

SURVIVAL AND HEIGHT GROWTH OF A RANGEWIDE
BLACK SPRUCE PROVENANCE TEST ON TWO SITES IN MINNESOTA 1/

by

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Abstract.--Heights, survival and periodic increment of 108 black spruce seed sources on two test sites were examined using data collected when trees were 6, 9, and 12 years from seed. Source x test site interactions were significant for all variables except height growth at 6 years old. Differences among sources were significant for survival and heights at ages 6, 9, and 12, but not for periodic increments. Analysis of data for the two tests suggested that materials from the northern, western and eastern extremities of the range were poor performers. No clearly superior geographic sources could be identified.

Additional Keywords: *Picea mariana*, geographic variation.

Black spruce (*Picea mariana* (Mill.) B.S.P.) is a major pulpwood species in Minnesota and a prime candidate for inclusion in the tree improvement programs of forestry organizations in the state. While Canadian forest geneticists have worked extensively with the species, information on the extent and pattern of seed source related variation expressed under Lake States conditions is quite limited. This paper reports the survival and heights through age 12 of a range-wide black spruce provenance test established at two different locations in Minnesota. The data were examined with two objectives: 1) describing the pattern of variation associated with geographic origin of seed and 2) gaining insight into provenance x environment interactions. Information in both of these areas is important for the development of effective tree improvement programs.

MATERIALS AND METHODS

The plantings established in Minnesota were part of a cooperative project involving the Canadian and U.S. Forest Service. Seed collections were coordinated by the Petawawa Forest Experiment Station at Chalk River, Ontario, and the seedlings were grown at the USDA Forest Service's Forestry Sciences Laboratory in Rhinelander, Wisconsin. Seedlings were derived from 108 stand collections made between Alaska in the northwest and Connecticut in the southeast. The bulk of the stand collections were made between 45 and 51 north latitude and between 65 and 95 west longitude. Stock was started in containers at Rhinelander, transplanted to a nursery and shipped to Minnesota for field planting in the spring of 1974, when it was approximately 3 years from seed.

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The two planting sites were widely separated and in different vegetational zones. The northern site, at Blackberry (47.1 N., 93.2 W), was in the northern coniferous zone. The soil was a sand with a high water table, resulting in poor drainage and standing water during wet periods. The southern site, near Rosemount (44:4 N, 93.1 W), was in the prairie-oak hickory transition zone. The soil was a silt-loam over a coarse gravel and the site was well-drained.

Both tests were planted in a randomized complete block design with five replications and four tree row-plots. The Blackberry site had been farmed at one time and site preparation was limited to removal of invading brush. A thin sod cover was present at the time of planting. The Rosemount site had been in row crops the year before planting and it was plowed and disked in the spring of 1974. Seedlings were planted by hand using shovels. Weeds presented serious competition on both sites. Chemical and mechanical treatments were used in 1975 and 1976 and the Rosemount site has been mowed annually to control noxious weeds. Trees on the Blackberry site were treated with a balanced fertilizer (about 200 lbs active/acre) in 1976, because of obvious signs of nutrient deficiency. This compounded the weed problem.

Heights were measured to the nearest centimeter at the end of the 1976, 1979 and 1982 growing seasons. These three heights and the two growth increments, 1976-79 and 1979-82, were analyzed using standard Analysis of Variance techniques. Plot means were used in these analyses because of extensive mortality. Missing plot values were estimated using Yate's approximation (Steel and Torrie, 1980). Survival was analyzed using Chi-square and standard non-parametric tests.

RESULTS

Survival was low in both plantings. In 1982 only 44 percent of the trees planted were living in the Blackberry plantation and at Rosemount survival was 47 percent. When seedlots were compared, survival ranged from 18 to 75 percent in the Rosemount test and from 7 to 90 percent at Blackberry. Chi-square test indicated that survival was not independent of seed source in either plantation (.001 level of probability). Spearman's rank correlation for survival of seedlots in the two plantations was .22. The probability of obtaining this value by chance was .02.

Figures 1 and 2 graphically present the relationships between survival and the geographic origin of seed in the two plantations. Survival was correlated with latitude and longitude of seed origin at Blackberry, but not at Rosemount. The correlation coefficients at Blackberry were $-.31$ for survival with latitude and $-.28$ for survival with longitude. Both coefficients were significant at the .05 level.

Figure 1, -- Relationship between survival and geographic origin of seedlots at the Blackberry, Mn location.

