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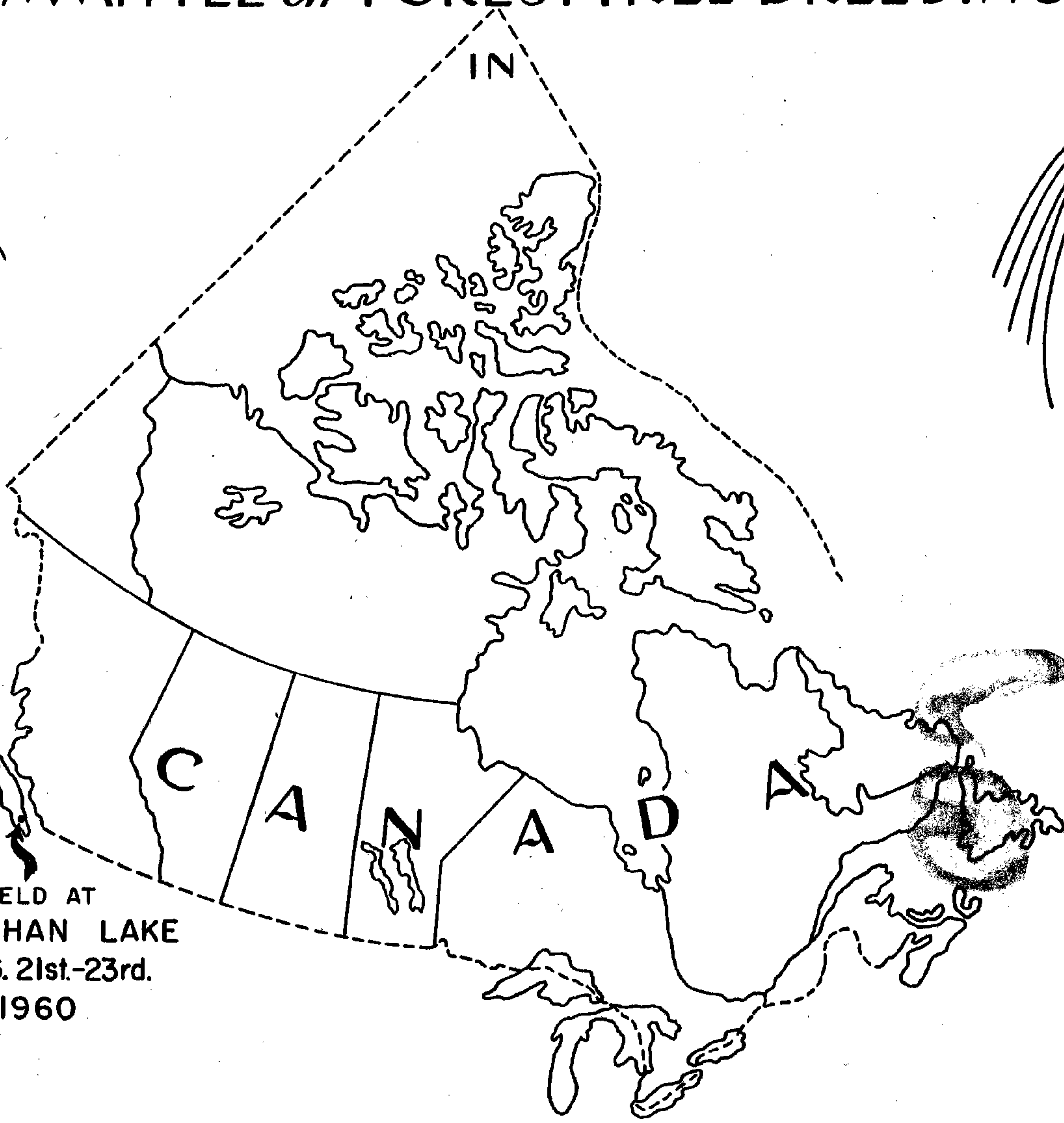
Proceedings of the Seventh Meeting of the Committee on Forest Tree Breeding in Canada



HELD AT
COWICHAN LAKE
AUG. 21st.-23rd.
1960

Part II
Reports and Reviews

PROCEEDINGS OF THE SEVENTH MEETING OF

THE COMMITTEE ON FOREST TREE BREEDING

IN CANADA

Held at the Forest Experiment Station of the British Columbia Forest Service, Lake Cowichan, Vancouver Island, B.C., on August 21st to 23rd, 1960.

PART II

MEMBERS' PROGRESS REPORTS AND VISITORS' PROGRAMME REVIEWS

Prepared and distributed by the Forest Research Branch, Canada Department of Forestry, Ottawa. Part I, Minutes and Discussions, received restricted distribution to Committee members only. Part II received wider distribution to persons and organizations actively engaged or interested in forest tree breeding and improvement.

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NOT FOR PUBLICATION

REPORT TO COMMITTEE ON FOREST TREE BREEDING

July 1960

Michael G. Boyer

Canadian Department of Agriculture
Forest Biology Laboratory
Quebec, P.Q.

Investigations have been undertaken since 1958 on diseases of poplar present in the Province of Quebec, with particular emphasis on their effect on hybrid and introduced poplars.

At the present time, introduced poplars are not widely distributed in this Province. Only three plantations have been established; the Harrington Forest Farm (C.I.P.) at Calumet, the Morgan Arboretum at Montreal and the Forest Biology Laboratory at Quebec City. Approximately 33 diseases have been recorded on poplar in the Province, many of them at present established on introduced poplar. The identified fungous diseases of introduced and native poplars in Quebec are presented in Table I.

Diseases

1) *Ciborinia pseudobifrons* Whetzel

2) *Ciborinia whetzelii* (Seav.) Seav.

3) *Cladosporium subsessile* Ell. Barthold

4) *Didymosphaeria populina* Vuill.

5) *Dothichiza populea* Sacc & Br.

6) *Fusarium solani* sensu. S. and H.

7) *Fusicladium radiosum* (Lib.) (Lind.)

8) *Guignardia populi* Thompson

9) Hypoxylon pruinatum (Klot.) Cke.

10) Linospora tetrospora Thompson

11) Marssonina populi (Lib.) Magn.

12) Marssonina rhabdospora (Ell. & Ev.) Magn.

13) Melampsora abietes-canadensis (Farl.) C.A. Ludwig

14) Melampsora medusae Thüm.

15) Mycosphaerella populicola Thompson

16) Mycosphaerella populorum Thompson

17) Mycosphaerella populorum (canker phase)

18) Nectria canker

19) Neofabraea populi Thompson

20) Septotinia populiperda Waterm. & Cash

21) Taphrina johansonii Sadeb.

22) Taphrina populina Fr.

23) Uncinula salicis (DC) Wint.

24) Valsa nivea (Hoff.) Fr.

25) Valsa sordida Nit.

TABLE I

Fungous diseases of native and introduced poplars in Quebec

Native poplars

Populus alba var. nivea 11, 25 *

" balsamifera 4, 10, 11, 13, 14, 15, 16, 23, 25

" grandidentata 6, 11, 14, 16, 19, 21, 24, 25

" deltoides 2, 3, 7, 9, 11, 13, 14, 16, 18, 23, 24, 25

" tremuloides 1, 2, 3, 7, 8, 9, 11, 14, 16, 18, 21, 23, 24, 25

* numbers refer to diseases listed previously

TABLE I (Continued)

Introduced poplars

Populus alba x grandidenta 7, 11, 14, 25

" angulata x simonii 10, 11, 25

" berolinensis x simonii 11, 16, 17

" candicans x berolinensis 11, 16, 20, 25

" charkowiensis x caudina 11, 14

" charkowiensis x incrassatta 11

" charkowiensis x robusta 11, 25

" deltoides x balsamifera 11, 14, 20, 25

" deltoides x petrowoskyana 5, 11, 16

" deltoides x trichocarpa 11, 25

" deltoides x volga 11, 25

" eugenii 1, 11, 14, 25

" euramericana 10, 11, 14

" euramericana x serotina 11, 14

" generosa 11, 14

" grandidentata x alba x grandidentata 7, 14

" marilandica 11, 14, 20

" maximowiczii x berolinensis 16, 25

" maximowiczii x plantierensis 11, 14, 16

" maximowiczii x trichocarpa 11, 14, 16

" nigra x laurifolia 10, 11, 14, 16, 20

" nigra betulifolia x volga 11, 16, 25

" nigra italici 11, 14, 21

" nigra betulifolia x trichocarpa 14, 20

Oxford poplar 16

TABLE I (Continued)

<u>Populus</u> <u>pacheri</u> 11

" <u>petrowoskyana</u> 11, 14

" <u>rasmowskyana</u> x <u>plantierensis</u> 20, 25

" <u>raverdeau</u> 11, 14, 16, 25

" <u>robusta</u> 14, 16, 25

" <u>sargentii</u> 11, 16

" <u>serotina</u> 11, 14

" <u>tremula</u> 11, 14

" <u>tremuloides</u> x <u>tremula</u> 11, 14

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ONTARIO
DEPARTMENT OF LANDS AND FORESTS

Reforestation

Toronto, Ontario

FOREST TREE BREEDING

August, 1960

Hon. J. W. Spooner
Minister

F. A. MacDougall
Deputy Minister

J. A. Brodie, Chief
Timber Branch

REPORT TO COMMITTEE ON FOREST TREE BREEDING

August 1960

* A. J. Carmichael, B.Sc.F. R.P.F.

