DEVELOPMENT OF WHITE SPRUCE PROVENANCES FROM THE GREAT LAKES - ST. LAWRENCE FOREST REGION IN NEWFOUNDLAND

by
J. Nicholson

FOREST RESEARCH LABORATORY
ST. JOHN'S, NEWFOUNDLAND
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Development of White Spruce Provenances from the Great Lakes - St. Lawrence Forest Region in Newfoundland

By

J. Nicholson

INTRODUCTION

White spruce (*Picea glauca* (Moench) Voss) has a transcontinental distribution and grows under a great range of climatic soil and topographic conditions (Sutton, 1969). Research on the geographic variation of white spruce in eastern Canada has been in progress since about 1950 under the direction of Mark Holst of the Petawawa Forest Experiment Station, Chalk River, Ontario. As part of these investigations a series of plantations of provenances from the Great Lakes - St. Lawrence Forest Region (Rowe, 1959) has been established in several locations in North America. One of these plantations was established at the North Pond Experimental Area in the spring of 1963 (Wilton, 1964). The purpose of this plantation as it pertains to Newfoundland was to test the suitability of these provenances for forestation under local conditions and to compare their performances with that of a local control.

METHODS AND MATERIALS

Seed collection, growing of seedlings and the experimental design were planned and/or carried out by the staff at the Petawawa Forest Experiment Station. Planting of the experiment and subsequent maintenance and measurement has been carried out by staff in the Newfoundland Region.

There are 31 provenances whose origins range from northeastern New Brunswick west to Minnesota and from Napanee on the northeastern shore of Lake Ontario north to latitude 49° in northwestern Ontario (Appendix I, II). A local provenance from the Humber Valley in western Newfoundland was included for comparison. The mainland provenances were planted in the spring of 1963 as 2-2 nursery stock and the local provenance consisting of 3-to-5-year-old wildings was planted in the fall of 1963.

The experiment is established in a six-replicated randomized block design with plots consisting of two rows of 20 trees each (Appendix III). The entire plantation is encompassed by two rows of surround trees. All trees are planted at six-foot spacing.

The plantation is located about mid-slope along the south side of the shallow valley of the North Pond drainage system. The slope is about 10 percent with a northern aspect and the elevation is about 500 feet above sea level. The area is underlain by a deep glacial till. It formerly

supported an 80-year-old balsam fir-spruce stand which was clearfelled for pulpwood in 1956. It was subsequently burned over in a forest fire which occurred in August of 1961.

Site variations in the plantation were mapped in the summer of 1968 (Appendix III). There were three major site types: 1. fresh sites on deep, well-drained podzolic soil; 2. fresh sites on deep well-drained podzolic soil with moist sites in localized patches; 3. wet mucky organic soil.

Parent materials had a loamy texture (44% sand: 48% silt: 8% clay). There appeared to be no significant differences in the foliar mineral content of trees growing on the different types (Table 1) indicating small differences in nutritional properties of the various sites, at least for the minerals tested.

The first ten-year remeasurement, as suggested by the cooperator, was to be carried out in the fall of 1968. In addition to measuring the height of all living trees, some observations on phenology for the 1968 growing season and on annual leader growth for three years were made on five randomly selected seedlings per plot for each provenance.

Table 1. Mineral contents of white spruce needles from the site types in the plantation and from natural stands in the vicinity.

		Total mineral content, %			
		N	P	K	Na
Natural stands:	Gander	1.079	0.300	0.815	0.008
	Gambo	1.328	0.328	0.750	0.0095
	North Pond	1.301	0.288	0.715	0.025
Plantation:	Type I	1.207	0.364	0.750	0.0195
	Type II	1.204	0.328	0.715	0.0450
	Type III	1.312	0.300	0.680	0.0390

Complications arose when attempting to compare provenances statistically because the long axis of the blocks paralleled the direction of the slope and average height growth of seedlings on the lower portion of each block was often double that of seedling on the upper portion. Also, in spite of the random method of locating provenances in each block it was found that some provenances tended to occupy upper positions on the slope more frequently than others, Variation in site type within some blocks also caused differences in height. The above factors introduce bias in an analysis of variance so an analysis of convariance was used to test differences between provenances after heights had been adjusted to a standard position on the slope (Steel and Torrie, 1960, page 311). This analysis was carried out using data only for blocks

one and two because these were the only ones with a uniform site type and the relationship of height (Y) to position on the slope (X) was almost linear. The local provenance was omitted from this analysis because growth was extremely poor.

A non-statistical method was used also to adjust provenance mean heights. For each block the provenance height was plotted over position on the slope and a free-hand line that best fit the points was drawn. Deviations from this line (assumed to have been caused by inherent differences among the provenances) were determined for each provenance in each block. The average deviation for each provenance was then calculated, and added to the plantation mean. Provenances were then ranked.

In summary, the convariance analysis, based on two blocks, serves to establish the statistical significance of differences between provenances after the effects of position on the slope were removed. The non-statistical method, based on all six blocks, provides a means of comparing provenances after the major environmental effects were removed.