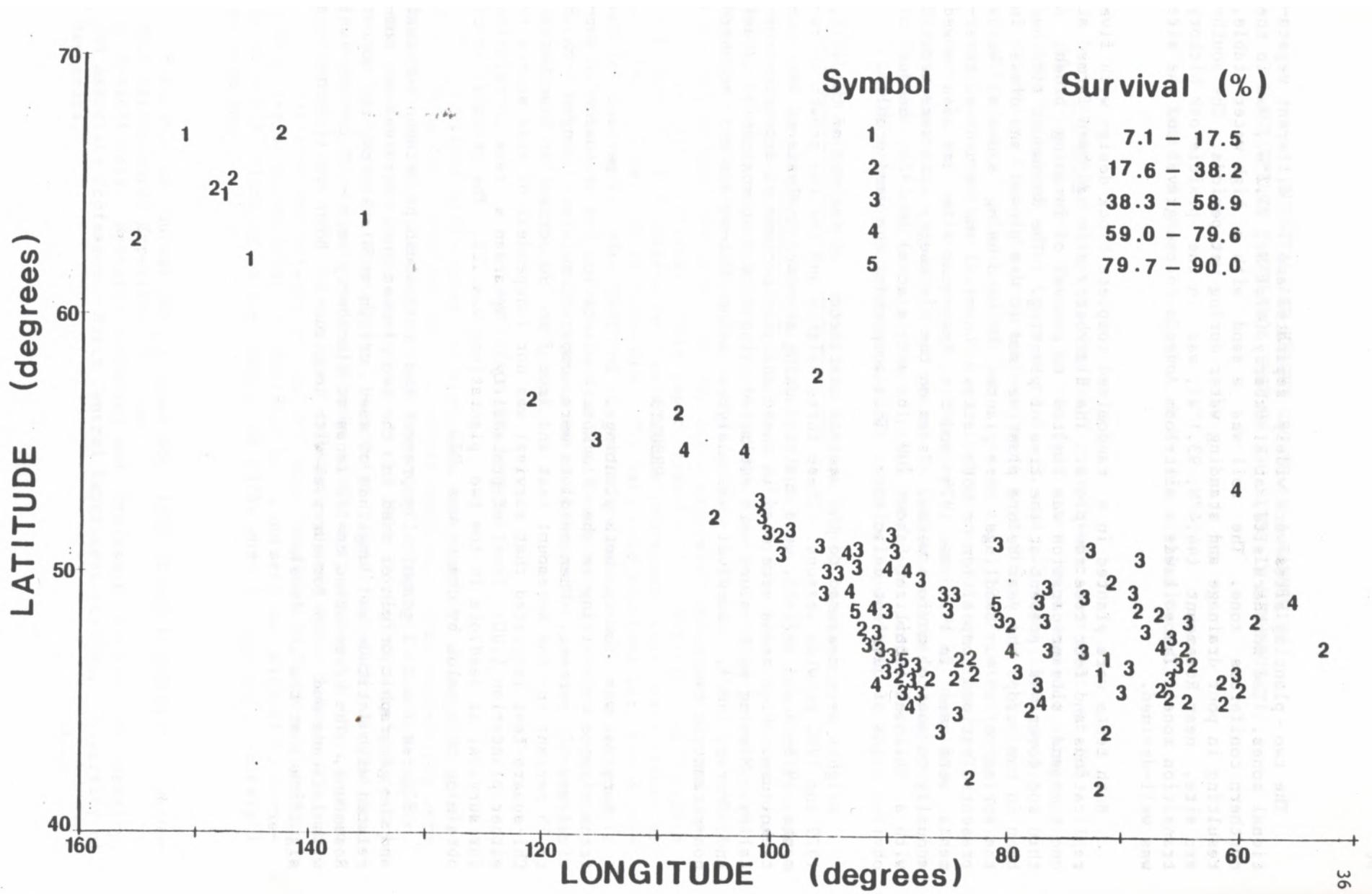