Ontario Department of Lands and Forests

I Provenance Tests

A. White Spruce

The existence of nutritional deficiencies has been indicated by foliar analysis in a white spruce provenance test. The test was established in 1958 at Artemesia township in southwestern Ontario, in co-operation with the Petawawa Forest Experiment Station. The pale colour of the foliage and the poor growth led to foliar sampling in fall 1959. Test results indicated a low level of nitrogen (less than 1.0%) and potassium (less than 0.36%) in three replicate plantings of the one seed source tested. This source (Essa Tp.) came from an area high in calcium and magnesium, and the soil at the planting site was derived from dolomitic limestone also high in its calcium and magnesium content. A further analysis is required, to determine whether another source from a high lime area shows similar deficiencies, and to compare these findings with those for a source from acid soil conditions.

A point is raised by these observations concerning the need for caution in selecting planting sites for provenance tests to avoid soil deficiences and for the necessity of having planting stock with an adequate nutrient content. Further information is required to develop norms for the nutrient requirements of different seed sources in seedling and transplant stages. Deficiencies induced by nursery management may obscure any ecotypic variation present and invalidate conclusions based on measurements of growth.

B. Red Pine

In addition to the nutrient condition of stock plants there are insect and disease complexes which affect provenance tests. Apart from the interaction of these, there are the organisms which develop on normal stock in plantations. A condition has developed in red pine provenance test plantings at Rose township in Central Ontario and in German township in Northern Ontario which is being studied to define the causal agents.

* Employed in the Reforestation Section of Timber Branch, Allan J. Carmichael is responsible for carrying out the forest tree breeding program of Timber Branch.

Foliar analyses of healthy and unhealthy red pine of Algoma source obviate the explanation of reduced vigour due to a nitrogen, phosphorous or potassium deficiency. The levels of minor elements will be checked in 1960 to evaluate their status: however, it seems that a disease or virus pathogen is responsible for the tree mortality and that this may be vectored by an insect.

C. Scotch Pine Christmas Tree Test

Measurements of height growth and form were made for test plantings of 12 seed sources growing in central and northern Ontario (Rose and German townships) which were 7 years old from seed. A similar planting at Cambridge township in the Ottawa valley could not be measured.

None of the sources planted at German township will produce satisfactory Christmas trees. Northern conditions on a medium quality jack pine site, produced slow growth and a sparse branching habit with shorter needled foliage than in southern plantings.

French sources, grown from seed obtained from Établissements Versepuy, grew too slowly in every planting to develop a satisfactory Christmas tree, i.e. 6 ft. within 7 years from seed. These sources will require generally at least 10 years to reach merchantable size. The needle retention and fall colour for French sources surpassed all others: however, the short needles produce an open tree requiring rather heavy pruning and this extends the period to reach merchantable size.

A rapid growing source called West Europe, sold by F. W. Schumacher, Jamaica Plains, produced the greatest number of merchantable trees. Proper development of this source would necessitate annual pruning to produce suitably formed trees, and cutting would have to be done early in the fall to avoid too high a percentage of yellowish trees.

The best source in Rose township was West Baltic obtained from F. W. Schumacher. Trees had a moderate growth rate, produced an adequate number of branches per whorl (8) were straight-stemmed and retained their colour reasonably well in the fall.

Scandinavian sources from Sweden and Finland have produced trees with very straight stems, and in Rose township some trees of Swedish source have obtained excellent form. However, fall discolouration of the foliage would prevent this source from ever being considered for Christmas trees.

A mixed source originating from plantations at St. Williams nursery in Southern Ontario, is included in a 1956 planting to be examined in 1961. This source is preferred by some Southern Ontario growers who have made comparisons with other sources available from seed dealers in the United States and Europe. It currently provides the only source grown for Christmas trees in Ontario government nurseries.

II Seed Orchards

A. General

The propagation of selections from northern and central Ontario continues, with the emphasis being placed on black and white spruce (Fig. 1,2). Criteria for the selection of spruce in Seed Zone 5 of Northern Ontario have been adopted to aid in the elimination of individual specimens from the rank of plus trees.

The preliminary outline of these characteristics is as follows:

WHITE SPRUCE

Primary Any one factor is sufficient cause to eliminate a tree.

1. Site Index below 75 (total height 75 ft. in 50 years breast-height age), using the Lake States F.E.S. Tech. Note 474, Jan. 1957. This rating may have to be reduced to S.I. 70 for Port Arthur District in recognition of the reduced growth rate caused by continued attacks by spruce budworms.

2. More than one terminal shoot or past attempt at twinning.

3. Moderate to excessive spiral grain.

Secondary A few factors in combination or individually in excessive degree, are sufficient cause to eliminate a tree, particularly if the tree is a borderline case for any primary factors.

1. An inactive growing point at the tree apex (less than 1 ft.).

2. Broad, oval crown with irregular branching habit, particularly when one or more branches stand out from the crown in the upper third of the tree.

3. A small diameter or excessive taper, representing low wood volume for the tree.

4. Pendulous branches with a branch angle greater than 110°.

5. Heavy or numerous persistent branches as exemplified by a poorly cleaned stem. These branches are usually longer than 10 ft.

6. An asymmetrical bole or one which shows excessive fluting or butt flare or swelling due to buttress roots.

7. Large vole scars or depressions at the branch root, often associated with gum bleeding.

BLACK SPRUCE

The factors are similar to those for white spruce except that trees are eliminated, which have on uplands a Site Index rating below 50 (total height 50 ft. in 50 years breast-height age), and in swamps a rating below Site Class I (total height 36 ft. in 50 years breast-height age).

The upland data referred to are from the Lake States F.E.S. Tech. Note 473, Jan. 1957, and the swamp type data from Dr. Plonski's Normal Yield Tables, L. & F. Rep. No. 24, 1956.

B. Red Pine

A red pine seed orchard has been established at Grenfell township in Northeastern Ontario, to supply seed for the eastern portion of Zone 5. Plantings of about 1 acre in size were carried out in 1959 and 1960 following a plan designed to promote pollen dispersal. The basic unit within the orchard has been a block containing 144 trees (12 representatives of 12 clones) planted at a uniform spacing of 15 ft. x 15 ft.

Trees used for the orchard planting were grown in the nursery for 3 to 4 years following grafting. Stock should have been pruned in the third year in the nursery but was prevented until data were available to define the proper pruning time. Plants were moved as balled stock and planted at spots prepared by hand cultivation, with the addition of ½ cu. ft. shredded peat moss in each spot.

Foliar analyses for orchard plants after the first field season indicated nitrogen and phosphorous deficiencies. These were remedied in the spring of 1960 by broadcasting Ammonium Nitrate (500 lbs. per acre) and Triple Superphosphate (200 lbs. per acre) on a 4 sq. ft. area surrounding each plant.

The movement of orchard stock in closed polythene plastic sleeves, 18 in. wide x 36 in. long, tied at both ends with twistem wire, has improved the vigour of plants lifted early in the season for shipment to the north. Planting is simplified also, since removal from the plastic sleeve is accomplished by unfastening the basal wire tie and releasing the tree into a prepared hole. Fall lifting of red pine and cool storage overwinter in plastic bags at a northern location was carried out in 1959 to prevent shoot growth prior to the planting period. Clear plastic sleeves (3 mil) have been used and these were placed in burlap bags to prevent damage by exposure to sunlight.

C. Black Spruce Wood Quality

In order to obtain a means of mapping the natural variation of different wood characteristics found in black spruce, a sampling technique is required. An ivestigation was prepared in co-operation with the Forest Products Laboratory to measure some of the physical wood properties of black spruce trees, and to relate these to measures made on breast-height increment core samples. When a sampling technique is available, it will be possible to determine what variation is present for such factors as specific gravity, fibre length, fibril angle and summerwood percent, and hence to map this variation. An obvious advantage for a method requiring only increment cores, is that it does not destroy the subject but leaves desirable trees for future propagation.

Five trees of good form were selected from the dominant height class on wet sites in both Fournier and Challies townships, and on drier sites in both Kennedy and Leitch townships. The north side of each tree was marked and the tree felled. Trees were sectioned to remove 8 in. blocks at stump level (10 in.) breast-height level (54 in.), and at each 100 in. level above the ground to a 3 in. top diameter (4 in. top diameter in Kennedy Twp.).

In Ottawa, sample blocks will be sectioned and analysed to determine the average specific gravity, fibril angle, fibre length, fibre diameter and summerwood percent for an optimum location at each height level in the tree. Specific gravity will be determined also on 5/8 in. increment cores taken at breast-height on minimum, maximum and average radii, and measurements will be made for each 20 year group of annual layers from the bark to the pith. Precautions will be taken to avoid compression wood in the selection of specific gravity samples. Any doubtful selection will be verified by a check on fibril angle since this angle is greater in compression wood fibres.

Before samples were sent to Ottawa, the growth rings were counted on the upper surface of each block and diameter measurements made by decades along an average diameter. These measurements have been plotted to show the relationship of height to age and height to diameter.

From this data, tree volumes have been calculated and annual volume increments determined. As would be expected there is a close relation between total volume and total age, with the oldest trees being the largest and having the greatest average annual volume increment. The most noticeable exception to this is tree 294 from Kennedy township. This is the youngest tree sampled but it is the third largest tree and has the largest average annual volume increment, .22 cu. ft. per year. If we look at the volumes of the different trees at 100 years of age, we find that there are similar differences between townships and that the relationships between trees changes, showing a few trees which have poor volumes and were apparently suppressed, and one tree 294 with very good volume (Fig. 3 and 4).

Fibre analyses must be completed before it will be possible to compare the various trees for volume and quality combined. It will be most interesting to see how tree 294 fares. Will it have a low density as would be expected normally, or will it be the type of tree we are looking for, having superior volume increment with high density and the fibre yield required for a special tree.