Measurements of leader growth in 1966, 1967 and 1968 and bud bursting and bud setting dates in 1968 were obtained for five randomly selected trees per plot for each provenance (30 per provenance for the whole experiment). Bud bursting date was defined as the date on which new needles became visible on the terminal. Bud setting date was defined as the date on which the terminal bud became visible. Great difficulty was experienced in making the latter observations because, although the needles on the terminal became stiff and whorled, buds did not develop substantially. The reason for this is thought to be the unusually cold weather in August (and indeed during the whole summer of 1968, Table 2) which prevented a normal "ripening" process.

Table 2. Mean daily temperatures in the summer months for 1966, 1967, 1968 at Gander International Airport

Month	1966	1967	1968	Normal
May	43.5	41.7	39.3	43.8
June	54.4	56.5	46.8	52.8
July	63.6	66.2	58.5	62.3
August	59.4	66.2	53.1	61.0
Mean	55.2	57.6	49.4	54.9

Analyses of variance were carried out on these factors and correlations between them were calculated using individual seedling values and provenance mean values. The means and coefficients of variation are listed in Appendix VI.

RESULTS

The general appearance of the plantation was good. The majority of trees had healthy leaders and were growing well. Survival over the whole plantation was 86 percent and the plantation mean height was 91.5 cm. (Appendix IV). Height and survival on the different site types can be seen in Table 3.

Table 3. Mean height and survival in the different site types

Site type	No. of trees Planted	No. of trees Surviving	Survival (%)	Means height (cm.)
I	2,989	2,849	95.3	97.3
II	3,633	3,004	82.5	88.6
IIa	70	65	92.8	96.2
IIb	88	86	97.7	99.2
III	800	501	62.6	88.6
IIIa	13	6	46.1	76.6

Site type IIb with a mean height of 99.2 cm. supported the best growth but this was due largely to its low location on the slope. Therefore, the well-drained loam of site type I on which the mean height was 97.3 cm. provides the best conditions for growth. The mean height on site type IIa, situated on the lower part of the slope, was 96.2 cm. The height growth on site types II and III were equivalent and were approximately 9 percent less than on site type I. The mean height on site type IIIa was more than 20 percent less than on site type I indicating very poor growing conditions, but it represented an insignificant part of the total area.

The survival was best on site types IIa and IIb at 92.8 and 97.7 percent respectively and was slightly less on site type I at 95.3 percent (93.8 percent if the replaced seedlings in blocks 1 and 2 are considered). Survival on site type II was intermediate at 82.5 percent and was least on site types III (62.6 percent) and IIIa (46.1 percent). Survival therefore was higher on the better drained sites.

Height growth differences between provenances in blocks I and 2 were statistically significant (Table 4) indicating that differences over all six blocks would most likely be significant as well if they could be tested by a valid statistical method. Provenances were ranked for observed mean height and mean height adjusted according to the

freehand graphical method (Table 5). It is thought that the latter method offers better provenance comparisons because the affects of site variations and position on the slope were largely removed and six as opposed to two blocks were included in the analysis.

The tallest provenance was from Grandes Piles, Quebec (No. 2447). Other top-ranking provenances were also from the region encompassing eastern Ontario and southwestern Quebec (No. 2444, 2445, 2459). There is a general decrease in height with distance from this region with the provenances from northwestern Ontario (No. 2480, 2483) and one from Minnesota (No. 2601) being the shortest. Exceptions to this pattern are the second provenance from Minnesota (No. 2571) which is 19 cm. taller than its neighbor; the Martin River, Ontario, provenance (No. 2478) which is shorter than others in the vicinity and the two from northwestern New Brunswick (No. 2473, 2475) which are taller than neighboring ones to the north and west in Quebec. These results correlate well with those of other investigators working with provenances from approximately the same region. Genys (1964) and Nienstaedt (1966) both reported that provenances from eastern Ontario and southwestern Quebec grew bent and that there were clines of decreasing growth rate both northeast and northwest from that general region. The provenance from western Newfoundland was much shorter than the others but this may be primarily due to a slow recovery from the uprooting - planting shock rather than from an inherently inferior growth rate.

Table 4. Analysis of covariance on blocks 1 and 2 to test the significance of differences in provenance heights (Y) after the effects of position on the slope (X) are removed.

Source	df	Sum of products yy	xy	xx	Y adjusted for X df	ss	ms	F
Total	61	21,184.88	8,011.07	5,270.34				
Blocks	1	1,411.20	-68.62	2.68				
Provenances	30	14.808.40	5,185.40	3,265.80				
Error	30	4,965.28	2,894.29	2,001.86	29	314.77	10.85	
Provenances + Error	60	19,773.68	8,079.69	5,267.66	59	1,966.24		
Provenances adjusted					30	1,651.47	55.04	5.07*

*F significant at 95 percent level

Table 5. Mean heights of white spruce provenances ranked from shortest to the tallest.