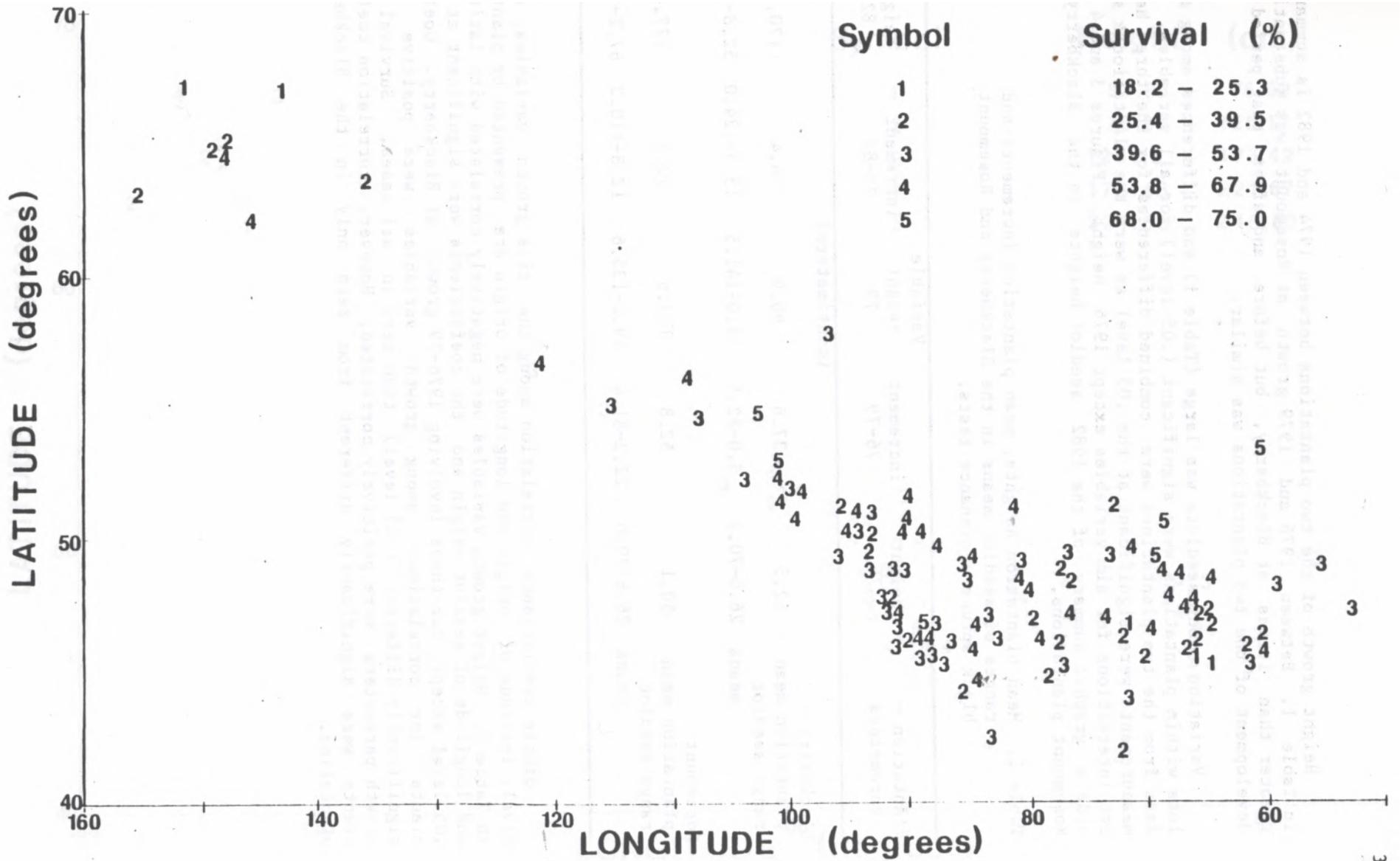


