

SELECTION OF SUPERIOR STANDS OF WHITE SPRUCE
IN NOVA SCOTIA

by

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INFORMATION REPORT M-X-27

DEPARTMENT OF THE ENVIRONMENT
CANADIAN FORESTRY SERVICE

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FREDERICTON, NEW BRUNSWICK

January, 1972

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1. INTRODUCTION

The Province of Nova Scotia is committed to a program of reforestation on at least some of its Crown lands. It is probable that artificial reforestation will play an increasingly important role over the next decades in Nova Scotia as it is predicted it will in Canada as a whole (Cayford and Bickerstaff 1968). Future reforestation programs would be most useful if inputs (costs) can be fully realized in the output (production). To do this, productivity must be maximized.

Productivity can be increased by optimum stocking, shortening rotations, reducing losses due to diseases and insects, fertilizing, and using genetically more productive species or populations of trees. White spruce is a genetically variable species in which a significant improvement in productivity should be attainable through selection and breeding.

Personnel of the Canadian Forestry Service and the Nova Scotia Department of Lands and Forests met on 21 June 1971 to discuss the selection of superior stands of white spruce in Nova Scotia. A contract, of 3 months duration, between the author and the Canadian Forestry Service was drawn up to get this work started and to develop techniques for its continuation. It was proposed at that time that the selected stands should fulfill the following minimum requirements:

- (a) be larger than 10 acres -- A round or square shaped stand would be preferred to an elongated one of equal area;
- (b) be pure white spruce, i.e. white spruce make up 75% or more of volume;
- (c) be situated on sites similar to those that will be planted in the future; and
- (d) be reasonably young and vigorous -- A 40-year-old vigorous stand would be preferred to a 100-year-old one.

In general, the trees in the selected stand should:

- (a) be of above average growth rate for the site upon which they are growing;

- (b) be of good stem form (single, straight, little taper, and moderate to fine branching); and
- (c) be free of serious disease or insect problems.

This report describes the procedures used to locate and evaluate white spruce stands of possible value as seed production areas in the future and provides guide lines for further work on this project in Nova Scotia.

2. PROCEDURES

Stands (populations) of white spruce from different sites and climatic conditions may contain individuals of different genetic capabilities in different proportions; therefore, the present methods were designed to select stands with above-average proportions of phenotypically desirable trees.

It was assumed that the genetic superiority of white spruce individuals is expressed in their superior phenotypes and the progenies of the superior phenotypes would be significantly better than the progenies of normal phenotypes. It is true that the phenotypes of the 'desirable' trees are the result of interactions among: genotype, site conditions, stand density, interspecific competition, and a wide array of additional ecological factors. Although the phenotypes under evaluation are the result of interactions among several of these factors, it is likely that a better phenotype is partly a reflection of a superior genotype.

Procedures of stand selection are presented in the following four subsections.

2.1 *Locating White Spruce Areas*

Aerial photographs were studied to locate white spruce stands having a closed canopy and covering 10 acres or more. Stands of smaller dimensions in which individuals were suspected, or known, to be exceptional were also identified. A number of such areas were located in different parts of Nova Scotia. I visited these areas alone or with the staff of the N.S. Department of Lands and Forests, and travelled over 7,000 miles in 10 weeks throughout the province. Antigonish and Guysborough counties were inadequately surveyed and need further study.

2.2 Preliminary Sampling

The selected stands were evaluated on the basis of height, age, stem form, and incidence of damage on five or more dominant trees in each stand. Stands dominated by slow growing and older individuals (>60 years old) were not considered for further evaluation.

2.3 Intensive Sampling of Specific Stands

Intensive sampling of stands (see Appendix) was designed to seek information on:

- 1) Stand density (stems/acre);
- 2) Stand composition;
- 3) Basal area per acre;
- 4) Evaluation of each individual tree which constituted the sample for:
 - i) rate of growth (height/age),
 - ii) diameter at breast height,
 - iii) crown class, and
 - iv) bole quality (Notes were taken on the incidence of forking, extreme taper, sweeps, galls or other disease damage, cracks, scars, and broken tops);
- 5) Crown size:
 - i) length of live crown,
 - ii) length of longest living branch;
- 6) Limbiness and natural pruning:
 - i) thickness of persistent dead branches,
 - ii) height of the stem from ground to first persistent branch which was 3 feet or longer, and
 - iii) frequency of limbs (interval between consecutive limbs or whorls of limbs).