Observed Means			Means adjusted for position on slope and site variations		
No.	Origin	Height cm.	No.	Origin	Height cm.
301	Western Newfoundland	52.2	301	Western Newfoundland	53.0
2601	Cook Co., Minn.	72.7	2601	Cook Co., Minn.	74.0
2480	Kakabeka Falls, Ont.	73.4	2483	Pagwachuan Lake, Ont.	82.0
2478	Martin River, Ont.	77.9	2478	Martin River, Ont.	82.3
2604	Shipshaw River, Quebec	82.7	2480	Kakabeka Falls, Ont.	82.8
2602	Luce Co., Mich.	83.6	2602	Luce Co., Mich.	85.2
2440	Napanee, Ont.	84.6	2570	Cheguamegon Nat. For., Wisc.	86.3
2482	Kapuskasing, Ont.	87.2	2604	Shipshaw River, P.Q.	87.2
2486	Swastika, Ont.	88.1	2472	Price, P.Q.	88.2
2570	Cheguamegon Nat. For., Wisc.	90.1	2479	Aubrey Falls, Ont.	88.4
2473	Edmundston, N.B.	90.4	2486	Swastika, Ont.	88.5
2484	Mitchenamakus Lake, P.Q.	90.7	2462	McNally Lake, P.Q.	89.0
2491	Valcartier, P.Q.	90.9	2482	Kapuskasing, Ont.	89.4
2468	Searchmont, Ont.	91.2	2491	Valcartier, P.Q.	90.8
2483	Pagwachuan Lake, Ont.	91.8	2440	Napanee, Ont.	91.5
2472	Price, P.Q.	92.1	2463	Notre Dame du Laus, P.Q.	92.1
2572	Huron Nat. For., Mich.	92.3	2477	Ashley Mines, Ont.	92.2
2477	Ashley Mines, Ont.	92.6	2481	Potter, Ont.	92.3
2479	Aubrey Falls, Ont.	92.7	2468	Searchmont, Ont.	92.5
2454	N. Baskatong Lake, P.Q.	93.6	2572	Huron Nat. For., Mich.	93.0
2462	McNally Lake, P.Q.	96.0	2571	Grand Rapids, Minn.	93.0
2475	Upper Green River, N.B.	96.4	2484	Mitchenamakus Lake, P.Q.	93.5
2481	Potter, Ont.	96.5	2475	Upper Green River, N.B.	95.2
2485	Lac Simard, P.Q.	98.9	2473	Edmundston, N.B.	95.7
2438	Peterborough, Ont.	99.5	2451	Lake Edward, P.Q.	96.4
2463	Notre Dames du Laus, P.Q.	99.6	2454	N. Baskatong Lake, P.Q.	96.7
2571	Grand Rapids, Minn.	99.8	2438	Peterborough, Ont.	98.2
2451	Lake Edward, P.Q.	100.2	2485	Lac Simard, P.Q.	99.7
2445	Cushing, P.Q.	100.9	2444	Beachburg, Ont.	102.8
2444	Beachburg, Ont.	103.4	2445	Cushing, P.Q.	102.8
2459	Algonquin Park, Ont.	109.0	2459	Algonquin Park, Ont.	105.1
2447	Grande Piles, P.Q.	113.1	2447	Grande Piles, P.Q.	106.6

The mean survival (Appendix IV) of the mainland provenances ranged from 73 to 93 percent. Those with lowest survival were No. 2444 (73%), No. 2486 (75%), one of the better and one of the poorer provenances respectively in terms of height growth. Those with highest survival were No. 2438 (93%), No. 2459 (93%), No. 2484 (93%), No. 2571 (92%), No. 2481 (91%) and No. 2485 (91%). All of these showed above average height growth as well. The survival in the local provenance (56%) was much less than in the other provenances; probably for the same reasons that height growth was less.

The ability of a provenance to perform consistently with regard to others in different environments, i.e. always above average or always below average, has been termed "adaptive stability" (Nienstaedt, 1966). A tentative appraisal of the adaptive stability of these provenances may be made by looking at the graphs of provenance heights plotted over position on the slope for each block which were used previously to adjust provenance heights for position on the slope and site variations. If the deviation from the freehand line fitted to these points is fairly consistent in magnitude and direction in all six blocks, then the provenance has a high adaptive stability; if the converse is true it has low adaptive stability. Those provenances with relatively high adaptive stability are No. 2445, 2459, 2463, 2480, 2491, and 2571. Those with the least adaptive stability are No. 2440, 2454, 2462, 2475, 2479, and 2572. In practical application, plantations made up of provenance(s) from the former group would make relatively uniform stands on variable planting sites while the opposite is true of the latter group. However, no conclusions should be made in this regard until other plantations in the series are analyzed.

An analysis of variance showed significant differences between provenances for the phenology and leader growth parameters (Table 6). No further comparisons were made between provenances due to the complicating effects of site variations that were not accounted for in the analysis. It is noted however that leader growth of the Newfoundland provenance (No. 301) in 1967 and 1968 has increased substantially over that of 1966. This suggests a recovery from the planting stock mentioned earlier.

Table 6. Summary of analyses of variance for phenology and height growth parameters

Parameter	Provenances	Blocks	PXB
Date of bud burst	4.948**	4.886**	1.343
Date of bud set	1.863**	0.718	0.984
Days of growth	1.774*	0.314	1.055
Leader length, 1968	3.418**	20.241**	1.702**
Leader length, 1967	4.243**	10.440**	1.959**
Leader length, 1966	3.893**	7.891**	1.390*
Leader growth, 1966-68	4.793**	10.171**	1.813**
Height of tree	6.457**	9.970**	1.694**

* = significant at .95 level, ** = significant at .99 level.