Figure 2,-- Relationship between survival and geographic origin of seedlots at the Rosemount, Mn location.



Height growth of the two plantations between 1974 and 1982 is summarized in Table 1. Between 1976 and 1979 growth at Rosemount was substantially greater than it was at Blackberry, but before and after that period the development of the two plantations was similar.

Variation among seedlots was large (Table 1) and differences among seedlots within plantations were significant (.05 level) for all variables. When data from the two plantations were combined differences for the three height measurements were significant at the .05 level as were the plantation x seedlot interactions for all variables except 1976 height. Figures 3 and 4 provide a graphic summary of the 1982 seedlot heights in the Blackberry and Rosemount plantations.

Table 1. Mean plantation heights, mean plantation increments and ranges of seedlot means in the Blackberry and Rosemount black spruce provenance tests.

Plantation - Parameters	height	increment	Variable		
	76	76-79	height 79	increment 79-82	height 82
	(centimeters)				
Blackberry - plantation mean	52.3	37.6	90.9	76.4	170.5
range seedlot means	26.0-70.2	5.0-82.5	33.0-141.5	15.5-124.0	52.8-245.8
Rosemount plantation mean	50.1	52.8	103.6	72.7	177.4
range seedlot means	26.6-70.6	22.2-81.4	49.2-135.6	12.8-110.2	67.2-221.2

Simple coefficients correlation among the five growth variables, survival, latitude of origin and longitude of origin are presented by planting in Table 2. Height growth variables were negatively correlated with latitude and longitude of seedlot origin and the coefficients were significant at the .05 level except for those involving 1976-79 growth at Blackberry. Coefficients for correlations among growth variables were positive and significantly different (.05 level) than zero in all cases. Survival and growth parameters were positively correlated. However, correlation coefficients were significantly different from zero only in the Blackberry plantation.

Figure 3,-- Relationship between 1982 height and geographic origin of seedlots at the Blackberry, MN location.

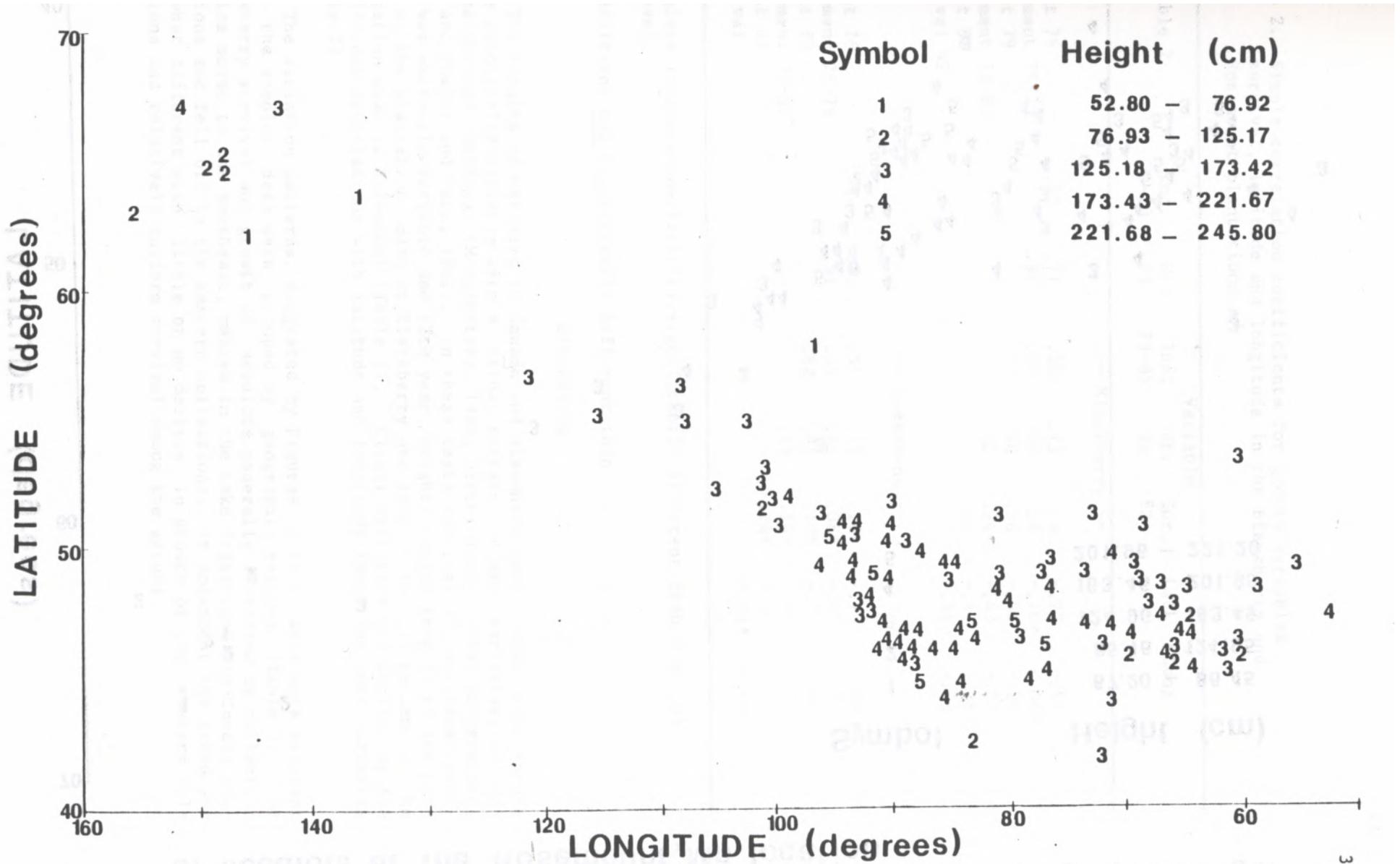


Figure 4, -- Relationship between 1982 height and geographic origin of seedlots at the Rosemount, Mn location.