III Seed Production Areas

A. General

Potential areas have been located for white spruce in Zone 5 (Northern Ontario), for black spruce in Zones 4 and 5 (Central and Northern Ontario), and for red pine in Zones 2, 3 and 5 (Southern, Central and Northern Ontario). Additional areas are required but are difficult to locate since there are few young stands available which are pure, even-aged and growing on sites that are drier than normal for the species.

B. Red Pine, Lynn Tract, Simcoe County

Red pine were thinned to a spacing of 12 ft. x 12 ft. in 1957 and flower and cone counts have been made annually following thinning. Individuals were selected in fall 1959 which showed a consistently low flowering pattern for trees growing on sites providing adequate tree growth.

On each of three sites, four trees were selected with three to be fertilized and one to form a control. Foliar analyses were made for each tree in fall 1959 and these show a uniformly low nitrogen level and uniformly adequate levels of phosphorous and potassium.

Three nitrogen levels (1.50%, 1.75% and 2.00%) will be held in the foliage of the treated trees on each site. By annual foliar analysis the effects of treatments can be measured and succeeding fertilizer applications modified to maintain the required foliar levels. The application of nutrients other than nitrogen will be made when the foliar analyses indicate inadequacies. Cone production will be examined to see how the size of cone crop or the frequency of crops has been affected by the three nitrogen levels maintained.