Correlation coefficients are listed in Table 7 and the main features of the analysis are summarized below;

Table 7. Correlation coefficients between growth and phenology parameters calculated on the basis of (a) individual tree values and (b) provenance mean values

Parameter			Parameter Number 1	2	3	4	5	6
1.	Date of bud burst '68	(a)	1.000					
		(b)	1.000					
2.	Date of bud set '68	(a)	0.222	1.000				
		(b)	0.354*	1.000				
3.	Days of growth '68	(a)	-0.158	0.925	1.000			
		(b)	-0.224	0.831**	1.000			
4.	Leader length '68	(a)	-0.193		0.130	1.000		
		(b)	0.175	0.284	0.188	1.000		
5.	Leader length '67	(a)	0.081			0.694	1.000	
		(b)	0.381*	0.256	0.044	0.848**	1.000	
6.	Leader length, '66	(a)	0.217			0.384	0.677	
		(b)	0.503**	0.128	-0.150	0.648**	0.870**	
7.	Three-year growth	(a)		0.066				
		(b)	0.386*	0.249	0.037			
8.	Height of tree, '68	(a)	0.109					
		(b)	0.480**	0.221	-0.047			
9.	Height of tree, '67	(b)				0.760*		
10.	Height of tree, '66	(b)					0.855*	
11.	Height of tree, '65	(b)						0.842*

Note: for (a), r.05 = .062, r.01 = .081 ... 958 d.f.
for (b), r.05 = .349, r.01 = .449 ... 30 d.f.

1. The number of days of growth (time from bud break to bud set) is closely related to date of bud set but not to date of bud break.

2. There was little relationship between days of growth in 1968 with leader length in 1968 or other growth measures.

3. Leader lengths in successive years were quite closely correlated but there was a substantial drop in the level of correlation when leader length in 1966 was correlated with leader length in 1968.

4. Correlation coefficients between leader lengths based on "all seedlings" were approximately .3 less than those based on provenance means. The differences are related to the variation of individuals within provenances.

CONCLUSION

It is not possible to recommend the most suitable provenances for introduction to Newfoundland on the basis of this remeasurement. However, those from southeastern Ontario and southwestern Quebec appear to be the most promising as their growth is up to 15 percent above average and survival is on a par with the others. The local provenance appears to be recovering from a poor start and may yet prove to be as good as those from southeastern Ontario and southwestern Quebec.

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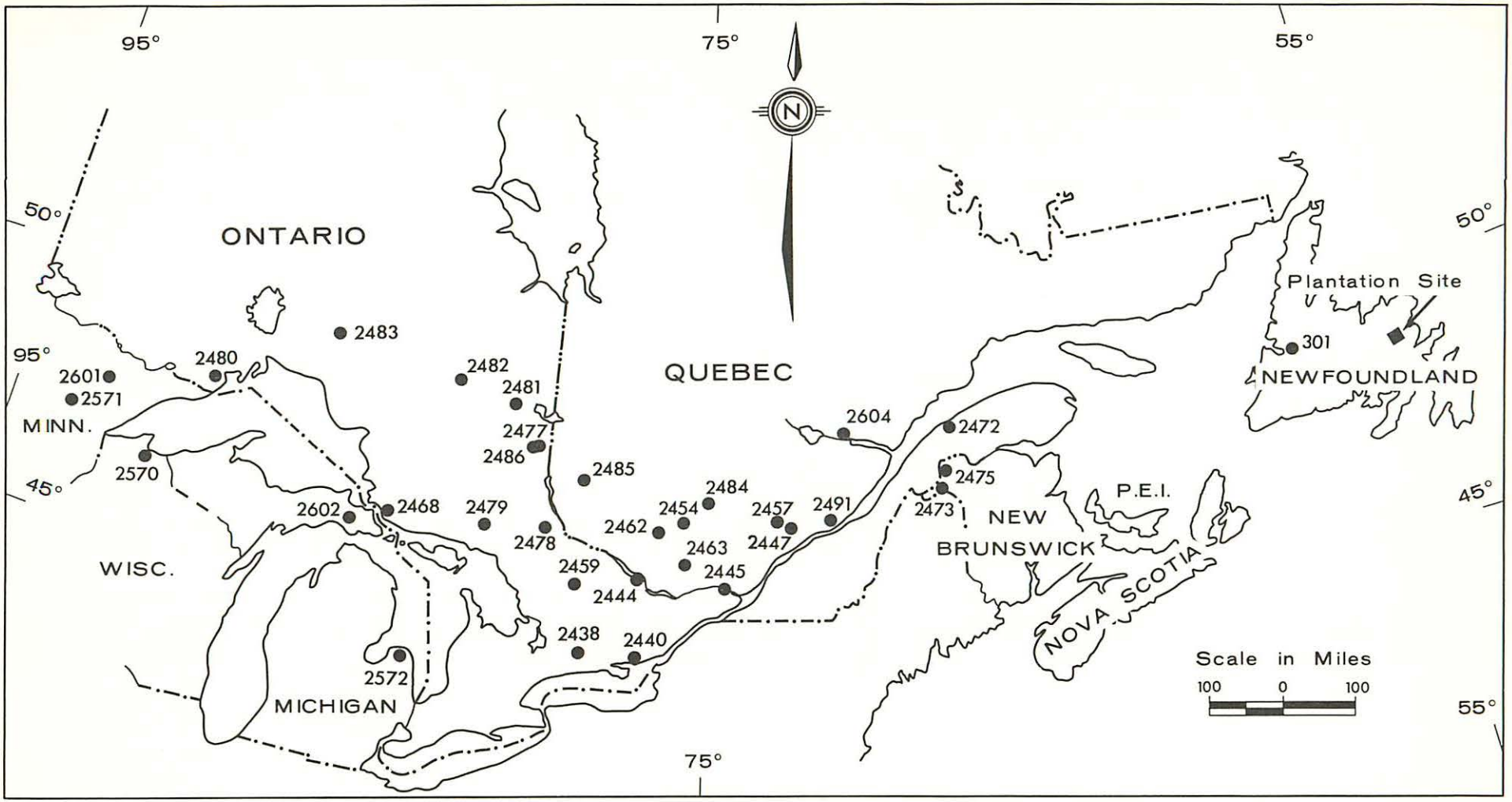
Appendix I

