PRELIMINARY RESULTS OF A WHITE SPRUCE (PICEA GLAUCA (MOENCH) VOSS) HALF-SIB PROGENY TEST IN MAINE

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ABSTRACT .--White spruce progeny test plantations were measured for total height, seasonal height increment, percent survival, and flushing date. Analysis of variance was used to determine differences between families for these traits. Heritabilities were determined for each trait measured. Genetic gains were calculated for each trait for the next generation. Recommendations were made for culling of inferior families at the half-sib progeny test plantations and for maintenance of superiority in the plantation for future use as a seed orchard.

IN THE MIDDLE 1960's under the direction of Art Hart of the U.S. Forest Service, a cooperative, the Spruce Committee, was formed among the U.S. Forest Service, the Maine Forest Service, the University of Maine, several other public institutions, and a number cf private landowners to study the genetic improvement of the native spruces in the northeast. The program undertaken was phenotypic selection of superior trees, establishment of progeny tests, and development of seedling seed orchards from these progeny tests.

METHODS

Plus trees were selected on the basis of superior volume growth by the comparison tree method. Initial selections were made by field foresters and final screening of candidate trees was performed by Clyde Hunt of the U.S. Forest Service. The location of the selected trees is shown in Figure 1. Seeds were collected from the selections in the period 1967 to 1970. They were sown at the New Hampshire State Nursery and the Maine State Nursery in 1971.

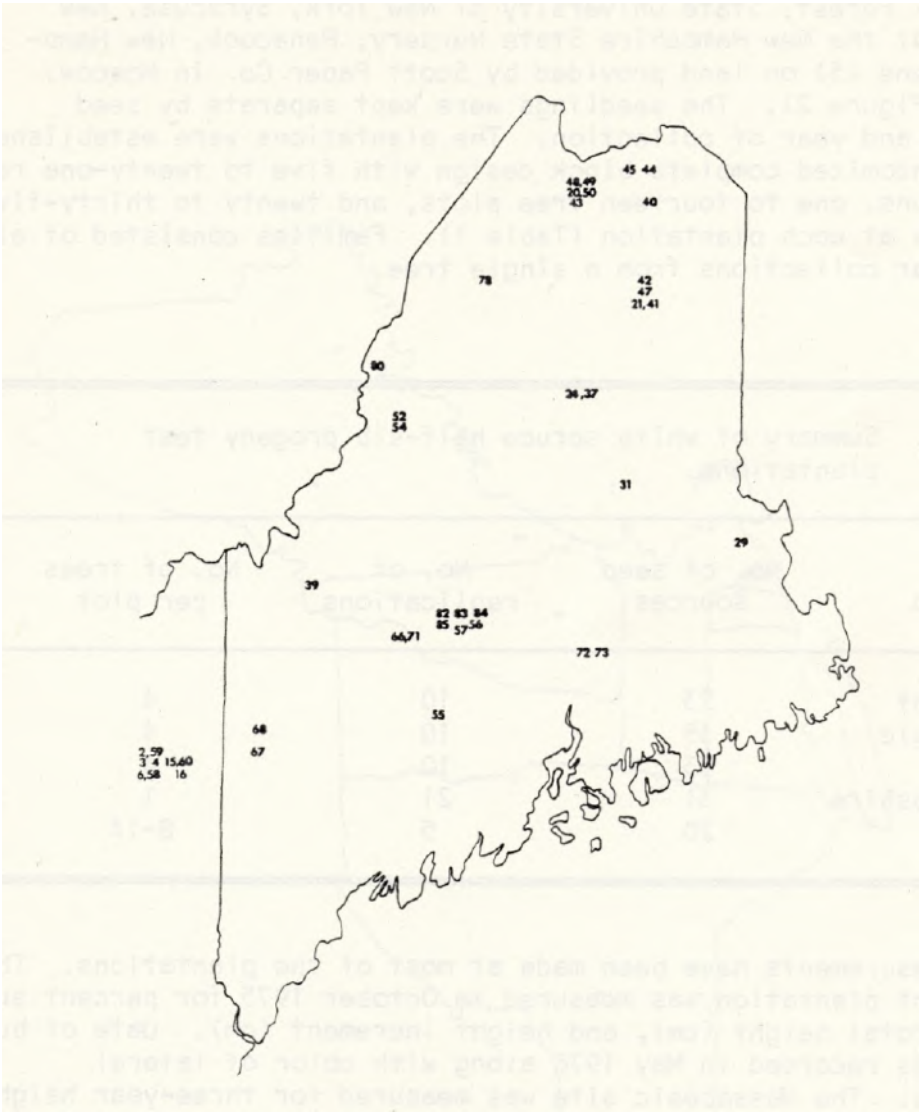

Figure 1. Location of plus trees selected in Maine and New Hampshire by the Spruce Committee. The numbers indicated are those assigned by the US Forest Service designating seedlots. Two numbers separated by a comma indicate two years of seed collection from the same tree.