Figure 1

TREE SELECTIONS

WHITE SPRUCE

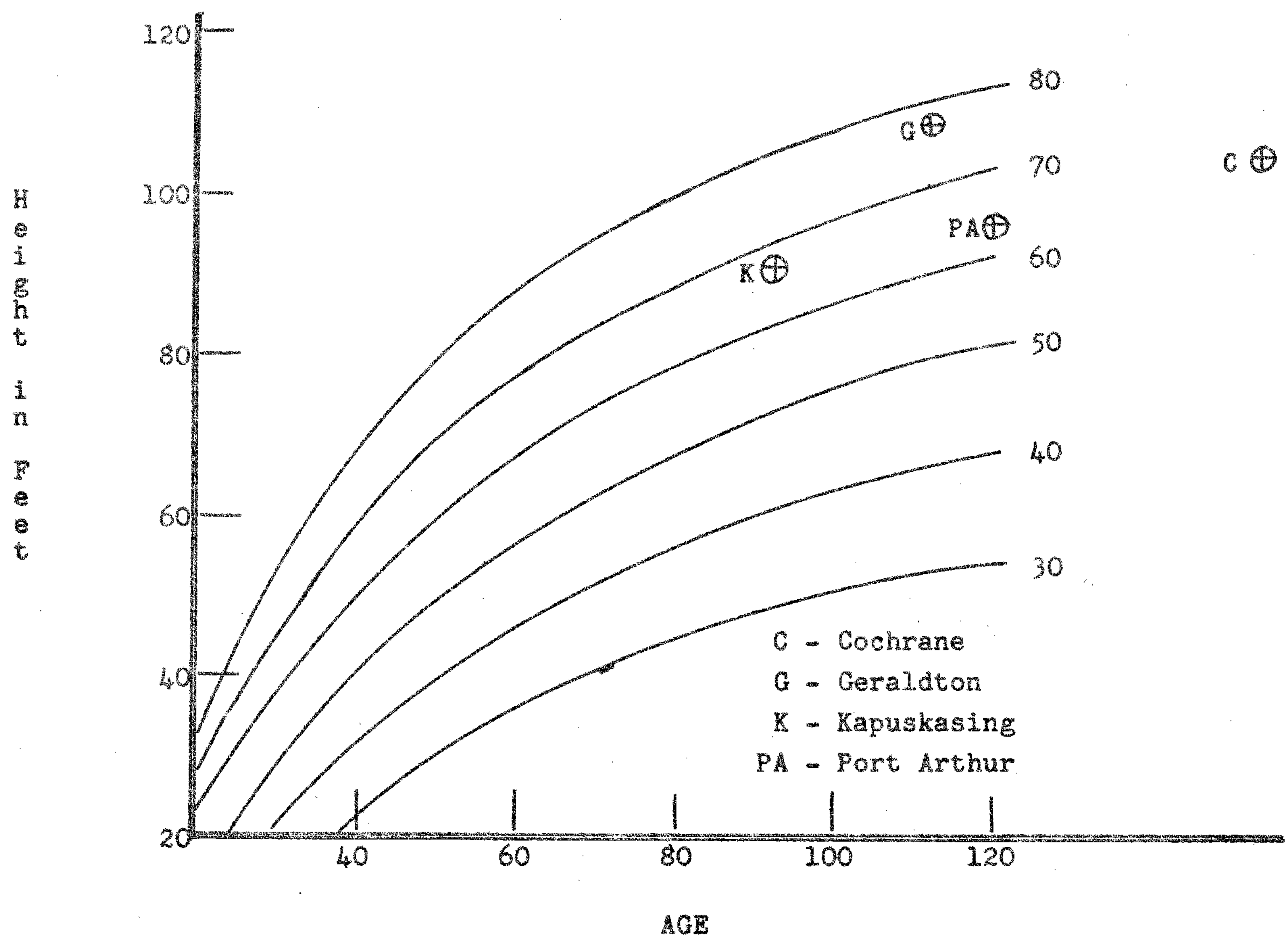


Figure 2

TREE SELECTIONS

BLACK SPRUCE

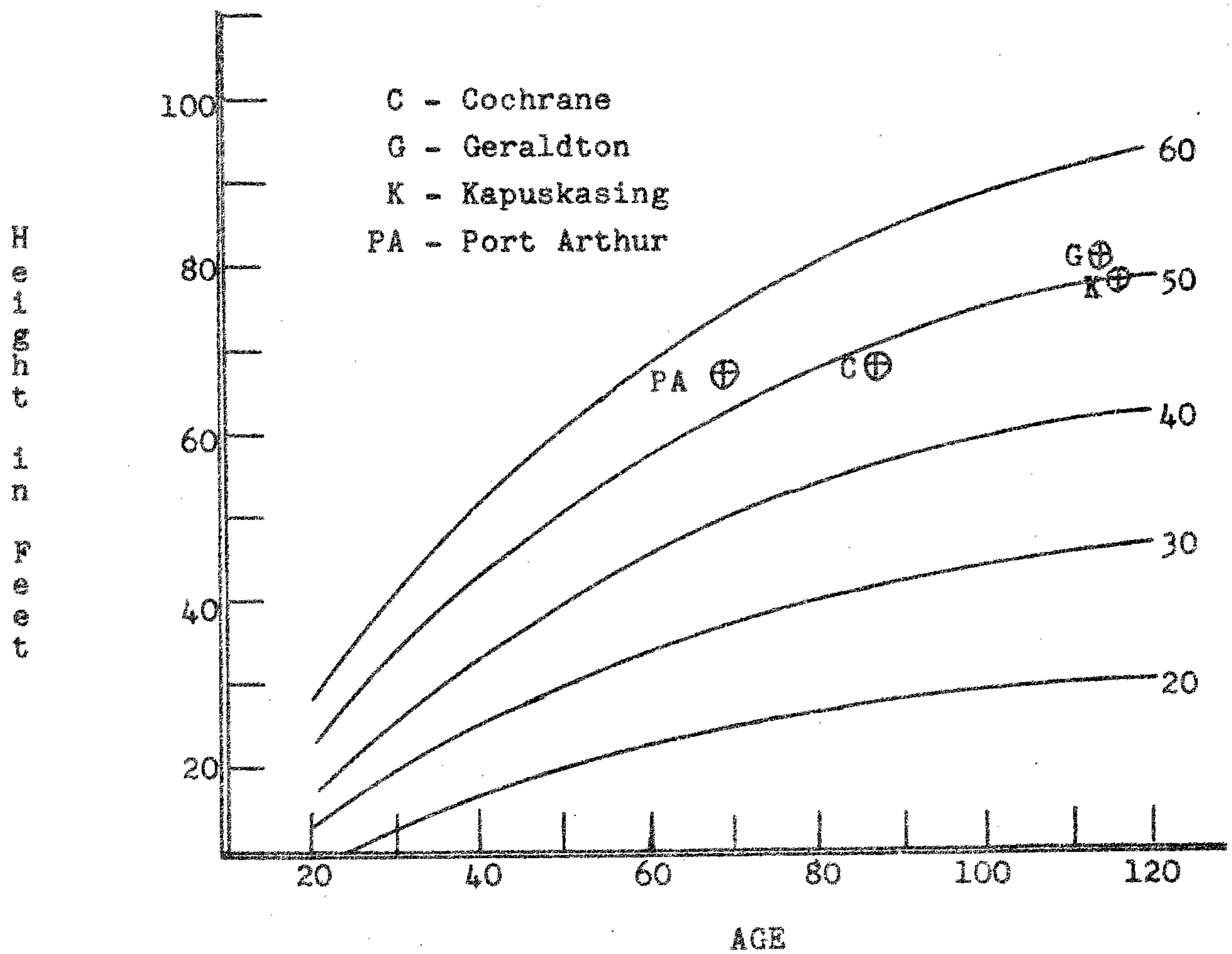


Figure 3

BLACK SPRUCE WOOD QUALITY

TOTAL TRUNK VOLUMES AND AVERAGE ANNUAL VOLUME INCREMENT

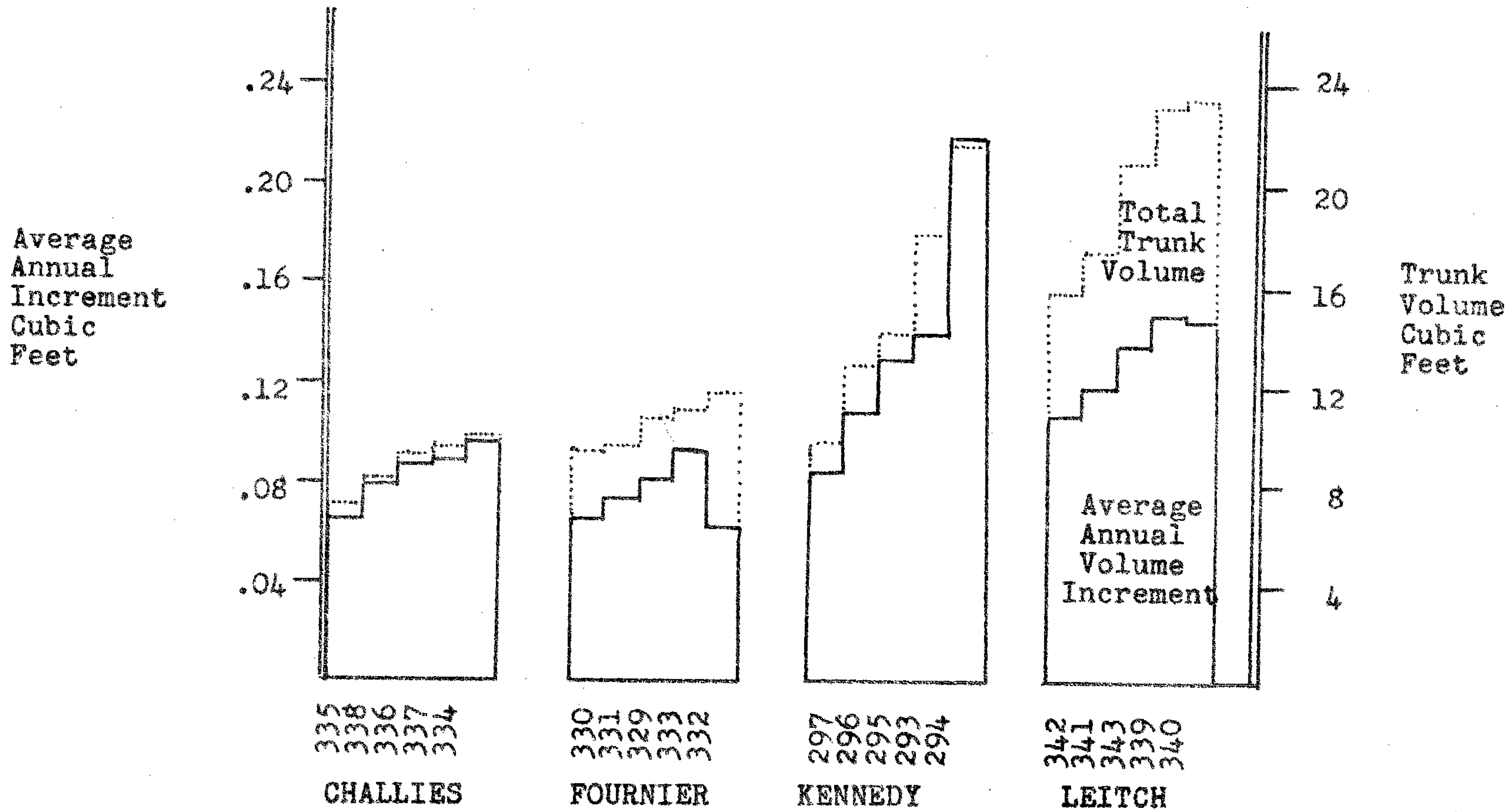
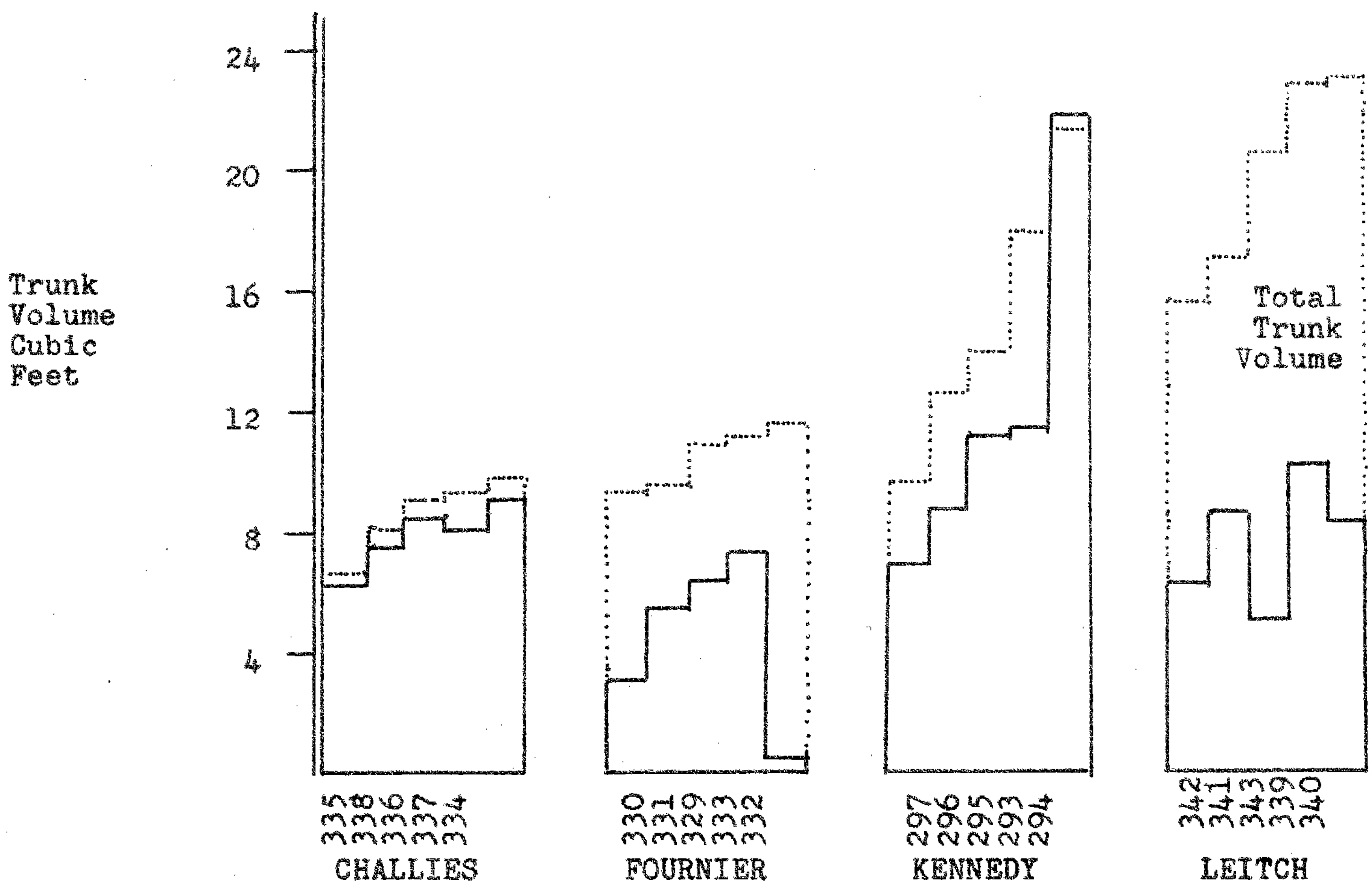


Figure 4

BLACK SPRUCE WOOD QUALITY

TOTAL TRUNK VOLUME AND VOLUME AT 100 YEARS



1960 Report on Tree Breeding Research

L. P. Chiasson St. Francis Xavier University
Antigonish, N. S.

Since the last report facilities for genetic research on the campus have been increased by the erection of a greenhouse by the Nova Scotia Research Foundation. Several projects had to be interrupted during the past winter owing to the loss of most of the glass in this greenhouse as the result of a fire in a neighboring building.

Interspecific Hybridization in *Abies*.

The principal programme of investigations has been and still is the production of interspecific hybrids of fir (*Abies*) species. In the last two years, ovulate cones of *A. balsamea* had been artifically pollinated with "foreign" pollens of the following species: *A. cephalonica*, *A. grandis*, *A. homolepis*, *A. homolepis* var. *umbellata*, *A. nobilis* var. *glauca*, *A. Veitchii*. Seeds had been obtained from most isolated cones, but it remained to test whether or not these putative crosses were real hybrids or, possibly, the results of self-pollination. In defiance of the proverbial injunction not to "put all your eggs in one basket," all these putative hybrid seeds were planted in the greenhouse after stratification. Indoor planting was resorted to for the following reasons: difficulty in getting outdoor seed-beds ready at the proper time was anticipated, and it was considered that sorting true hybrids from possible self-fertilized types would be more easily achieved under greenhouse conditions. Germination of these seeds was generally good, but the seedlings had not been subjected to careful examination when they were killed by heat and frost.

In the spring of 1960 artificial crosses have been attempted with A. balsamea as the female parent, and pollen of the following Abies species: cephalonica, concolor, homolepis, homolepis var. umbellata, koreana, lasiocarpa, and nordmanniana. These pollens have been applied to isolated cones on groups of trees located in four well-separated areas within a radius of 10 miles of Antigonish.

Ovule Development and Fertilization.

A study has been made of the "timing" of various stages in the development of the ovule. The occurrence of a 4-6 week lag between pollination and fertilization has been confirmed. During this lag there is no evident change in the pollen grains until they come in contact with the nucellus, at which time processes of germination become apparent.