White spruce provenances planted in experiment

Seedlot Number	Origin	Latitude	Longitude
S.2438-59	Peterborough, Ont.	44°18'	78°18'
S.2440-59	Napanee, Ont.	44°12'	76°54'
S.2444-59	Beachburg, Ont.	43° 6'	80°36'
S.2445-59	Cushing, P.Q.	45°48'	74°54'
S.2447-59	Grandes Piles, P.Q.	46°48'	72°42'
S.2451-59	Lake Edward, P.Q.	46°48'	72°54'
S.2454-59	N. Baskatong Lake, P.Q.	46°54'	75°48'
S.2459-59	Algonquin Park, Ont.	45°36'	78°36'
S.2462-59	McNally Lake, P.Q.	46°42'	76°30'
S.2463-59	Notre Dames du Laus, P.Q.	46° 6'	75°36'
S.2468-59	Searchmont, Ont.	46°48'	84°00'
S.2472-59	Price, P.Q.	48°36'	68° 6'
S.2473-59	Edmundston, N.B.	47°24'	68°24'
S.2475-59	Upper Green River, N.B.	47°48'	68°12'
As above for double surround rows			
S.2477-59	Ashley Mines, Ont.	48° 6'	80°00'
S.2478-59	Marten River, Ont.	46°42'	79°48'
S.2479-59	Aubrey Falls, Ont.	46°36'	82°24'
S.2480-59	Kakabeka Falls, Ont.	48°24'	89°36'
S.2481-59	Potter, Ont.	48°54'	80°48'
S.2482-59	Kapuskasing, Ont.	49°24'	82°24'
S.2483-59	Pagwachuan Lake, Ont.	49°30'	86° 6'
S.2484-59	Mitchinamekus Lake, P.Q.	47°15'	75°00'
S.2485-59	Lac Simard, P.Q.	47°36'	78°42'
S.2486-59	Swastika, Ont.	48° 6'	80° 6'
S.2491-59	Valcartier, P.Q.	46°54'	71°36'
S.2570-59	Cheguamegon Nat. For., Wisc.	46°36'	91°00'
S.2571-59	Grand Rapids, Minn.	47°12'	93°30'
S.2572-59	Huron Nat. For., Mich.	43°48'	83°00'
S.2601-59	Cook Co., Minn.	47°48'	92°42'
S.2602-59	Luce Co., Mich.	46°18'	85°00'
S.2604-59	Shipshaw River, P.Q.	48°30'	71° 6'
301	Western Newfoundland	49°00'	58°45'



APPENDIX II - LOCATION OF WHITE SPRUCE PROVENANCES

Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
2473	2445	2454	2485	2602	2447
2484	2478	2477	2483	2486	2440
2602	2440	2604	2445	2462 III	301
2440	2480	2601	2571	2451	2485
2459	2491	2572	2447	2468	2473
2480	2604	2485	2478	2484	2444
2601	2454	2484	2462	2482	2480
2445	2482	2462	2572	2481	2486
2478	2486	301	2438	2483	2572
2482	2468	2472 III	2440	2475	2570
2468	2602	2438	2482	301	2472
2481	2485	2571	2480	2473	2451
2479	2451	2468	2570	2472	2463
2486	2475	2479	2468	2480	2571
2570 I	2473	2447	2451	2479	2484
2604	2462	2481	2491	2444	2459
2438	301	2463	2604	IIIa 2572	2479
2477	2572	2440	2454	2491 II	2475
2475	2438	2451	2477	2463	2454
2451	2484	2570	301	2447	2482
2444	2472	2602	2486	2438	2601
2485	2571	2486 II	2602	2440	2445
2463	2447	2459	2444	2601	2438
2454	2481	2445	2475	2477	2473
2572	2570	2475 III	2473	2485	2481
2571	2459	2478	2601	2570	2463
2491	2477	2482	2472	2571	2462
2483	2444	2473	2450	2478	2602
2472	2463	2491	2481	2454	2604
301	2483	2480	2463	2604	2477
2447	2601	2483	2479	2445	2491
2462	2479	2444	2484 IIa	2459 IIb	2483

Plantation Description

32 provenances
6 blocks
2 rows of 20 trees in each plot
240 trees per provenance
744 trees in 2 surround rows
(Provenance No. 2475)
Tree spacing 6 x 6 feet
Length 738 feet
Width 402 feet
Area 6.8 acres
Planted April 1963 with
2-2 stock

Site Types

I Characterized by fairly deep soil and organic layer, dry-moist; vegetation chiefly pin cherry, aspen, Polytrichum with occasional Kalmia.