The point-centered quarter method of Cottam and Curtis (1956) was adapted for sampling stands. The stand to be sampled was surveyed for the uniform area to be covered. The 100- to 200-foot border areas of the stands were not included in the sample to avoid border effects.

For the first two stands, 25 points (uniformly distributed within the sampling area) were sampled. At each point of sampling, the area around the point was divided into four quarters by two lines; a line of traverse or compass line and another line running at right angles to it (Fig. 1).

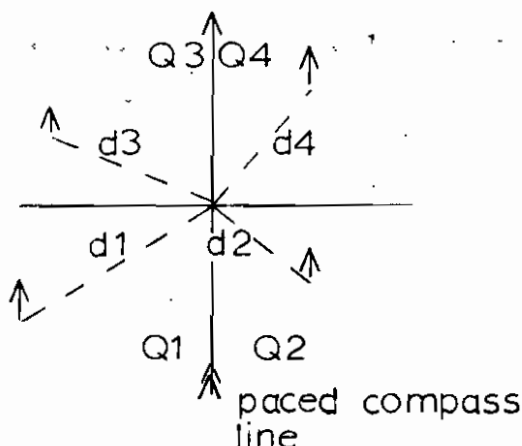


Fig. 1. Selection of sample trees by the point-centered quarter method.

The nearest tree of any species in each quarter (Q) was sampled for its distance (d) from the point (feet) and its breast height diameter (inches). The species of the nearest tree in each quarter was recorded. Thus there were four distances and four diameters recorded at each point.

Other parameters (e.g. age, height, and crown length) were recorded for the nearest white spruce tree in quarter 1 at each of the 25 points. Thus detailed measurements were available for one white spruce tree at each point. The sample was tested for adequacy (Fig. 2). It was concluded from this test that 10 points per stand were an adequate sample. This was true at least for stands being 90% or more white spruce. Therefore, in the rest of the stands, only 10 points were sampled for each stand.

2.4 Treatment of the Data

1) Stand Density.

The following formulae were used to calculate the number of stems per acre for all species included in the sample:

$$\begin{aligned} \text{Mean distance (M)} &= \frac{[\text{Sum of all distances (d)}]}{[\text{Number of sample points}] \times 4} \\ \text{Mean area} &= (M)^2 \\ \text{Stems/acre (S)} &= [43560] / [(M)^2] \end{aligned}$$