In view of the short period of time each spring for the task of artificial pollination, the possibility of "late" artificial pollination is being explored. Two methods are being tested: the injection of pollen between the closed scales of previously isolated cones, and the injection of pollen through artificial openings bored in the scales before the time of fertilization. No results are as yet available as to the practicality of these methods.

Pollen Germination.

Studies of pollen germination have been instituted. These are intended to check the adequacy of some common and simple germination tests with respect to pollen of various Abies species. Since some of the pollens used may be transported considerable distances and may be in transit for varying periods of time, some general test of viability is desirable. Tests performed to date with various concentrations of sucrose and of lactose in water or in agar do not indicate gross differences in response on the part of 10 different Abies species.

Dormancy Studies.

Two decelerating features of a genetic programme in conifers are the production of flowers at an advanced age, and the necessary period of dormancy during the fall and winter months even under greenhouse conditions.

The variability of results obtained by the experimental application of gibberellic acid (GA) has given hope that almost any physiological effect might be produced in a hitherto untested species. Two sets of experiments have been performed with GA, one in the field and one in the greenhouse. In the field growing tips of firs 7-10 years old were sprayed periodically with GA dissolved in distilled water in some instances, and in Dermen's mixture in others. (Dermen's mixture contains morpholine and lanolin, and appears to provide good continuous contact with the foliage.) Floral formation has not been induced by these treatments; the collection and analysis of the information concerning possible effects of GA on vegetative growth have not been completed yet.

Greenhouse experiments were initiated with young fir trees (mostly 3-4 years old) brought in from the field at intervals from mid-November to February. Different concentrations of GA were sprayed on undisturbed and on artifically open vegetative buds. There were some indications that dormancy had been broken by the application of GA, but the numbers were not statistically significant, and the experiment could not be carried to its anticipated conclusion.

1958 - 59 Biennial Progress Report

"SHELTERBELT TREE BREEDING"

W. H. Cram, Superintendent.

Forest Nursery Station,
Research Branch,
Canada Agriculture,
INDIAN HEAD, Sask.

General:-

Drought conditions, which prevailed in 1958 and 1959, were unfavorable to Nursery and Breeding Research. In 1958 the frost free period was 103 days (from June 13 to September 24) with only 5.0" of precipitation, that of 1959 was 110 days (May 27 to September 13) with 10.6" of precipitation.

Staff changes in 1958 included the retirement of the Superintendent, Mr. John Walker on June 24, and the appointment of Dr. Cram as his successor on July 16, 1958. In addition, an Entomologist, Mr. L.O.T. Peterson, was transferred to the Forest Nursery Station from the Forest Biology Division to investigate insect problems. A position for a Plant Physiologist to conduct herbacidal and seed technology investigations has remained vacant since July of 1958. Mr. A.W. Crookshanks, who was assigned to research on Nursery Problems in February of 1959, was fatally injured in November.

The research program for 1958 and 1959 included Nursery, Seed and Insect problems related to the Breeding Projects for Caragana and Spruce. However, the above staff and climatic conditions materially reduced the volume of research possible.

Caragana Breeding:-

Evaluation of the combining ability for self-incompatible selections continued to be a major phase of the breeding program for Caragana arborescens Lam. In Table 1 are presented data for the cross-compatibility of five such clones with the vigor of their F_1 progenies. It was evident from Table 1 that cross-compatibility of caragana selections vary greatly depending on the seedtree

Table 1. Cross-compatibility of Five Self-incompatible Caragana Clones with Five Vigor Selections in 1955 with the Vigor of the Resulting 5 year-old Progenies in 1959.

Incompatible Clones ♀	Pollen Parents ♂ V-2	B2-4B	B4-2	B5-1A	B4-5	Means for ♀ Clone
Cross-Compatibility[1]						
15-2	12	12	3	16	11	11
21-16	21	19	38	15	44	27
B2-4	23	35	20	40	29	29
V-16	61	39	29	16	35	36
A-1	30	49	33	25	63	40
Vigor of Progenies[2]						
A-1	4.7	4.5	4.8	4.7	4.0	4.6
A-16	4.5	4.8	4.8	4.7	4.0	4.6
21-16	5.0	4.7	5.0	3.5	4.8	4.6
15-2	5.0	5.0	4.6	4.5	4.6	4.8
B2-4	5.6*	5.3	5.1	5.0	4.8	5.2*
Means	5.0	4.9	4.9	4.5	4.5	

[1] Cross-compatibility as percent of pollinated flowers producing seed
[2] Vigor expressed as average height of plants in feet.

Table 2. Self-fertility Distribution of 140 Vigorous Selections from 8 seed Accessions

Accession Source	Selections No.	Self-fertility classes[1] and frequencies 0	1-20	20-40	41-60	61-80	81-100	+100	Means
France	7	2	3	1	1	-	-	-	15
Czechoslovakia	59	11	23	12	8	3	2	-	23
Holland	5	1	1	2	-	-	1	-	31
Denmark	7	-	3	3	-	-	1	-	33
U. S. A.	15	1	1	4	5	4	-	-	45
Ottawa	8	-	2	3	-	1	1	1	46
Germany	33	-	6	4	10	6	7	-	52
Holland	6	-	-	1	1	3	1	-	64

[1] Self-fertility as % selfed flowers producing seed.

and pollen. The vigor data suggests the relative combining ability of the 10 selections. Good general combining ability is demonstrated for one self-incompatible selection, B2-4, by the outstanding vigor of all hybrid progenies in which it was involved. In addition high specific combining ability of the selections B2-4 and V-2 was shown by the hybrids, B2-4 x V-2. Thus mass production of this hybrid seed will be possible from isolated crossing blocks to be planted with 2,000 rooted cuttings of B2-4 and V-2 in 1960. It is anticipated that the first hybrid seed (to be harvested only from the B2-4 plants) will be available for retests in 1965.

Self-compatibility was determined for 140 vigorous selection of C. arborescens from 8 seed accessions. Compatibility results, which were calculated as the percent of tripped flowers producing seed, are summarized in Table 2. It was evident that self-fertility of the 140 selections ranged from 0 to 96%. One selection, which originated from Ottawa, was found to be autogamous (self-tripping) with a fertility rating of 110%. Fifteen selections proved self-incompatible and of these 11 were of Czechoslovakian seed, 2 from France, and one each from Holland and U.S.A. These new Caragana selections should ensure genetic diversity for future hybrids.

Rooting of Softwood Cuttings of Caragana under mist watering increased over that under hand watering, and also materially prolonged the period of successful rooting to 8 weeks. Basal cuttings rooted best when the shoot was in an active stage of growth, but when the moisture content of the wood reached a constant level than terminal cuttings were superior. Maximum rooting (96%) with maturity of the wood over the 8-week period. Rooting in sand was significantly greater than in mixed media with vermiculite and/or moss.

Moisture Content of Stratifying media was investigated for increasing germination of caragana seed. Maximum germination occurred after stratification for 15 days in sand with 10% moisture, and decreased as the moisture content of the stratifying media was increased to 20 and 25%.

The relationship between seed size and plant vigor is being investigated for caragana. Height, of the same seedlings for 5 inbred progenies from two seed sizes, was recorded over a period of 5 years with the results listed in Table 3. Plants from larger seed were on the average 1/3 taller at one year, 1/7 taller at three years and only 1/8 taller at the end of 5 years growth. Evidently, the differential for vigor due to seed size was gradually decreasing as the plants approached sexual maturity. From this it would appear that caragana plants retain their juvenile growth character at least for the first five years of growth.

Table 3. Height of 5 Inbred Progenies from Seed of Two Sizes as One, - Three, and Five-year-old Seedlings

Age of Plants	Seed Size	Inbred Progenies					Means
		V-3	B4-4	V-10	21-27	B4-4	
(Yrs.)	(mm.)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm.)
One	3.5	20	20	30	32	17	24
	3.0	16	14	23	26	10	18
Three	3.5	53	80	61	63	63	64
	3.0	43	65	59	64	49	56
Five	3.5	137	166	125	126	140	139
	3.0	94	144	125	120	136	124

Spruce Breeding:-

Self-, Cross-, and Open-compatibility were determined for 36 "blue" selection of Colorado Spruce (Picea pungens Engelm.) in 1959. The set of seeds-per-cone following artificial self-pollination ranged from 0 to 75, and averaged 8.5; the set from artificial cross-pollination ranged from 0 to 85, and averaged 32; and the set under natural open-pollination ranged from 0 to 159, and averaged 77 seeds-per-cone. Thus the average seed yield for self-pollination was only 11% of the natural seed yield, whereas that for artificial cross-pollination was 41% of the natural yield. Three of the 36 trees proved self-incompatible, while four were cross-incompatible with the same tester selection. The presence of self-, and cross incompatibilities in Colorado spruce can be used to advantage in future phases of the breeding program.

Four insecticidal sprays were evaluated by Mr. L.O.T. Peterson for control of Colorado cone and seed insects. All insecticides increased the yield of sound seed. Maximum seed yields were obtained following application of a mixed spray with 2.5 pounds of 50% DDT and 5 pounds of 25% Malathion per 50 gallons of water. Subsequent investigations confirmed that seed viability was conditioned by the degree of insect infestations during the production process.

A recessive and lethal albino character for Colorado spruce was identified from germination data on inbred seed. Self-pollinated seed of one tree produced 281 green and 83 yellow seedlings, for an excellent fit to a 3:1 ratio. Open-pollinated seed of the same tree gave only 2 albino seedlings and 42 green. These data suggest the tree was heterogygous (Aa) for the albino factor, which was lethal in the homogygous recessive state. These results suggest only 8 of 44 or 18%, of the seed from open-pollination in Colorado spruce, is from natural self-pollination.