Two- and three-year seedlings were outplanted at five locations in New England in the springs of 1973 and 1974, They are: (1) The Penobscot Experimental Forest, Bradley, Maine, (2) the Massabesic Experimental Forest, Alfred, Maine, (3) the Heiberg Memorial Forest, State University of New York, Syracuse, New York, (4) the New Hampshire State Nursery, Penacook, New Hampshire, and (5) on land provided by Scott Paper Co. in Moscow, Maine (Figure 2). The seedlings were kept separate by seed sources and year of collection, The plantations were established in a randomized complete block design with five to twenty-one replications, one to fourteen tree plots, and twenty to thirty-five families at each plantation (Table 1). Families consisted of all seed year collections from a single tree.

Table 1. Summary of white spruce half-sib progeny test plantations.

Location	No. of seed sources	No. of replications	No. of trees per plot
Penobscot	23	10	4
Massabesic	35	10	4
Heiberg	33	10	4
New Hampshire	31	21	1
Scott	20	5	8-14

Measurements have been made at most or the plantations. the Penobscot plantation was measured in October 1975 for percent survival, total height (cm), and height increment (cm). Date of bud burst was recorded in May 1976 along with color of lateral Branches. The Massabesic site was measured for three-year height (cm), four-year height (cm), height increment for the growing seaeons 1974 and 1975 (cm), percent survival in 1974 and 1975, date of flushing 1975, and needle color of laterals in 1976. The Scott plantation was measured for six-year height (cm), height increment 1976 (cm), and percent survival 1976. Survival was recorded in New Hampshire in 1975. Due to severe mortality because of grass competition, no measurements have been made at Heiberg.

The total height, height increment, survival, and flushing data were analyzed by analysis of variance and Duncan's new multiple range test. Most of the data was analyzed on the University of Maine's IBM 370 system. Due to a large number of missing plots at the Penobscot and Massabesic plantations, the total