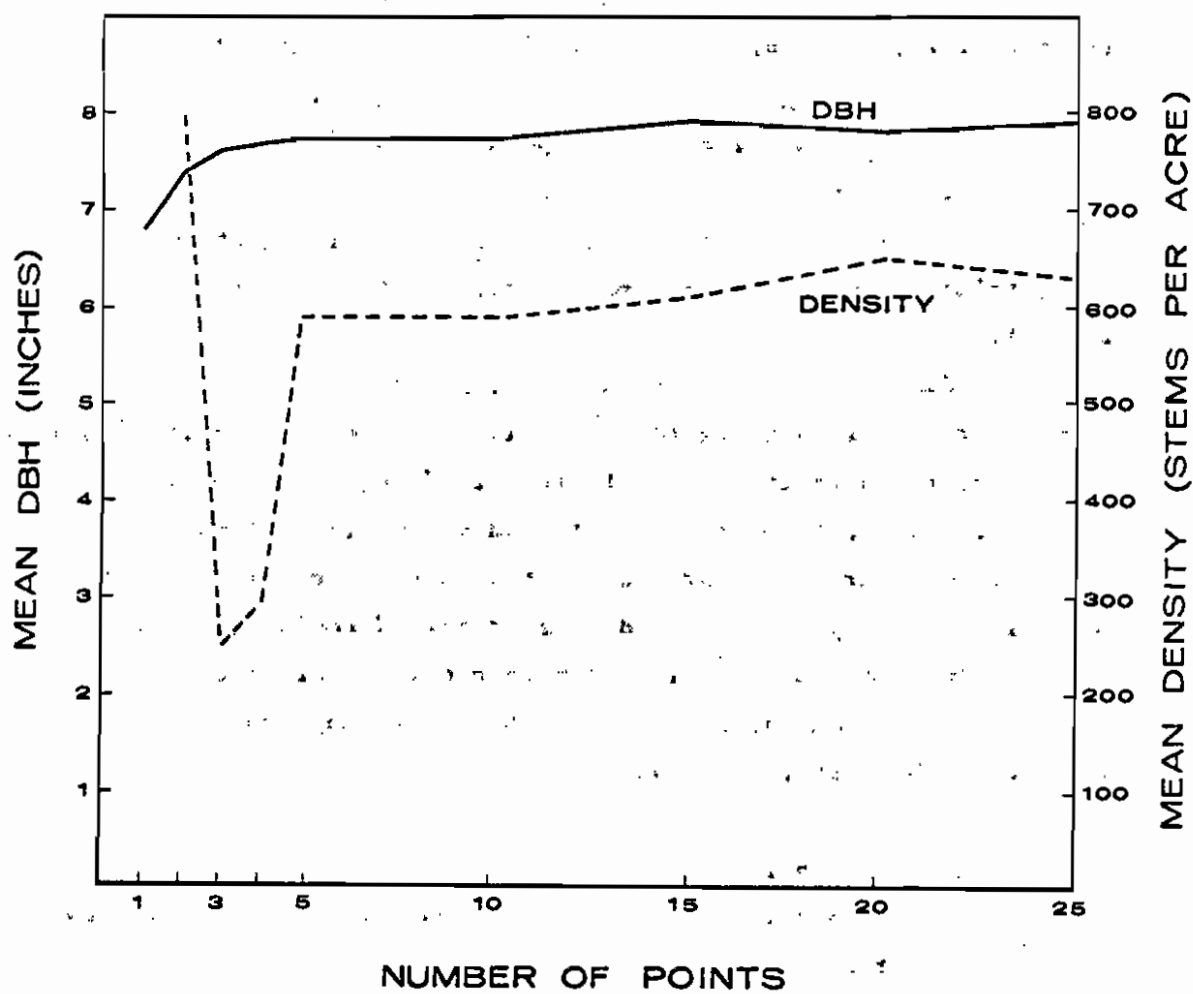


Fig. 2. Relationship between sample size and estimates of breast height diameter and stem density.

2) Stand Composition.

Density (stems/acre) of each species included in the sample was calculated as:

$$\text{Density of species A} = \frac{[\text{Number of stems of A in sample}] \times S}{[\text{Number of sample points}] \times 4}$$

3) Basal Area per Stand.

Basal area was obtained indirectly using a mean basal area (Manning 1970, table 6) from a calculated mean diameter:

$$\text{Mean dbh.} = \frac{[\text{Sum of dbh. of all sample trees}]}{[\text{Number of sample points}] \times 4}$$

$$\text{BA/acre} = \text{Mean BA} \times [\text{Stems/acre}]$$

Density, basal area, and composition of six stands along with other information (location, area, etc.) for these stands are given in Table 1.

Comparable values of density, basal area, and composition of stands were obtained using the Bitterlich method of sampling (Anon. 1966). Therefore, it is up to the man in the field to choose one of the two methods for determining the density and volume in a stand. The Bitterlich method is simpler. However, the distances for each tree at each sample point in case of point-centered quarter method could eventually be used to determine the cause of limbiness in a particular tree in a detailed study. This method would be useful when selecting individual trees in the second phase of the study.

4) Height/Age Ratio in Stand Evaluation.

Height/age ratios were calculated for 10 trees per stand for measured height and age of each sample tree and for its height standardized to age 50 years. The heights at 50 years were calculated from height/age curves used by land inventory section of the N.S. Department of Lands and Forests.

Based on the array of values in six stands, the following height/age classes were formed, using age at breast height plus 5 years.

Table 1. Basic information on six stands of white spruce

Stand no.	Topo. sheet	Photo no. (Line)	Seed ^a zone	Parameters for white spruce				Species composition ^c (% relative density)	Ownership, Acreage, and Remarks
				Height (feet)	Age ^b (years)	Diam. ^b (in.)	Stems/acre	BA/acre (ft ²)	
1	11E/3E	22(32)	6	Mean Range	48 41-54	7.9 4.1-14.2	603	207	wS 96 bF 4 Private 9 acres Fair
2	11K/7W	77(40)	9	Mean Range	37 30-51	5.8 2.0-11.5	1264	240	wS 100 Private 10 acres Undesirable
3	11K/2E	142(30)	8	Mean Range	52 41-61	7.1 4.3-15.5	962	263	wS 100 Crown 4 acres Undesirable
4	11K/2W	149(31)	9	Mean Range	43 34-49	6.6 3.4-10.4	1003	246	wS 100 Private 3 acres Fair
5	11K/2W	125(30)	9	Mean Range	37 31-42	7.8 4.8-11.7	821	272	wS 90 bF 7.5 wB 2.5 Crown 3 acres Good
6	11D/14W	164(25)	6	Mean Range	37 28-42	7.2 3.9-11.5	493	141	wS 58 wP 15 bF 12.5 rS 12.5 eH 2 Private 10 acres Good

a. Seed zones from Fowler and MacGillivray (1967).