Some 35 "blue" selections of Colorado spruce, from across the Canadian Prairies, were added to the grafted pot-orchard in 1958-59. Observations suggest several clones have blue coloration equal to Koster with superior resistance to needle-burn. Approximately 12,000 hybrid seedlings are now available for transplanting in 1961, to investigate the inheritance of the blue needle color character in Colorado spruce.

Ten stratification treatments were investigated for seed of Colorado spruce. Stratification for 15 days at 41°F in sand with 10% moisture proved superior to all other treatments with 96% germination. Sand stratification for 30 days and soaking for one day with 15 days "naked" stratification also showed promise with 94 and 91% germination respectively. However, longer periods of soaking and of naked stratification proved detrimental.

Miscellaneous Items

Forty-six selections of Scotch pine, which demonstrated absence of needle-burn in 1955-56, have been established in a pot-graft orchard for retesting.

Phytotoxicity of 12 promising fungicides were studies in co-operation with Dr. O. Vaartaja of the Forest Biology Division. Non-toxic rates of application were resolved for future research in the control of seedbed diseases.

The influence of soil salinity on performance of conifer seedlings was investigated with the co-operation of Mr. H. Lueken of the Experimental Farm. Growth, and survival of Scot pine transplants were significantly reduced as soil salinity increased. After 124 days fresh weight of plants decreased by 30%, 75% and 14%, and stand by 5, 41 and 16%, respectively, as soil salinity was increased from 1 to 3, 3 to 6 and 6 to 12 mmhos./cm. Fresh weight of tops was found to provide a valid estimate of growth for the entire seedling in salinity studies.

TESTING POPLARS FOR DISEASE RESISTANCE IN ONTARIO

B. W. Dance

Forest Biology Laboratory, Maple, Ontario

The field seasons of 1958 and 1959 were devoted mainly to artificial infection trials, to life history studies, and to further elucidation of the fungus flora of Populus in Ontario. In addition, a preliminary investigation was made of the effect of bark and leaf extracts from different poplar species and varieties on the growth of Hypoxylon pruinatum.

I. Artificial Infection Trials

Selected pathogens, noted for their destructiveness on certain poplars, were used to inoculate various poplar species and varieties whose susceptibility to these pathogens is either unknown or imperfectly understood. All the trees were located at the Petawawa Forest Experiment Station, Chalk River; they were either naturally occurring native species or planted introduced species and varieties. Inoculation techniques simulated natural methods of inoculation except when the inoculum consisted of mycelium. For this reason the methods varied with the organism involved. With fungi that cause stem or branch cankers or both, the usual procedure was to inoculate trees of different diameters on the assumption that certain diameter classes are more susceptible than others. This was assumed to favor the likelihood of infection developing in some instances. The controls consisted of treatments identical with the inoculations except that inoculum was omitted. Each control was located on the same stem or branch and about 15 in. above the inoculation. With organisms that cause diseases of leaves, e.g. Pollaccia radiosa, one half of a leaf was inoculated while the untreated half was retained as the control.

The results secured to date range from consistent infections with one pathogen (Dothichiza populea) and certain susceptible hosts, to inconclusive and often negative results with other organisms and hosts. The latter might be interpreted either as evidence of temporary or permanent immunity or as ineffective inoculation techniques. (It would seem that the only indisputable result is that in which susceptibility is proven through the recovery of fruiting structures of the pathogen used as inoculum, from a host that develops the characteristic disease symptoms caused by that pathogen. This creates a dilemma because the objective of these trials is not to prove that poplars are all susceptible to serious diseases, but rather that they are disease-resistant.) To permit the maximum number of different poplar species to be assessed for disease resistance, each host-parasite combination was usually limited to ten separate inoculations and to an equal number of controls. This number was deemed adequate to establish trends. Later, in those instances where infections had been secured, more extensive testing is planned. It is assumed such tests will yield an accurate measurement of the reaction of various poplars to different pathogens throughout a comprehensive range of environmental and site conditions. In view of the consistent infections already secured with D. populea (Table I), it is proposed in 1960 to thoroughly test the susceptibility, to this pathogen, of all the remaining untested poplar species and varieties at Chalk River. Furthermore, species already tested will be re-tested on a large scale and on every recognizable site in order to clearly elucidate the exact susceptibility of each.

TABLE 1. Susceptibility of poplar species and varieties to various pathogens

Pathogen	Inoculum	Host	Infection percent. (estimated)	Remarks
Dothichiza populea	Conidial spore suspension. Germinability confirmed by germination tests as 50% in 24 hrs.	_Populus maximowiczii_ X _berolinensis_	35	Results based on the recovery, in 1960, of pycnidia and conidia on shoots inoculated in 1959. Where infections had developed, the treated shoot was dead in 1960. On most killed shoots, pycnidia were recovered from the late growth of 1958.
		P. angulata X _vernirubens_	100	
		P. alba	100	
		Carolina	100	
		Geneva	100	
Cytospora chrysosperma	Conidial spore suspension. Germinability ensured by germination tests. Stems wounded by hammering.	_P. tremuloides_	62	On trembling aspen, the best results were obtained on stems ½ - 1" dia. and 1' above the ground. Results are based on the appearance of large cankers, consisting of concentric orange rings, and pycnidia with spore horns, 12 days after inoculation in Sept. 1959, and on the subsequent enlargement of the cankers in the spring, 1960. The resistance to infection shown by largetooth aspen contradicts the
		P. tremula	20	
		P. grandidentata	5	
		P. maximowiczii X _berolinensis_	0	

TABLE 1. (Cont'd.)

Pathogen	Inoculum	Host	Infection percent. (estimated)	Remarks
C. chryso-sperma (cont'd.)				prevalence of C. chrysosperma on this host, in this area.
Hypoxylon pruinatum	Mycelium	P. maximowiczii X berolinensis	0	Reputed infections are based only on symptomatology, not on signs of the fungus which may yet appear. Profuse perithecia were observed on a natural infection on P. tremula.
		P. angulata X vernirubens	0	
		P. nigra	0	
		P. tristis	0	
		P. balsamifera	0	
		P. angulata X generosa	0	
		P. tremuloides	0	
		P. Jackii	0	
		Maine	0	
		Strathglass	0	
		P. tremuloides	30	
		P. grandidentata	50	
		P. alba X grandidentata	50	
		P. tremula	90	
	Oxospores germinability of spores predetermined	P. tremula	0	Spores shot from perithecia onto exposed cambium; heavy deposition.
Pollaccia radiosa	Spore suspension	P. tremuloides	50	Leaf development inhibited or arrested on the half leaf in-

TABLE 1. (Cont'd.)

Pathogen	Inoculum	Host	Infection percent. (estimated)	Remarks
P. radiosa (cont'd.)	Germinability of spores predetermined (85%)	P. grandidentata	50	oculated. As a result, the leaves curve strongly to one side and become folded. Sporulation occurs 12 days or more following inoculation.
		P. alba X grandentata	40	
Fungus "X" (isolated from large, black, spindle-shaped perennial cankers on branches of P. tremuloides)	Mycelium	P. tremuloides	62	Results based on inoculations which resulted in sunken cankers; typical symptoms not yet evident.
		P. tremula	75	
Fungus "Y" (light-colored) One of 2 fungi isolated from diseased branch stubs of P. adenopoda from which scions had been removed.	Mycelium	P. tremula	0	
		P. Jackii	0	
		P. alba	0	
		P. grandidentata	20	Based on preliminary symptoms.
Fungus "Z" (dark-colored) The second of 2 fungi isolated from P. adenopoda	Mycelium	P. tremula	0	
		P. tremuloides	0	
		P. grandidentata	0	

II. Life History Studies

Didymosphaeria sp. on P. alba X grandidentata: This apparently new species is prevalent on the petioles of dead, overwintered leaves. It has been obtained in culture from ascospores; however, no imperfect stage spores have yet developed. To induce their development, the fungus is being cultivated on various media including ground poplar leaves. In view of its prevalence, the pathogenic capability of this fungus is being tested using mycelium, and eventually it is hoped, with conidia.

Leptosphaeria sp. on P. tremuloides and P. grandidentata: This fungus is occasionally found on dead, overwintered shoots of both hosts. Its parasitic capability and life history is being investigated.

Plagiostoma populi on P. alba X grandidentata: Efforts are underway to connect this fungus with its supposed imperfect stage, Gloeosporium sp. on the same host. Difficulty has been experienced in securing ascospore discharge and germination.

Venturia tremulae on trembling aspen and largetooth aspen: This uncommon ascomycete was connected culturally with its ubiquitous imperfect stage Pollaccia radiosa.

III. The Fungus Flora of Populus in Ontario

Numerous fungi, still mostly unidentified, were isolated from cankers and other disease lesions on native and introduced poplars. These organisms are being retained in culture pending their identification, investigations of their life histories, and their use in artificial infection studies.

IV. Effect of Bark and Leaf Extracts on the Mycelial Development of H. pruinatum

Extracts from poplar bark and leaves were incorporated in synthetic media used to cultivate fungi. An infusion prepared from the bark of P. tremula completely inhibited mycelial development of H. pruinatum. Infusions of other poplar species including P. tremuloides and P. balsamifera exerted only a minor effect or none at all. These experiments are to be repeated and expanded to include other fungi and infusions from other poplar species. It is noted that although bark infusions of P. tremula were most effective in checking the growth of H. pruinatum, in the artificial infection studies carried out P. tremula seemed to be the most susceptible host. Conversely, while extracts from P. tremuloides had negligible effect on mycelial development, the number of probable infections secured was significantly lower than with P. tremula. Further investigation may disclose if leaf and bark extracts form a defense mechanism of poplars against certain fungal pathogens.