II Characterized by widely varying soil depths and moisture conditions in localized patches; vegetation is scattered aspen, alder, pin cherry, Polytrichum, Dichranum and occasional bunches of Carex, Vaccinium, Kalmia and Cornus.

IIa Like II but with organic material burned off exposing stones and medium-sized boulders; dry-moist.

IIb Like IIa but with less organic matter burned off.

III Wet site with mucky soil; vegetation is alder, some willow, dense, high Carex spp. with occasional patches of Sphagnum.

IIIa Wet site; vegetation alder with coarse Carex spp.

APPENDIX III - LAYOUT AND SITE DESCRIPTION OF WHITE SPRUCE PROVENANCE PLANTATION

Appendix IV. Mean height and survival of white spruce provenances

Prov. No.	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6		Mean	
	Ht. cm.	No. trees	Ht. cm.	No. trees	Ht. cm.	No. trees	Ht. cm.	No. trees	Ht. cm.	No. trees	Ht. cm.	No. trees	Ht. cm.	Survival %
2438	116.0	39	104.1	38	85.9	38	95.8	36	96.1	38	98.9	36	99.5	93
2440	79.7	37	76.8	37	85.6	36	87.0	34	86.3	31	92.0	23	84.6	82
2444	136.5	40	125.6	38	100.3	27	85.9	22	85.7	27	86.5	21	103.4	73
2445	93.8	37	85.2	42	110.6	32	106.3	35	109.6	35	100.2	34	100.9	90
2447	133.9	39	109.0	38	115.9	37	112.4	39	98.2	31	109.4	22	113.1	86
2451	121.9	38	94.1	40	107.2	35	99.8	32	100.2	29	77.7	27	100.2	84
2454	111.2	35	95.3	39	78.8	37	91.2	25	103.1	36	82.1	36	93.6	86
2459	95.0	40	118.6	40	118.6	32	114.1	37	114.7	39	93.0	36	109.0	93
2462	121.3	39	96.6	38	73.7	31	88.4	40	97.3	30	98.7	37	96.0	90
2463	113.9	34	121.8	40	97.3	37	100.2	35	83.5	30	80.7	31	99.6	86
2468	95.8	39	78.8	37	94.4	39	92.8	33	97.7	30	87.8	37	91.2	90
2472	122.3	37	104.5	40	73.2	34	92.5	27	84.7	21	75.4	35	92.1	81
2473	87.5	40	87.3	38	93.1	31	92.8	23	90.6	32	91.5	39	90.4	85
2475	126.7	37	85.5	36	104.8	27	101.6	31	77.9	28	82.1	33	96.4	80
2477	116.5	39	107.0	37	80.2	37	76.2	29	90.4	32	85.4	36	92.6	87
2478	85.2	39	69.2	40	92.4	28	74.2	26	74.9	35	71.8	21	77.9	79
2479	105.2	38	105.0	40	97.7	37	92.3	36	81.5	29	74.4	32	92.7	88
2480	69.8	38	63.7	41	83.0	33	81.5	36	64.6	31	77.6	25	73.4	85
2481	101.9	37	109.6	38	91.9	37	88.9	35	95.6	34	90.8	38	96.5	91
2482	72.4	36	76.5	35	102.6	34	93.2	26	91.0	24	87.5	34	87.2	79
2483	119.1	39	101.8	40	80.4	24	84.4	40	74.2	29	90.9	35	91.8	86
2484	79.5	39	114.0	40	78.7	40	98.2	36	92.2	32	81.6	36	90.7	93
2485	120.0	37	87.2	40	91.6	40	98.0	37	105.4	40	91.2	25	98.9	91
2486	97.4	34	71.0	40	95.1	32	87.6	26	105.0	23	72.7	24	88.1	75
2491	122.3	38	74.5	39	90.8	27	90.4	35	78.2	27	89.4	40	90.9	86
2570	92.3	38	102.3	38	87.8	34	85.8	37	81.9	36	90.5	26	90.1	87
2571	122.1	36	104.2	37	92.4	39	96.2	37	100.5	37	83.2	35	99.8	92
2572	96.3	39	113.6	40	76.8	36	109.6	31	78.5	28	79.6	34	92.3	87
2601	73.9	37	80.6	41	60.1	39	81.3	23	69.3	35	70.8	38	72.7	89
2602	78.7	40	74.2	39	88.1	24	85.9	25	96.1	28	78.9	33	83.6	79
2604	100.3	37	75.0	40	69.5	36	83.8	20	77.4	36	90.1	39	82.7	87
301	60.0	29	59.9	31	44.5	28	51.5	15	57.7	14	52.2	18	54.3	56
Mean	102.1		92.9		88.4		91.2		89.7		84.8		91.5	85.7

