relation to the mineral soil seedbed. On this site, germination on the disturbed seedbeds, was better than on the humus seedbeds in only one of the eight seedings carried out.

Climatic conditions during the germinating period would appear to be the most important factor in the successful establishment of white spruce germinants. However the generally drier conditions necessary for good germination on the moister sites results in poor germination on the fresher sites.

Survival of the observed germination to the end of the second summer is shown in Table 39. Survival was essentially the same for the two disturbed seedbeds (54 per cent) on the moderately fresh to moderately moist sites, both being slightly better than on the humus seedbeds (52 per cent). There would appear to have been only one failure to obtain satisfactory survival on this site to the end of two summers, caused probably by a drought as previously described in that area's results.

Survival to the end of the second summer on the moist to very moist site was considerably better on the humus seedbed (51 per cent) than on the mixed seedbed which was a little better than on the mineral soil seedbed (31 per cent). A large part of the mortality on this site can be ascribed to flooding which is more severe at the lower elevation of the mineral soil and mixed seedbeds.

(B) JACK PINE

Germination of jack pine found in the first summer after sowing, as a per cent of the estimated viable seed sown is compared for all areas and years of seeding in Table 40.

The difference, in the rate of germination, between seedbeds is small, however the humus seedbed would appear to be slightly superior to the other seedbeds. Germination was very poor in three of the years of sowing when compared to the fourth year indicating a need for pre-seeding treatment that would help to ensure a higher rate of germination.

Survival of jack pine seedlings at the end of two summers was generally highest on the humus seedbeds, lowest on the mineral soil seedbeds, and intermediate on the mixed seedbed (Table 41).

FUTURE WORK

Established areas will be examined and assessed as indicated in the project plan (Waldron, 1962) and no new areas will be established.

TABLE 38

PER CENT GERMINATION OF VIABLE SEED SOWN FOR ALL AREAS AND YEARS

Seedbed Type	Moisture Regime	Observed First Year Germination as a Per cent of Viable Seed Sown								
		1962 ^o		1963		1964		1965		All ¹
		Fish Road	Nutimik	Fish Road	Nutimik	Mantago	West Hawk	Mantago	West Hawk	All
Mineral Soil	2,3,4	7.9	11.0	29.4*	20.4	5.8*	14.6*	14.9*	7.6*	14.0
Humus	2,3,4	10.9*	19.3	38.2	20.4	2.5*	3.1*	12.5*	35.1	17.8
Mixed	2,3,4	7.5*	27.7	21.1	23.9	3.6*	12.6*	13.6*	13.9*	15.5
All	2,3,4,	8.8*	19.3	29.6	21.5	4.0*	10.0*	13.6*	18.9	15.7
Mineral Soil	5,6	10.6	4.0	3.9	1.5	15.9	9.8	25.4	1.5	9.1
Humus	5,6	18.2	5.3	20.7	12.2	7.0	40.1	61.7	28.9	24.3
Mixed	5,6	19.6	-	3.7	5.2	20.5	19.5	12.4*	2.4	11.9
All	5,6	16.1	4.7	9.4	6.3	14.4	23.1	33.2	11.0	14.8

*More than 10 per cent of the germination occurred the second year after seeding.

¹ Unweighed average of the percentages.

^o Seed pelleted with Captan 50 - W.

TABLE 39

PERCENT SURVIVAL OF FIRST YEAR GERMINATION FOR ALL AREAS AND YEARS

Seedbed Type	Moisture Regime	Percent Survival of First Year Germination to the End of the Second Summer								
		1962		1963		1964		1965		All [†]
		Fish Road	Nutimik	Fish Road	Nutimik*	Mantago	West Hawk	Mantago	West Hawk	All
Mineral Soil	2,3,4	60.0	48.5	78.9	46.2	41.7	71.4	22.4	61.8	53.9
Humus	2,3,4	68.8	46.6	42.8	54.5	42.0	73.6	17.8	66.7	51.6
Mixed	2,3,4	71.5	41.0	68.0	73.5	38.9	63.3	10.2	72.0	54.1
All	2,3,4	67.0	44.2	60.8	58.9	40.9	68.3	16.9	67.3	53.0
Mineral Soil	5,6	-	0.0	7.1	54.5	76.4	14.2	62.3	0.0	30.6
Humus	5,6	-	50.0	17.7	65.5	62.8	70.7	68.5	21.2	50.9
Mixed	5,6	-	-	3.8	40.5	67.8	57.1	43.8	11.8	37.5
All	5,6	-	28.6	14.4	57.8	70.1	59.0	63.8	19.5	44.7

* Survival in second spring - no examination in the autumn.

† Unweighed average of the percentages.

TABLE 40

PER CENT GERMINATION OF VIABLE SEED SOWN FOR ALL AREAS AND YEARS

Seedbed Type	Moisture Regime	Observed First Year Germination as a Per Cent of Viable Seed Sown				
		1962* Fish Road	1963 Fish Road	1964 Mantago	1965 Mantago	All ¹ All
Mineral Soil	2,3-4	12.5	53.9	3.8	5.9	19.0
Humus	2,3-4	6.8	67.6	5.6	7.5	21.9
Mixed	2,3-4	10.8	38.0	5.0	14.1	17.0
All	2,3-4	10.0	53.1	4.8	8.4	19.1
Mineral Soil	0-1	-	-	2.6	9.5	6.0
Humus	0-1	-	-	2.3	10.2	6.2
All	0-1	-	-	2.4	9.9	6.2

¹ Unweighed average of the percentages.

* Seed pelleted with Captan 50 - W.

TABLE 4I

PER CENT SURVIVAL OF FIRST YEAR GERMINATION FOR ALL AREAS AND YEARS

Seedbed Type	Moisture Regime	Per Cent Survival of First Year Germination to the End of the Second Summer				
		1962 Fish Road	1963 Fish Road	1964 Mantago	1965 Mantago	All* All
Mineral Soil	2,3-4	72.0	91.3	16.7	3.8	46.0
Humus	2,3-4	92.7	86.1	59.2	12.1	62.5
Mixed	2,3-4	78.1	90.3	45.8	9.6	56.0
All	2,3-4	79.2	88.9	43.5	9.0	55.2
Mineral Soil	0-1	-	-	56.0	26.2	41.1
Humus	0-1	-	-	77.3	26.7	52.0
All	0-1	-	-	66.0	26.4	46.2

* Unweighed average of the percentages.

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