PHYSIOLOGY OF FLOWERING AND CONE PRODUCTION IN DOUGLAS FIR, 1959-60

by L. F. Ebell

No flowering response or effect on growth followed intensive foliar applications of growth regulators. Chemical fertilization of young Douglas fir showed that application of nitrogen fertilizers was associated with markedly increased cone production in 1959 on trees which had also shown previous stem diameter growth response from fertilization. Stem analysis of two unfertilized trees with long-term cone production records showed that heavy cone crops years were usually preceded by a season of good increment and consistently accompanied by decreased increment. These observations, to be investigated further, indicate a close relationship between nutrition and cone production.

Girdling in the autumn of 1957 and spring of 1958 induced heavy cone production in 1959 on the treated trunks of double-trunked trees, while the control trunks produced few cones. Analysis to determine total sugar, starch, and hemicellulose in the tissues of branches of these trees is being carried out to investigate relationships between seasonal changes in carbohydrate reserves and cone production.

The period of anthesis and amount of pollen produced were recorded for Douglas fir and all associated species at Victoria and over an elevational transect in central Vancouver Island, using recording pollen-samplers. The earliest flowering species were red and yellow cedar, followed by Douglas fir, western hemlock, grand fir, amabilis fir, lodgepole pine, white pine, alpine fir, and mountain hemlock, in that order. Extensive circulation of pollen was evident in both upslope and downslope directions in mountainous topography. Pollen production of Douglas fir at the higher elevations appeared adequate to assure good fertilization. Anthesis of this species was five to seven days later per thousand feet increase in elevation and was more prolonged at the higher elevation. These data will be related to prevailing weather conditions recorded at each sampling station by members of the British Columbia Forest Service, who are co-operators in this study.

Six Douglas fir clones representing exceptionally reliable and heavy cone-producing parent trees and barren parent trees were propagated by winter grafting in the greenhouse. It is hoped that these clones will adopt the reproduction habits of the parent trees to provide a tool for studies on the biochemistry of flowering and other physiological studies where uniformity of material is desirable. Methods of forcing rootstocks for winter grafting were simultaneously investigated. It was determined that a short chilling period was required and that extending the photoperiod to 16 hours promoted earlier flushing. Where neither of these requirements was met, some individuals went through the entire growing season without flushing.

Spring and late summer air-layering of Douglas fir has been tried with only one success out of several hundred. This branch, from the lower crown, took almost one year to root after treatment in August and produced 29 male cones the first season after potting. Red cedar, which propagates well from cuttings, was found to air-layer readily.

Appendix G

Report to Committee on Forest Tree Breeding in Canada Regarding Work in Forest Genetics, July 1958-July 1959

FACULTY OF FORESTRY, UNIVERSITY OF TORONTO

by J. L. Farrar

Our work has been principally concerned with the collection of data on the variation between seed lots and individuals with regard to the physiology of growth. Plants have been subjected to a variety of experimental conditions so that inherited differences would have a fuller opportunity to be expressed. Most of the material has kindly been supplied by Mr. Mark Holst, Petawawa Forest Experiment Station.

A group of five seed lots of Norway spruce have been subjected to artificial variations in the natural cycle of favourable and unfavourable seasons. Much variation was observed in the growth pattern of individuals, but there was little consistency within seed lots. Immediately after bud-set, exposure to 20-hour photoperiods caused buds to resume growth after a comparatively short period which varied from days to weeks. After buds had reached a state of winter dormancy under outdoor conditions, they resumed growth about 200 days after bud-set under summer weather conditions and without exposure to chilling. After natural chilling, bud break occurred within 3 to 4 weeks of being brought into the greenhouse.

There was much variation in the flush of growth which resulted when a summer-dormant bud was stimulated by long photoperiods. Sometimes growth consisted of the normal expansion of pre-formed initials. In other cases growth was indeterminate as occurs in an annual plant. Such growth eventually ceased after a few months, but could be stopped sooner by exposure to short photoperiods. Plants with the indeterminate type of growth showed no inherited tendency to repeat that type of growth after a subsequent similar treatment. Other experiments with mineral nutrients have shown that the nature of extension growth is also affected by the nutrient supply.

Plants retained more than one year under summer conditions showed a number of peculiarities. Lateral buds often developed while the terminal remained dormant. Buds produced an abnormally large number of bud scales. New shoots were often dwarfed with needles reduced to scales. After two years many plants had died.

Plants induced to flush during an off-season returned to their normal rhythm after being exposed to a natural winter.

In another experiment with the same five seed lots, heavy shading for five weeks after bud-set had no discernible effect on growth during the same year or in the following year. This suggests that those plants were not making full use of the growing season.

A graduate student - M. Giertych - carried out an experiment in growth chambers in which nine seed lots of jackpine and one of lodgepole pine were grown with five levels of nitrogen under two photoperiods. Responses to treatment were marked. Seed collected from northern localities showed a greater response to photoperiod than those from southern localities. Two related experiments are in progress with the same seed lots in which the amount of light is varied.

Another graduate student - K. Morgenstern - is making a study of introgression of red and black spruce.

A number of provenance trials of black spruce, white spruce, red spruce, Norway spruce, red pine, scots pine, and larch have been set out at the Dunlap Observatory Arboretum and the University Forest near Dorset, Ontario.

A technique was developed for the accurate measurement of the diameters of seedling stems (Farrar and Zichmanis 1960).

White pine was successfully reproduced by layering (Farrar and McJannet, 1959).

Seed of silver maple was successfully ripened on detached branches after artificial pollination. The time from pollination to germination was 44 days.

A number of species were grown in plastic tubes one inch in diameter filled with shredded sphagnum with added mineral nutrients under a 20-hour day. Seed sown during November to January produced stock big enough for field planting in May. The sphagnum moss remained with the roots and provided a temporary source of water and nutrients immediately after transplanting. The transplants grew very well in the field. Species which responded favourably were Acer saccharinum, Betula papyrifera, B. lutea, Ulmus americana, Gleditsia triacanthos, Robinia pseudoacacia, Larix laricina, Thuja occidentalis, Pinus sylvestris, P. banksiana, Picea glauca, P.mariana, P. abies. Pinus resinosa was very poor and P. strobus and Abies balsamea only fair; apparently a standard nutrient solution is not suitable for them. While the method is expensive, it would seem to be worthwhile for growing valuable seeds.

Publications:

Farrar, J. L. and McJannet, W. D. Air-layering of Eastern White Pine (Pinus strobus L.) For. Chron. 35:18-21. 1959.

____________ and Zichmanis, H. The Accurate Measurement of Diameter Changes in Small Stems. Annual Ring, Faculty of Forestry, University of Toronto, 1960, pp.16-17.

REPORT

for the Committee on Forest Tree Breeding

in Canada

Tree Physiology Section

Petawawa Forest Experiment Station

D. A. Fraser, D. T. Durzan and W. H. Vanden Born

July 4, 1960.

Flower primordia of white and black spruce were recognized through microscopical investigation in early August, 1959. Floral initiation followed the warm dry period of the preceding two months. A similar situation occurred in 1955. The environmental factors considered conducive to flowering of spruce trees in nature are being used to design growth chamber experiments for physiological investigations.

Correlations were made between radial growth of 16 forest trees species and annual variations in soil moisture, rainfall, and potential evapotranspiration during the 1955-1959 period. Radial growth was greatest for most species in 1958, when early initiation of growth and adequate moisture contributed to a very long growing season. Drought occurred in 1955 and 1959, but whereas in the former year it extended throughout the summer and reduced tree growth, in the latter it was broken by August rains which led to the continuation of radial growth. Cambial activity in the stem of all trees studied had ceased by early September, even on sites where neither moisture nor temperature were limiting.

A contribution on the experiment l control of growth in spruce seedlings is nearing completion. This paper summarizes growth chamber, greenhouse and nursery experiments on accelerated growth by means of long photoperiods at various temperatures in conjunction with adequate nutrient and moisture supply. Three-foot-high black spruce trees with stem diameter ranging from 1/2" to 3/4" were grown in 18 months. Supplementary illumination to give a 24-hour photoperiod to nursery stock growing outside stimulated 20 per cent more apical growth. In an evaluation of the effect of anti-auxins, periodic foliar sprays of (2, 4 dichlorophenoxy) Butyric acid reduced apical growth of 3-foot white spruce trees by about 25 per cent.

One - and two-dimensional paper chromatographic analyses of ethanol extracts of white spruce buds have facilitated the separation of nearly 30 nitrogenous compounds. Identification of these compounds indicates that there are many free amino acids and their amides. Concentrations of the constituents in the free nitrogen pool change with various stages in development of the buds. This could aid in an early recognition of flower initiation.

A number of histochemical tests was applied to sections of white spruce buds made with a freezing-microtome periodically during the growing season. Localization patterns were established for 10 enzymes. Differences between flowering and vegetative buds were most marked in patterns obtained for peroxidase, cytochrome oxidase, and in sections treated with osmic acid.

An evaluation of auxin activity in white and black spruce trees is also in progress.

NOT FOR PUBLICATION

REPORT TO COMMITTEE ON FOREST TREE BREEDING

July 1960

Camilien Gagnon

Canadian Department of Agriculture
Forest Biology Laboratory
Quebec, P.Q.

Dutch Elm Disease

Testing American elm trees for resistance.