Appendix Va. Height and survival of provenances in the three main site types

Prov. No.	Site Type I				Site Type II				Site Type III			
	No. trees Planted	Living	Survival %	Mean Ht. cm.	No. trees Planted	Living	Survival %	Mean Ht. cm.	No. trees Planted	Living	Survival %	Mean Ht. cm.
2438	94	93	98.9	102.3	130	125	96.1	97.1	9	7	77.7	107.8
2440	96	90	93.7	84.6	90	70	77.7	86.7	53	37	69.8	87.0
2444	90	88	97.7	128.1	104	62	59.6	88.3	43	25	58.1	93.7
2445	96	94	97.9	92.5	109	96	88.0	106.6	16	10	62.5	89.0
2447	92	91	98.9	121.3	111	92	82.8	107.2	33	23	69.6	112.5
2451	97	95	97.9	109.3	95	75	78.9	99.3	41	29	70.7	93.5
2454	90	84	93.3	99.6	131	110	83.9	92.8	4	4	100.0	105.0
2459	97	94	96.9	110.8	94	87	92.5	105.8	23	16	69.5	129.7
2462	90	88	97.7	102.5	124	114	91.9	93.9	17	12	70.5	89.5
2463	98	91	92.8	113.3	96	77	80.2	96.4	23	17	73.9	95.3
2468	93	90	96.7	86.8	121	109	90.0	93.6	22	17	77.2	96.8
2472	98	92	93.8	104.7	115	90	78.2	84.1	25	12	48.0	76.2
2473	95	92	96.8	89.7	99	85	85.8	91.2	46	26	56.5	88.3
2475	92	85	92.3	108.7	104	85	81.7	88.3	38	24	63.2	78.1
2477	90	84	93.3	110.2	135	114	84.4	84.0	4	3	75.0	68.3
2478	95	92	96.8	80.9	110	88	80.0	65.6	31	17	54.8	79.8
2479	96	92	95.8	103.9	117	99	84.6	84.9	11	7	63.6	97.6
2480	94	91	96.8	70.3	122	92	75.4	74.8	28	21	75.0	76.5
2481	92	89	96.7	103.8	99	95	95.9	91.9	29	23	79.3	92.6
2482	95	87	91.5	82.7	100	71	71.0	90.8	40	31	77.5	90.0
2483	89	89	100.0	108.6	99	90	90.9	82.9	39	18	46.1	75.1
2484	88	87	98.8	94.6	114	103	90.4	85.3	22	16	72.7	94.6
2485	88	85	96.5	101.2	138	127	92.0	98.0	13	6	46.1	110.7
2486	98	91	92.8	88.7	108	77	71.2	88.2	32	11	34.3	69.5
2491	93	90	96.7	98.5	88	74	84.0	88.4	36	22	61.1	81.5
2570	97	93	95.8	99.4	122	100	81.9	85.9	17	13	76.5	77.5
2571	95	90	94.7	106.0	141	131	92.9	94.7	0	0	-	-
2572	88	86	97.7	103.5	142	118	83.0	85.6	4	2	50.0	51.0
2601	90	87	96.6	76.3	134	117	87.3	68.5	17	9	52.9	79.4
2602	99	94	94.9	78.8	103	76	73.8	86.8	35	17	48.5	83.6
2604	90	87	96.6	86.3	137	109	79.5	78.8	5	5	100.0	99.0
301	94	68	72.3	57.5	101	46	45.5	52.2	44	21	47.7	50.2
Total/ Mean	2,989	2,849	95.3	97.3	3,633	3004	82.5	88.6	800	501	62.6	88.6

NOTE: 14 seedlings were replaced in block 1 and 30 in block 2 in the fall of 1970. Both of these blocks are included in Type 1. If these seedlings were subtracted from the number surviving, the percent survival would be 93.8.

Appendix Vb. Height and survival of provenances in the three subsidiary site types.

Prov. No.	Site Type IIa				Site Type IIb				Site Type IIIa			
	No. trees		Survival	Mean Ht.	No. trees		Survival	Mean Ht.	No. trees		Survival	Mean Ht.
	Planted	Living	%	cm.	Planted	Living	%	cm.	Planted	Living	%	cm.
2445					16	16	100.0	108.2				
2454					4	4	100.0	101.0				
2459	4	4	100.0	128.0	25	25	100.0	118.4				
2463	15	15	100.0	101.0								
2477					9	8	88.8	76.7				
2479	18	15	83.3	88.3								
2481	12	12	100.0	86.7								
2483					10	10	100.0	88.8				
2484	21	19	90.4	98.0					1	0.0	0.0	-
2491					16	16	100.0	84.0	7	4	57.1	79.0
2572									5	2	40.1	72.0
2604					8	7	87.5	84.4				
Total or Mean	70	65	92.8	96.2	88	86	97.7	99.2	13	6	46.1	76.6

Appendix VI

Provenance means and coefficients of variation of parameters measured on individual seedlings