b. At breast height.

c. wS = white spruce, bF = balsam fir, wB = white birch, wP = white pine, rS = red spruce, eH = eastern hemlock.

<u>Class</u>	<u>Height/age</u>
1	0.73 to 0.83
2	0.84 to 0.94
3	0.95 to 1.05
4	1.06 to 1.16
5	1.17 to 1.27
6	1.28 to 1.38
7	1.39 to 1.49

The percentages of trees in each height/age class were calculated and the results are presented in Figs. 3 and 4. It is clear that the six stands have different proportions of trees with different rates of growth. For example, in stand 3 most of the trees are slow growing whereas in stand 6 over 60% are fast growing (Fig. 3).

Desirability of stands as future seed source areas is evaluated as follows:

- i) Stands in which 50% or more of the trees have a height/age ratio greater than 1.27, are rated as good, e.g. 5 and 6.
- ii) Stands in which 50% or more of the trees have a height/age ratio greater than 1.16, are rated as fair, e.g. 1 and 2.

A close look at the individuals in different height/age classes revealed that at least in stands rated 'good', classes 3 and 4 are composed of suppressed and intermediates; therefore, through cleaning and well planned thinning, 'good' and 'fair' stands could be converted to 'excellent' and 'good' stands.

The stands rated 'good' are not 10 acres, or greater, in size. The criterion "*10 acres or more*" should be changed to "*area having at least 500 good trees*" in the requirements for stand selection.

The evaluation of stands does not change when standardized heights were used instead of normal heights. Therefore, the use of normal values of height and age (at stump height) is advisable as it is less time consuming.

5) Measure of Limbiness and Self-Pruning Ability of Individual Trees

Once the stands with faster growing individuals have been selected, individual trees can be evaluated for stem form, resistance to disease and insect damage, etc.