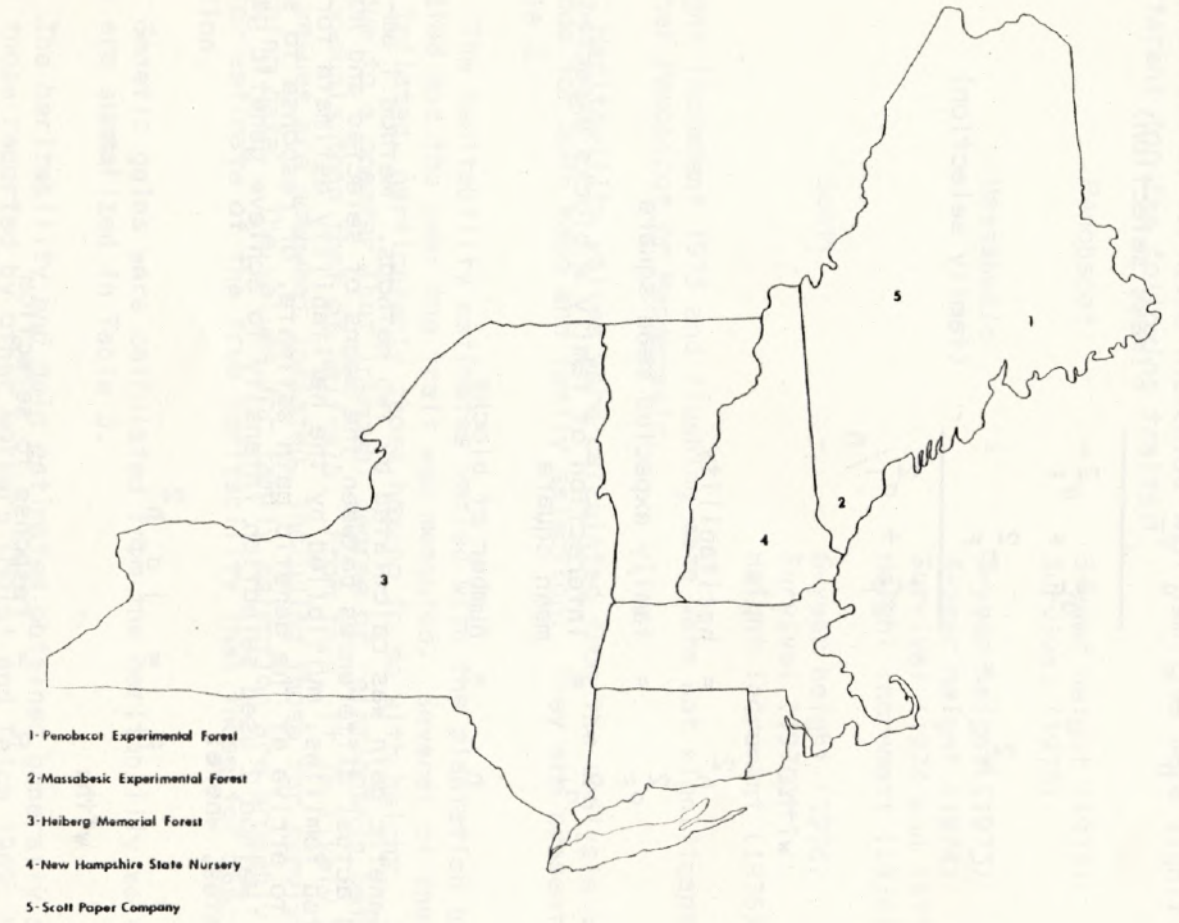

Figure 2. Location of white spruce half-sib progeny test plantations.

height, height increment, and flushing data were analyzed by the U.S,F.S., Durham, New Hampshire using a least squares method of analysis of variance. Survival percentages were converted to arcsin before analysis to more closely approximate a normal distribution. The color data was not analyzed.

Heritability values were calculated for both mass and family selection by the following formulas:

$$h^2 = \frac{4\,\sigma_F^2}{\sigma_F^2 + \sigma_I^2} \quad \text{(mass selection)}$$

$$h^2 = \frac{\sigma_F^2}{\sigma_F^2 + \sigma_{I/n}^2} \quad \text{(family selection)}$$

with:

h^2 = heritability

σ_F^2 = family expected mean square

σ_I^2 = interaction of family x blocks expected mean square

n = number of blocks

Genetic gain was calculated by two methods. Method 1 employed actual differences between the means of selected and non-selected families, multiplied by the heritability estimate for the trait to arrive at the genetic gain estimate, or response to selection. Method 2 used selection intensity to achieve genetic gain estimates, where:

$$R = i\,\sigma_p\,h^2$$

with:

R = response to selection

i = intensity of selection (Becker 1967)

σ_p = standard deviation of the trait

h^2 = heritability

For both methods, the top 25% of the families were selected for each trait.

RESULTS

Analysis of variance indicated that families were significantly different for the following traits:

Penobscot	5-year height (1975)
	Survival (1975)
Massabesic	3-year height (1973)
	4-year height (1974)
	Survival (1974 and 1975)
	Height increment (1974)
Scott	6-year height (1976)
	Survival (1976)
	Height increment (1976)

Height increment 1975 and flushing date were not significant at either Penobscot or Massabesic.

Heritability values were calculated from the analysis of variance for both mass and family selection. They are presented in Table 2.

The heritability estimates varied with the plantation being studied and the year the trait was measured. Several of the values are inflated, particularly those having to do with height. This is due to a greater (but inknown) degree of relationship between individuals than that of half-sib. From this, it is likely that all values are somewhat inflated, including those for survival and flushing date. The values for family selection are probably a better estimate of the true heritability than Those for mass selection.

Genetic gains were calculated from the heritability values. They are summarized in Table 3.

The heritability and gain estimates obtained generally agree with those reported by other workers (Hoist and Teich 1969, Mohn, et al. 1976, Nienstaedt 1974, Nienstaedt and King 1969, Teich and Khalil 1973, Wilkinson 1976). These values will be used to deter-

Table 2. Heritability values calculated for mass and family selection at the Penobscot, Massabesic and Scott white spruce half-sib progeny tests

Trait	Location	F	Heritability	
			mass	family
5-year height	PEN[a]	5.239*	1.191	0.809
Survival (1975)	PEN	2.232***	0.439	0.552
Ht. increment (1975)	PEN	2.206	0.430	0.547
Flushing date (1976)	PEN	1.412	0.304	0.292
3-year height	MAS	11.125***	3.640	0.990
4-year height	MAS	10.269**	1.924	0.903
Survival (1974)	MAS	2.228***	0.438	0.551
Survival (1975)	MAS	2.738***	0.592	0.635
Ht. increment (1974)	MAS	6.889*	1.484	0.855
Ht. increment (1975)	MAS	2.390	0.488	0.582
Flushina date (1975)	MAS	1.978	0.356	0.493
6-year height	SCO	2.371**	0.861	0.578
Survival (1976)	SCO	1.703*	0.493	0.413
Ht. increment (1976)	SCO	3.379***	1.290	0.704

[a] PEN = Penobscot, MAS = Massabesic, SCO = Scott

* - significant at 0.05 level

** - significant at 0.01 level

*** - significant at 0.001 level.

Table 3. Expected genetic gain from mass and family selection at the Penobscot, Massabesic, and Scott plantings. Heritability values greater than 1.0 were reduced to 1.0 for calculations.