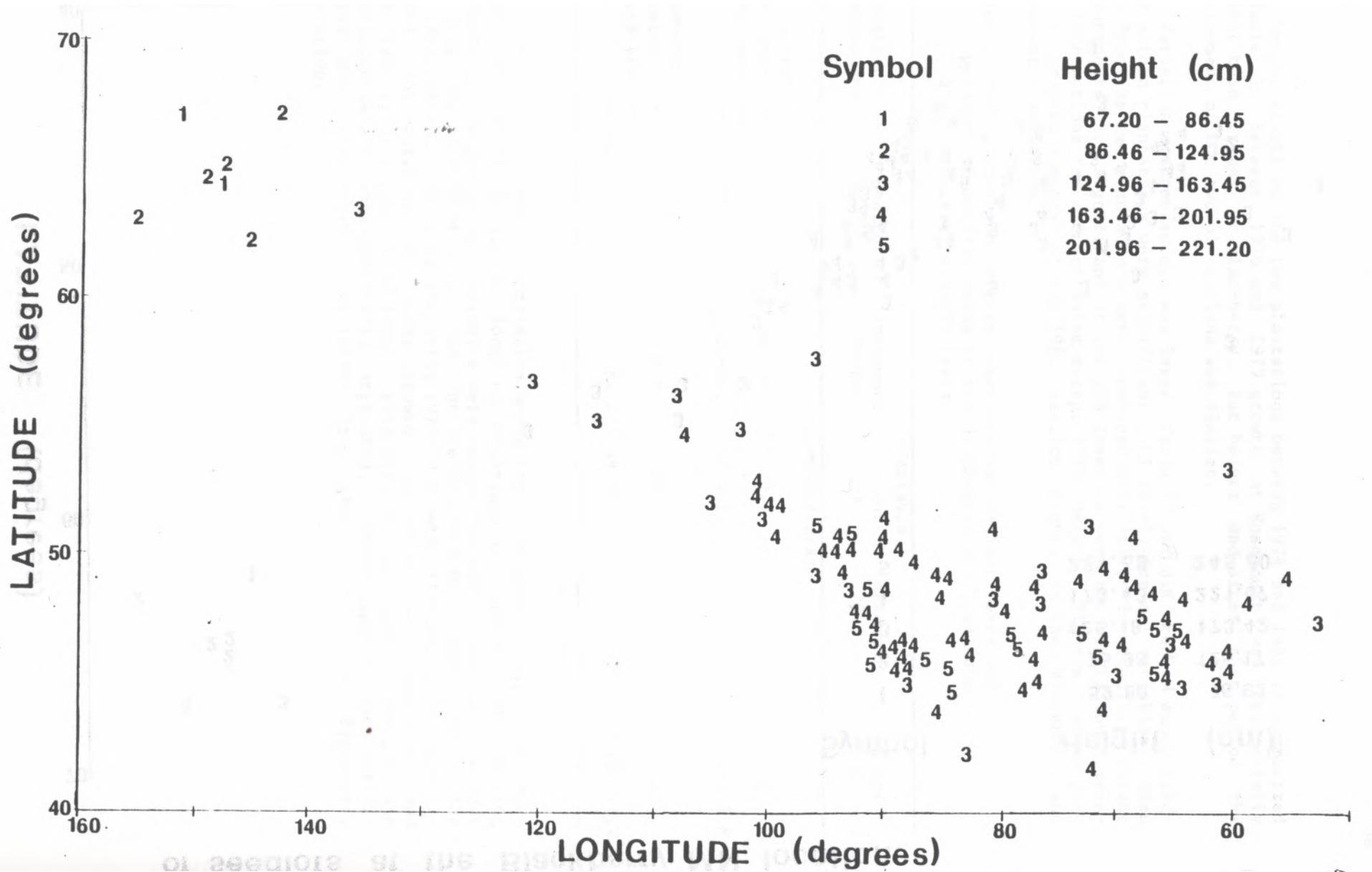


Table 2. Simple correlation coefficients for growth variables, survival, latitude and longitude in the Blackberry and Rosemount plantations.a/