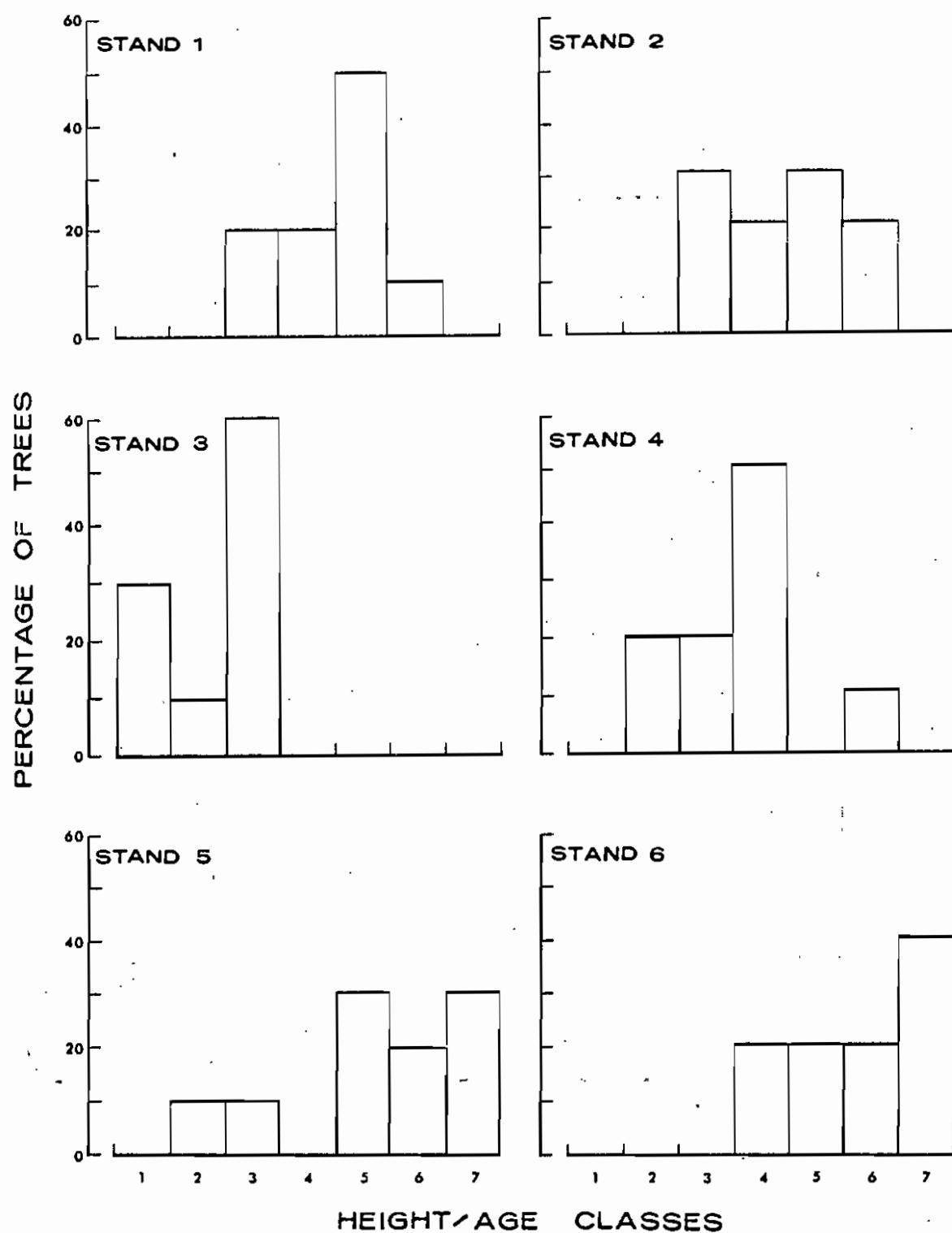


Fig. 3. Percentage of trees in each height/age class in six stands of white spruce.