		Mass Selection						Family Selection					
		Method 1[a]			Method 2[b]			Method 1			Method 2		
Trait	Location	Days	cm		Days	cm	%	Days	cm	%	Days	cm	%
5-year height	PEN[c]	---	6.05	16.4	---	8.39	22.7	---	4.89	13.2	---	6.79	18.4
Survival 1975	PEN	---	---	8.3	---	---	10.7	---	---	10.4	---	---	13.4
Ht. increment 1975	PEN	---	0,56	6.9	---	1.70	20.8	---	0.71	8.7	---	2.16	26.5
Flushing date 1976	PEN	0.52	---	2.8	0.80	---	4.4	0.50	---	2.7	0.77	---	4.2
3-year height	MAS	---	6.10	17.0	---	15.77	44.0	---	6.04	16.9	---	15.61	43.6
4-year height	MRS	---	6.20	14.9	---	6.86	16.5	---	5.60	13.5	---	6.19	14.9
Survival 1974	MRS	---	---	5.1	---	---	10.0	---	---	6.4	---	---	12.5
Survival 1975	MAS	---	---	12.8	---	---	17.0	---	---	13.8	---	---	18.3
Ht, increment 1974	MRS	---	1.10	18,5	---	1.26	21.1	---	0.94	15.8	---	1.08	18.1
Ht. increment 1975	MAS	---	0,98	17.3	---	1.39	24.6	---	1.16	20.5	---	1.66	29.4
Flushing date 1975	MRS	0.68	---	3.3	1.01	---	5.0	0.94	---	4.6	1.40	---	6.9
6-year height	SCO	---	7,33	13.8	---	8.96	16.8	---	4.92	9.2	---	6.02	11.3
Survival 1976	SCO	---	---	8.4	---	---	8.3.	---	---	7.0	---	---	6.9
Ht. increment 1976	SCO	---	5.47	39.5	---	5.18	37.4	---	3.85	27.8	---	3.65	26.3

[a] Method 1 - gain is calculated by multiplying heritability times differences in means between selected and non-selected families.

[b] Method 2 - gain is calculated by multiplying heritability times the intensity of selection and the standard deviation of the trait,

[c] PEN = Penobscot, MAS = Massabesic, SCO = Scott

mine which families should be removed from the plantation as inferior seed sources and which families will be kept as a future seed supply for Maine plantations. Those families recommended for retention are listed in Table 4.

Table 4. Families selected for retention at the Penobscot, Massabesic, and Scott white spruce half-sib progeny tests.

Family	Location	Age	DBH	Height
	Penobscot			
24.37	GNP, T5R8, Me.	56	16.6"	69'
84	Scott, Brighton, Me.	24	12.4"	54'
72	UMO, Old Town, Me.	33	10.5"	61'
55	Me. For. Ser., Fairfield, Me.	25	8.4"	52'
2,59	USFS, Bethlehem, N.H.	32	13.8"	64'
	Massabesic			
16	USFS, Bethlehem, N.H.	33	12.8"	67'
47	IP Co., Ashland, Me.	?	?	?
55	Me. For. Ser., Fairfield, Me.	25	8.4"	52'
3	USFS, Bethlehem, N.H.	35	12.1"	67'
2,59	USFS, Bethlehem, N.H.	32	13.8"	64'
	Scott			
55	Me. For. Ser., Fairfield, Me.	25	8.4"	52'
47	IP Co., Ashland, Me.	?	?	?
66,71	Boise Cascade, Lexington, Me.	30	13.4"	51'
2,59	USFS, Bethlehem, N.H.	32	13.8"	64'
85	Scott, Bingham, Me.	25	12.6"	56'
73	UMO, Old Town, Me.	33	11.5"	56'

These families have been selected on the basis of all-around superiority. They show superior growth and survival and a tendency towards late flushing. The parents are not the giants of the forest; their average age is 32.6 years, their average dbh 12.4 inches. Plus trees can be selected on the basis of early vigorous growth and production can be set forth at a much faster rate.

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