Prov. No.	Date of bud burst '68 $\bar{X}$	CV%	Date of bud set '68 $\bar{X}$	CV%	Days of leader growth '68 $\bar{X}$	CV%	Leader length '68 $\bar{X}$ cm	CV%	Leader length '67 $\bar{X}$ cm	CV%	Leader length '66 $\bar{X}$ cm	CV%	3 year leader growth $\bar{X}$ cm	CV%	Height, '68 $\bar{X}$ cm	CV%
2438	54.9	7.9	112.7	9.6	57.8	17.3	19.7	49.1	23.1	48.2	17.7	49.5	60.6	42.4	102.1	27.5
2440	50.2	6.9	111.2	8.8	61.0	14.9	19.0	43.2	17.6	36.7	14.4	48.2	51.0	33.6	89.4	23.4
2444	50.5	8.8	111.5	9.1	61.1	15.9	23.1	40.8	23.2	43.2	18.8	51.2	65.2	37.8	100.5	33.5
2445	50.9	6.9	114.6	10.6	63.7	17.4	24.1	38.9	23.9	40.7	18.6	50.3	67.8	37.1	106.1	31.7
2447	52.8	7.6	117.8	10.5	65.0	18.7	23.3	34.8	27.0	31.7	22.1	46.8	72.7	31.2	117.5	28.8
2451	52.0	9.1	108.6	7.9	56.7	14.6	19.2	36.6	20.0	44.3	16.7	53.2	55.7	38.9	95.6	32.3
2454	50.9	6.2	107.5	9.2	56.8	15.0	19.3	43.6	22.0	33.6	19.5	35.9	60.9	31.0	96.3	24.2
2459	52.4	7.1	110.8	10.5	58.3	18.8	24.9	45.1	24.1	47.8	18.1	52.6	67.1	40.6	112.2	33.1
2462	53.9	9.1	114.1	9.9	60.1	17.8	17.7	42.3	20.5	43.8	18.1	44.8	56.2	35.7	93.9	30.2
2463	52.9	8.5	110.3	10.6	57.4	20.7	18.2	46.9	21.1	39.2	19.6	41.9	58.8	36.1	98.3	32.3
2468	49.7	5.7	110.0	11.1	60.6	19.6	18.3	32.6	21.1	34.0	16.9	37.7	56.3	32.0	96.4	31.6
2472	49.1	7.5	107.1	8.5	57.9	16.1	20.4	46.1	21.9	48.8	18.7	49.1	61.0	42.4	99.6	36.7
2473	51.4	8.3	111.4	8.7	60.0	16.2	18.7	33.4	22.1	37.0	16.8	42.5	57.7	31.9	92.8	26.7
2475	50.1	5.2	108.3	9.3	58.2	17.0	22.0	42.4	24.3	40.2	18.3	38.7	64.2	35.1	101.5	30.0
2477	52.9	9.5	112.8	9.1	60.0	13.8	20.3	44.3	21.9	43.3	19.4	30.1	61.6	34.4	100.6	27.2
2478	51.0	6.9	107.8	10.3	57.0	20.6	16.9	41.3	15.9	43.8	13.4	56.6	46.2	37.9	76.5	28.2
2479	51.2	8.0	107.9	9.7	56.8	19.3	17.5	40.0	20.0	37.5	17.4	45.2	54.9	28.8	91.0	22.8
2480	51.0	8.6	109.5	11.1	58.5	20.7	15.4	49.5	15.7	50.0	13.0	54.1	44.1	43.2	73.7	32.3
2481	52.3	6.3	111.0	10.6	58.7	21.1	18.2	41.2	20.6	32.3	17.3	31.7	56.2	24.1	93.5	19.3
2482	52.4	7.7	106.8	10.3	54.2	18.6	16.8	31.6	16.4	55.7	15.1	66.8	48.4	42.3	84.4	34.2
2483	50.1	6.0	105.4	8.3	55.2	17.2	19.1	31.0	22.0	37.0	18.6	34.3	59.6	30.1	95.4	26.0
2484	52.4	7.4	111.9	9.7	59.8	20.0	17.2	44.6	20.1	38.4	20.1	43.3	57.7	35.8	99.1	30.1
2485	53.5	7.7	114.1	9.1	60.6	18.0	21.4	40.0	24.3	34.7	18.9	47.8	64.5	33.3	104.9	27.5
2486	54.0	9.1	110.4	10.1	56.4	18.6	17.6	44.6	21.6	43.5	18.5	53.3	57.7	42.1	97.7	31.7
2491	52.0	9.2	111.3	10.0	59.3	19.8	19.9	40.1	21.1	43.2	17.1	52.3	58.1	39.0	94.7	32.2
2570	52.0	9.4	108.1	8.9	55.5	18.3	19.1	41.2	21.1	42.5	17.0	44.6	57.2	34.0	94.3	22.5
2571	51.1	6.2	107.6	10.6	56.6	20.5	21.5	40.6	24.2	30.5	19.5	42.6	65.0	31.0	109.3	22.6
2572	52.4	8.5	111.0	9.8	58.6	18.7	20.5	43.0	21.6	42.1	16.8	38.6	58.6	38.6	98.7	30.4
2601	49.6	7.6	111.0	11.0	61.5	21.4	17.3	46.5	17.0	46.8	13.7	51.2	48.1	40.0	78.5	32.2
2602	50.0	7.2	107.4	9.3	57.2	16.8	18.2	41.6	20.9	47.1	16.1	61.2	55.3	43.0	91.8	33.7
2604	50.9	7.5	109.6	10.9	58.8	19.8	16.4	46.3	18.1	52.0	14.2	50.1	48.7	44.2	80.5	34.5
301	47.9	5.7	113.3	9.6	65.1	16.9	14.4	39.7	13.2	40.0	7.0	67.9	34.5	37.3	54.6	28.2
Mean	51.5		110.4		58.8		19.2		20.8		17.1		57.2		94.4	