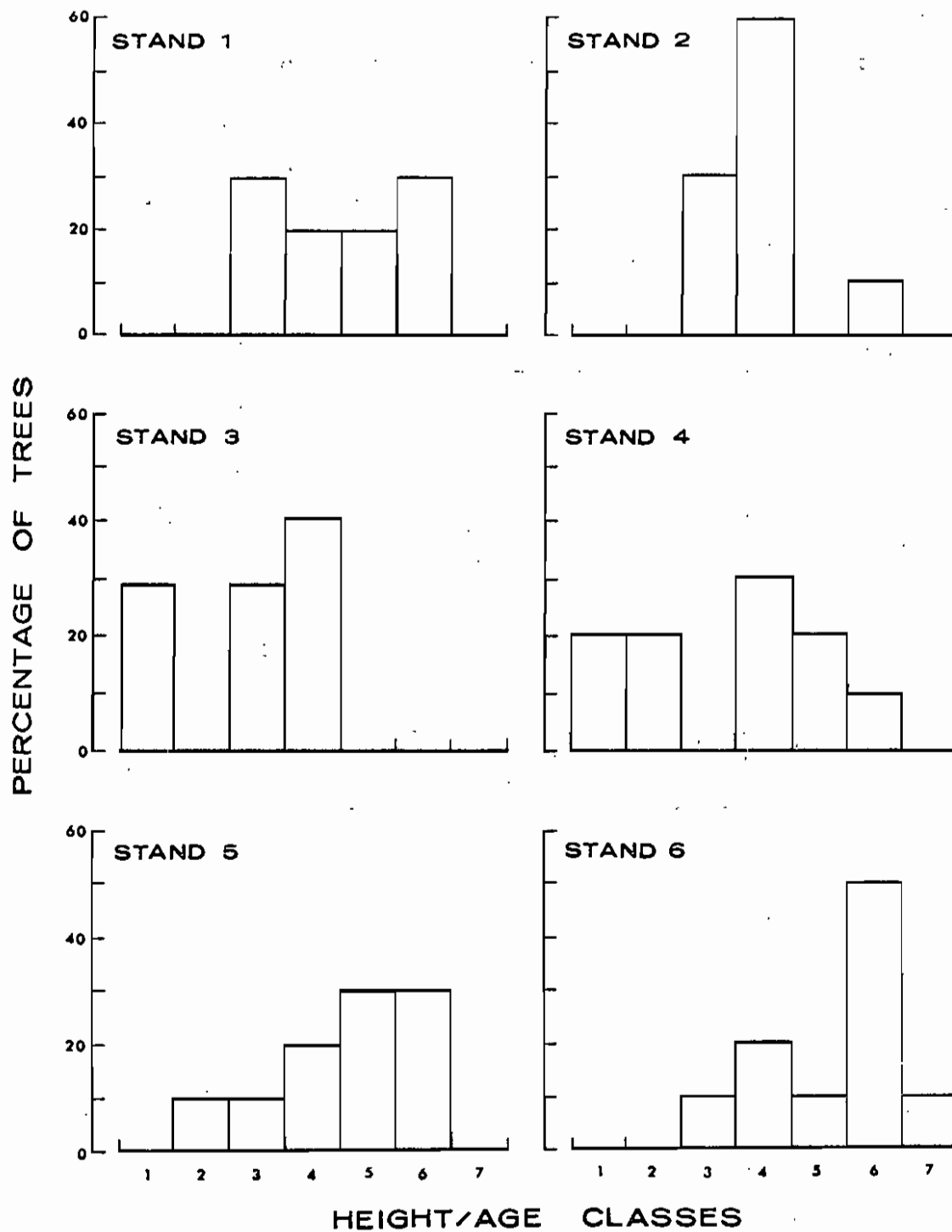


Fig. 4. Percentage of trees in each height/age class in six stands of white spruce, standardized to age 50 years.

The limby appearance of an individual tree depends on the length of the intact branches, interval between persistent branches, and thickness of these branches. It is also, to a great extent, determined by the density (stocking) of the stand and the age of the individual trees. Preliminary observations on this aspect show that:

i) Ratio of height to persistent branch (>3 feet)/Total tree height:

This ratio is a useful measure. Trees of the same crown class and in the same stand seem to vary in this character (Table 2). It is thus probable that limbiness is at least under partial genetic control. By intensive sampling within stands and by sophisticated analysis of the data, one can clarify such ambiguities.

ii) Thickness of the intact dead branches: The thickness (diameter) of the branches ranged from 0.5 to 3 inches. It was obvious from comparisons that trees which could be classified as limby had thicker branches (>1 inch diameter). Probably, the self-pruning ability depends on this character. Tentatively, five classes of self-pruning ability can be set as follows and percentages of trees in each class are given in Table 3.

<u>Thickness of branches (diam. in inches)</u>	<u>Self-pruning ability</u>
<0.5	Excellent
0.5-0.9	Good
1 -1.4	Fair
1.5-2	Poor
>2	Very Poor

The height to persistent branches seems to be correlated to thickness of branches in some trees at least (Tables 2 and 4).

6) A Measure of Crown Types

Again, this character depends on a number of factors: density of the stand; crown class of the individual tree; and age of the individual tree.

Ratios of crown length/total height were calculated for the sample trees in each stand (Table 4). However, no definite trends were noted in this statistic. There are indications that the dominant trees tend to have larger crowns in relation to their height. The trees that

Table 2. Ratios of height to persistent branch (> 3 feet)/total tree height in 10 sample trees in each of the six stands. The crown class of each tree is given in parenthesis^a

Tree	Stands					
	1	1	3	4	5	6
1	0.22(4)	0.13(2)	0.11(2)	0.46(3)	0.05(1)	0.14(1)
2	.03(2)	.03(1)	.10(2)	.18(2)	.02(4)	.24(1)
3	.31(3)	.44(2)	.01(2)	.18(2)	.01(1)	.12(4)
4	.08(1)	.13(2)	.21(2)	.01(1)	.18(2)	.02(4)
5	.25(1)	.20(1)	.25(4)	.23(3)	.18(2)	.21(2)
6	.32(1)	.31(2)	.04(4)	.05(1)	.11(2)	.10(4)
7	.44(2)	.34(3)	.37(4)	.01(3)	.29(1)	.12(4)
8	.36(2)	.11(3)	.50(3)	.08(1)	.24(4)	.01(2)
9	.14(2)	.05(1)	.75(4)	.16(4)	.15(2)	.25(1)
10	.08(3)	.35(3)	.01(2)	.22(2)	.02(2)	.11(1)

^aCrown classes: 1 = Dominant; 2 = Co-dominant; 3 = Intermediate;
4 = Suppressed.