Variable 2	Variable						
	Inc. 76-79	Ht. 79	Inc. 79-82	Ht. 82	Sur. 82	Lat.	Long.
-- Blackberry --							
Height 76	.40	.71	.58	.73	.56	-.77	-.59
Increment 76-79		.92	.70	.80	.32	-.16*	-.04*
Height 79			.77	.90	.46	-.44	-.28
Increment 79-82				.92	.34	-.43	-.22
Height 82					.46	-.49	-.28
Survival 82						-.31	-.28
-- Rosemount --							
Height 76	.49	.82	.51	.75	.10*	-.73	-.53
Increment 76-79		.91	.55	.82	.08*	-.62	-.51
Height 79			.62	.91	.10*	-.77	-.60
Increment 79-82				.89	.16*	-.54	-.50
Height 82					.14*	-.73	-.61
Survival						-.01*	-.04*

a/ Unless indicate coefficients significantly different than 0 at .05 level.

* Coefficient not significantly different than 0 at .05 level

DISCUSSION

The results of studies in Canada and elsewhere have shown black spruce to be genetically variable with a clinal pattern for many variables, including height and survival (Morgenstern, 1969; Dietrichson, 1969; Morgenstern, 1978 and Fowler and Park, 1982). In these tests survival of individual seedlots was extremely variable and 12th year heights ranged from 31 to 144 percent of the plantation mean at Blackberry and from 38 to 125 percent of the plantation mean at Rosemount (Table 1). Clinal variation was implied by the significant correlations with latitude and longitude found for most variables (Table 2).

The variation patterns, suggested by Figures 1 to 4, were more apparent when the seedlot data were grouped by geographic regions (Table 3). At Blackberry survival and growth of seedlots generally increased as collection origins moved to the southeast, peaked in the Lake States and mid-Canada collections and fell off in the eastern collections. At Rosemount the trend was somewhat different with little or no decline in growth of the eastern collections and relatively uniform survival among the groups.

Table 3. 1982 heights and survival of seedlots placed in 6 geographic groups at Blackberry and Rosemount.

Location-Material	Nr. Seedlots	1982 height		1982 survival	
		mean	range seedlots	mean	range seedlots
		(centimeters)		(percent)	
Blackberry					
Alaska-Yukon	9	108.0	52.8 - 177.4	17	7 - 29
Prairie Prov.	15	152.4	68.8 - 229.8	46	20 - 62
Lake States	19	189.6	116.0 - 239.0	46	20 - 90
Ont. - Que.	44	185.0	126.8 - 245.8	51	17 - 82
Maritime Prov.	17	155.0	112.4 - 207.6	42	24 - 70
Northeast U.S.	4	141.2	103.0 - 196.2	39	25 - 50
All Sources	108	170.5	52.8 - 245.8	44	7 - 90
Rosemount					
Alaska-Yukon	9	105.2	67.2 - 131.2	39	18 - 59
Prairie Prov.	15	169.1	125.0 - 202.6	56	33 - 74
Lake States	19	192.6	146.6 - 221.2	49	28 - 70
Ont. - Que.	44	182.3	143.6 - 217.6	49	21 - 75
Maritime Prov.	17	181.2	126.0 - 206.8	42	18 - 68
Northeast U.S.	4	191.5	189.0 - 197.0	41	27 - 64
All Sources	108	177.4	67.2 - 221.2	47	18 - 75

Given the differences in the test sites, the provenance x test site interaction found for most variables was not unexpected. The data do not present a clear insight into this interaction, but it does appear that stress associated with the Blackberry site limited the growth of eastern sources, although the impact on survival was small. The relatively good performance of seedlots from northeastern U.S. and the Maritime Provenances at Rosemount may reflect the more moderate temperatures at that location. The Blackberry site is more typical of those on which black spruce is planted in Minnesota and therefore should be given more weight when considering the implications of these results.

Data from both plantations suggests that the south-central portion of the species range represents the most promising source of materials for Minnesota. Western materials tended to grow slowly and eastern materials did not perform well consistently. As a group, the Lake States materials did well in terms of survival and growth in both plantations. Although numerous individual seedlots from other regions did as well as the "local" (Lake States) materials, the data suggest that the probability of developing well-adapted, vigorous materials for Minnesota will be highest in a program which utilizes Lake States and/or other germplasm from the south central portion of the species range as a base population.

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