Table 3. Percentage of individuals from six stands of white spruce in five self-pruning ability classes

Stand	Self-pruning ability classes				
	1 (excellent)	2 (good)	3 (fair)	4 (poor)	5 (very poor)
1	10	70	10	-	10
2	-	50	40	10	-
3	-	60	20	10	10
4	-	40	40	20	-
5	-	40	20	30	10
6	-	10	40	50	-

Table 4. Ratio of crown length to total tree height for 10 trees in each of six stands. Crown class of each tree is given in parenthesis

Tree	Stand					
	1	2	3	4	5	6
1	0.25(4)	0.25(2)	0.25(2)	0.16(3)	0.32(1)	0.27(1)
2	.30(2)	.16(1)	.20(2)	.27(2)	.29(4)	.20(1)
3	.41(3)	.33(2)	.26(2)	.27(2)	.37(2)	.25(4)
4	.50(1)	.15(2)	.21(2)	.19(1)	.33(2)	.28(4)
5	.42(1)	.23(1)	.12(4)	.23(3)	.34(2)	.29(2)
6	.40(1)	.14(2)	.10(4)	.31(2)	.32(2)	.14(4)
7	.25(2)	.11(3)	.14(4)	.14(3)	.38(1)	.18(1)
8	.30(2)	.16(3)	.20(3)	.28(1)	.30(4)	.21(2)
9	.50(2)	.33(1)	.24(4)	.27(4)	.25(2)	.28(1)
10	.50(3)	.25(3)	.32(2)	.22(3)	.30(2)	.24(1)

had values of 0.3 or less for crown length/height ratio were considered to have good crown form.

Another factor that could be used in evaluation of trees for desirable crown types is the relation between bole diameter and crown width. But for both of these parameters, sampling must be so designed that the relative effects of age, density, and site types can be determined. These factors should be examined when selection for plus trees is made from the plus stands.

3. RECOMMENDATIONS

Our knowledge of genetic variation in white spruce and the association of the specific genotypes to particular site and climatic conditions over the distribution range of this species in Nova Scotia is limited. The recommendations, therefore, are based on the interpretation of the results of this study which lasted only 3 months. Consequently, the present recommendations and procedures are open to modification as new information accumulates from future studies.

The selection of seed areas and further development of these areas may be carried out in two phases.

3.1 Phase I

This phase includes the present study and involves the selection of white spruce areas that contain a high proportion of above-average trees.

1) Where to Look?

Sites that are expected to be reforested in future are probably the best indicators of the kinds of sites which should be surveyed for locating seed source areas. In Nova Scotia, several million trees could be planted per year on sites of capability 4 and 5 (Personal communication, E. Bailey, N.S. Dep. Lands and Forests). Therefore, it is recommended that the sites similar to these capabilities or of class higher should be thoroughly surveyed to locate seed source areas in addition to the four recommended in this report (Table I).

2) What to Look For

There is a strong feeling that rotation age should be reduced to about 40 years for efficient use of land through intensive reforestation and management. Therefore, during the course of present study, first priority was given to the stands that had high proportion of fast growing trees.

The following criteria were used and are recommended for the selection of superior stands of white spruce:

- i) Stands should be located on sites similar to those expected to be reforested.
- ii) Areas should be large enough to yield about 500 dominant and codominant trees that are superior in growth rate, stem form, crown form, and resistance to disease and insect damage.
- iii) White spruce should make about 60% or more of the stand volume.
- iv) 50% or more of the white spruce trees should have a height/age ratio greater than 1.16.
- v) Stands should be reasonably young, 40-50 years at stump height.

These criteria can be evaluated by using the point-centered quarter method. Ten points would be an adequate sample and detailed observations should preferably be completed on 40 trees per stands instead of the maximum of 25 trees used in this study.

3) What to do to the Selected Stands

The following steps should be taken soon after the stands are selected so as to develop them as seed source areas:

- i) Those stands which are not under Crown ownership should be acquired by the N.S. Department of Lands and Forests. Additional land in the immediate vicinity, preferably of the same soil type, should be acquired. This land should be planted with seedlings from the seed obtained from the selected stand to assure a continued supply of material of these genotypes in the future.
- ii) Once the stands are acquired, the phenotypically best stands should be treated further as follows:
 - a) The stand should be cleaned of suppressed and intermediate white spruce trees and all other tree and shrub species.

Thinning should be carried out in at least two stages. The

second thinning (and possibly a third) should be primarily for spacing. This should be done in the first good seed year after selection of the stand. Cones collected at this time should be used for reforestation.

- b) With thinning and cleaning, a system of roads should be built that would facilitate the collection of seeds from the standing trees. The feasibility of using vehicles similar to those used for powerline-maintenance should be studied.
 - c) The stands should be fertilized to increase cone production.
 - d) Bulk seed collection should begin immediately. This would involve collecting seeds from the better trees within the stand to meet immediate seed requirements.
 - e) Seed should be collected from a representative sample of 'good' trees in each of the selected stands during a good seed year. This seed should be used to establish progeny tests to determine which of the selected stands is genetically best.
- iii) The work on Phase I should be continued so that additional good stands of white spruce (as well as stands of other species) are located in all the major seed zones of Nova Scotia.

3.2 Phase II

Phase II of the project on seed production would involve: Selection of Plus trees; progeny testing; and establishment of seed orchards.

It would be advisable for experts from the Genetics, Silviculture, and Land-capability Sections of the Canadian Forestry Service and N.S. Department of Lands and Forests to meet soon to discuss the problems involved in implementing Phase II and to develop acceptable and workable plans.

1) Selection of Plus Trees

The best trees in the selected stands, as well as exceptional trees in other stands, should be located and tested. They should be selected for the following characteristics:

- 1) Trees that have a height/age ratio of 1.38 or more.
- ii) The fastest growing trees in the stand may not possess the best

stem and crown form. In this case, trees that are slower than the fastest growing ones but have good stem and crown form should be selected. Trees with thin branches (<1 inch diameter) should be preferred to trees having thick branches (1 to 3 inches diameter).

- iii) Individuals in which the interval between consecutive branches exceeds 12 inches should be selected.
- iv) Individuals should be free of diseases and insect damage.
- v) Individuals having larger seeds should be preferred to those producing smaller seeds.

Probably, it would not be possible to have all the 'best characters' in a single individual, therefore, individuals may be classified into categories describing the unique character of each group of individuals.

2) Progeny Testing

Progenies from seed collected from individual trees should be tested on sites comparable to the ones to be reforested. It would be interesting to include seed of plus trees from other sites and even geographically different regions of Canada in the progeny tests. The seed collections from other than the local sites might show a better performance on some sites.

3) Establishment of Seed Orchards

Once the best trees in a superior stand have been identified, grafts and individual seed collections from these trees may be used to establish and develop seed orchards. These orchards should be established on the best sites available. The growth would be faster and the effects of the fertilizers and other operations would be enhanced because of better soil and moisture conditions.

ACKNOWLEDGEMENTS

The cooperation and assistance of the personnel of the Nova Scotia Department of Lands and Forests and the Canadian Forestry Service are sincerely appreciated. I am grateful to Dr. D.P. Fowler for his advice during this project.

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APPENDIX: *Site Description and Stand Assessment Tally Sheets***Abbreviations used on tally sheet.**

Pt = Point

No = Number

Sp = Species

Dist = Distance

Dbh = Diameter at breast height

St = Stump height

B = Breast height

Ht = Height of tree

CrCl = Crown class

BQ = Bole quality

CrL = Crown length

LBr = Length of the longest branch

CrLBr = Crown length above the living branch

PBr = Persistence of branches

TBr = Thickness of the longest branch

Dam = Insect and disease damage

SITE DESCRIPTION TALLY SHEET

Stand No. _____ Date _____
Stand Area _____ Ownership _____
Photo No. _____ Eco-region _____
Topo. Sheet _____ Sub-district _____
Location _____ Soil Series _____
County _____ Crew _____
Elevation _____ Seed Zone _____
Latitude _____ Longitude _____

Local Relief

Exposure

Position on Slope

1. Depressional

1. Exposed

1. Hilltop

2. Level

2. Mod. Exposed

2. Upper

3. Gently Undulating

3. Moderate

3. Middle

4. Rolling

4. Mod. Sheltered

4. Lower

5. Hilly

5. Sheltered

5. Flat

6. Mountainous

Slope (%) _____ Aspect (°M) _____ N. NW. NE. W. S. SW. SE. E.

Site Cover

History Fire, Cutover, Old Field, Pasture, Insects, Natural, Hurricane

Stand Number

[illegible]