The outline of this project and the results of the tests carried out at the L'Assomption Experiment Station were presented in 1957 and 1958. This programme was continued at L'Assomption during the past two years, and also since 1958 at the nursery of the Forest Biology Laboratory, Quebec City. Tests of resistance were also carried out on seedlings obtained from seeds collected in the Quebec City area. From 1952 to 1956 a grand total of 162,935 seedlings were inoculated, of which 108,374 came from X-rayed seeds, and 18,540 from seeds treated with Thermal neutrons. The results of the resistance tests carried out at L'Assomption in 1958 and 1959 are summarized in Table I.

Table I. Inoculation Tests of Elm Seedlings at L'Assomption during 1958 and 1959

Year of inoculation	Year seedlings were planted	Treatment	Number of previous inoculations	Number of Seedlings	
				Inoculated	Not infected
1958	1952	None	5	1	1(a)
	1954	None	3	2	0
	1956	None	1	846	23
	1957	None	0	1,555	(b)
	1955	X-Rays	2	185	12
	1956	X-Rays	1	4,574	74
	1957	X-Rays	0	15,946	(b)
	1956	T.N.	1	3,441	62
	1957	T.N.	0	3,623	(b)
1959	1952	None	6	1	1(a)
	1956	None	2	23	5
	1957	None	1	(b)	148
	1958	None	0	4,438	174
	1955	X-Rays	3	12	3
	1956	X-Rays	2	74	21
	1957	X-Rays	1	(b)	1,779
	1958	X-Rays	0	51,240	4,290
	1956	T.N.	2	62	10
	1957	T.N.	1	(b)	336
	1958	T.N.	0	2,436	237

(a) Stunted tree
(b) No data
T.N. Thermal Neutrons

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

One tree planted in 1952 has resisted inoculations every year. However, this particular tree is poorly developed and produces only small wood vessels in which the fungus development is apparently limited; for this reason it can hardly be accounted for as a good example of resistance.

About 15 per cent of the seedlings were not infected after the first inoculation. The percentage of seedlings that were not infected varied annually from 3.9 to 27.7 as shown in Table II. This large variation is probably due to climatic conditions as substantiated by the fact that the seedlings coming from seeds treated either by X-rays or Thermal neutrons gave similar variations.

Table II. Percentage of Seedlings not Infected the First Year of Inoculation

Year of inoculation	Seed Treatments		
	None	X-Rays	Thermal Neutrons
1952	11.5	-	-
1953	10.8	-	-
1954	15.3	-	-
1955	16.8	15.4	-
1956	5.3	6.6	-
1957	27.7	23.5	27.6
1958	-	-	-
1959	3.9	8.3	9.7

The percentage of seedlings that survived the inoculations in two consecutive years was usually less than one per cent as shown in Table III. Only three individuals planted in 1955 survived to three incoulations.

Table III. Percentage of Seedlings not Infected after 2nd Year of Inoculation

Year of inoculation	Seed Treatments		
	None	X-Rays	Thermal Neutrons
1953	5.32	-	-
1954	0.43	-	-
1955	0.46	-	-
1956	0.13	0.22	-
1957	0	0.97	-
1958	0.78	0.38	0.49
1959	9.51	11.17	9.27

The results of the resistance tests carried out at the Forest Biology Laboratory, Quebec, are summarized in Table IV. From the 1957 crop 420 individuals survived 2 inoculations, and 977 were not infected after one inoculation.

Table IV. Inoculation Tests of Seedlings in Quebec Laboratory Nursery during 1959

Year seedlings were planted	Number of previous inoculations	Number of Seedlings	
		Inoculated	Not infected
1957	1	1,253	420
1958	0	2,325	977

Hybrids of European elm species.

Hybrids of European elm species imported from the Willie Commelin Scholten Laboratory, Baarn, Holland, are propagated in the Laboratory greenhouses and nursery for testing their potentiality in Eastern Canada. These hybrids which were reported to be of low susceptibility in Europe have not yet been tested with our strains of *Ceratocystis ulmi*, nor with native pathogens. However, all of them appeared to be very susceptible to the early frosts which occurred in September 1958 and 1959. All the shoots were affected for the last two years and about 75 per cent of the current year growth was killed every year.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]

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Summary Reports on Forest Tree Breeding
1958 and 1959

C. Heimburger

Ontario Department of Lands and Forests

Research Branch
Maple, Ont.

1958

Breeding work with white pine, aspen poplars and hard pines was continued, and some new work with white cedar was expanded.

White Pine.

Resistance to blister rust and weevil, and satisfactory growth form and growth rate were the main objectives in breeding. The acquisition of new materials comprised 56 clones of native white pine and of exotic species obtained in natural stands and from several arboreta. One additional seed lot for the international 5-station provenance test was received and sown. A new scion collection was undertaken in the plantation at Connaught Ranges near Ottawa, to replace materials lost after grafting at Angus, Ont. Sixteen seedlings, showing resistance after several inoculations with blister rust, were selected for vegetative propagation and further testing for resistance. An experiment in the raising of white pine seedlings under long photoperiods in the greenhouse during the winter yielded a nine-fold increase in growth under normal daylight plus continuous high intensity illumination in 9 months. Fifty-one inter-specific crosses out of 89 made in 1956 yielded 1090 seedlings, and 3481 seedlings were raised in the greenhouse from 59 crosses out of 115 made

in 1957. Fifty-four new crosses were made in 1958. Most of these were between Pinus peuce and the native white pines, prompted by the discovery in 1956 of a clone of P. peuce transmitting resistance to most of its offspring in a cross with native white pine. Inoculation with blister rust was very successful due to favourable weather conditions. A number of black currant seedlings retaining their leaves until the fall and showing good telia formation were selected for further propagation, to grow materials for white pine inoculation with blister rust.

Poplars.

The production of aspen-like hybrids suitable for growing in southern Ontario continued to be the chief aim of this project. Cuttings and scions of 54 new clones, and seeds and scions of 8 new populations were obtained by means of exchange with other poplar breeders. The new method for evaluating rooting ability of cuttings introduced in 1957 was improved by the addition of a soil conditioner to the rooting medium in beds prepared for this purpose. In mass production for industrial use 12 new hybrid populations were obtained. The breeding for good rooting ability yielded 14 hybrid populations and 7 hybrid populations were obtained in breeding for precocious flowering. It was possible to select for further testing 148 new seedlings, outstanding in respect to growth rate and form, from hybrid populations of previous years.

Hard Pines.

The development of new types, resistant to the European pine shoot moth and suitable for growing in southern Ontario, continued to be the aim of this project. New acquisitions comprised 42 clones and 24 populations, including red pine from Nova Scotia capable of growing in swamps and not found in Ontario. Two inter-specific crosses out of 38 made in 1956, yielded 3 seedlings in 1958. Out of 47 such crosses made in 1957, 12 yielded a total of 548 seedlings and 245 new crosses were made in 1958 because of the rather abundant flowering in that year. The plantation of hard pines at Turkey Point was augmented with 2378 seedlings and 19 grafts of materials grown and produced for shoot moth resistance tests. A red pine pollination experiment was started with six selected trees, that in the past had responded well to girdling and opening of the stand with heavy cone crops. The trees were selfed, top crossed with pollen of a selected tree, pollinated with mixed pollen and open-pollinated. This should determine, at least in part, the natural breeding system of red pine and yield information of basic value to seed orchard work.

White Cedar.

The production of improved types of this species and of western red cedar hardy in southern Ontario, is the aim of this project. Cuttings and scions of 19 new clones were obtained, yielding 416 rooted cuttings and 91 successful grafts. These were mostly western red cedar and Japanese red cedar obtained in British Columbia and from several arboretum collections. In addition, one lot of western red cedar seed from British Columbia yielded 502 seedlings. It was possible to make some crosses on

grafts in the greenhouse and in this manner to obtain some 20 hybrids of red cedar with native white cedar.

Chestnut

The aim of this project is the production of hardy dwarf types, resistant to blight and suitable as dwarfing stocks in a breeding program with timber-type chestnuts. Two seed lots, one of native chestnut and one of Chinese chestnut, obtained in the fall of 1957 and placed in boxes with sand below the frost line outside, yielded 11 and 228 seedlings respectively. It was also possible to obtain 25 seedlings of native chinkapin from a nursery in North Carolina and to establish these in the arboretum.

1959

Breeding work with white pine, aspen poplars, hard pines white cedar and chestnut was continued.

White Pine.

Resistance to blister rust and weevil, and satisfactory growth form and growth rate were the main objectives in breeding. The acquisition of new materials comprised 35 clones and 8 populations of native white pine and of exotic species obtained in natural stands and from several arboreta. This included scions from several plus trees in northern Ontario. Two exceptionally early flowering seedlings of western white pine were selected for vegetative propagation. Much useful information about the winter hardiness of exotic white pine species was obtained after the unusually hard winter of 1958-59. Heavy snow damage to grafts was also experienced during this winter, indicating that outside grafting above the snow line is advisable in areas with a deep snow cover during the winter. The raising of hybrid white pine seedlings under long photoperiods in the greenhouse has again been very successful. Fifty-nine interspecific

crosses out of 115 made in 1957 yielded 3781 seedlings and 29 out of 54 crosses made in 1958 yielded 926 good seeds. Eighty-two new crosses were made in 1959. The abundant flowering in 1959 of white pine grafts made 14 intraspecific crosses between blister-rust resistant native white pines possible. Inoculation with blister rust was rather poor because of adverse weather conditions. The selection of black currant materials capable of retaining their leaves with blister rust until the inoculation period was continued. The population of P.strobus x peuce so promising during the last 4 years was in 1959 heavily infected with blister rust and is at present not above average unselected white pine in resistance. Several seedling populations of P.griffithii x strobus and reciprocal are standing up very well after repeated infections with blister rust and look promising thus far. Portions of white pine seeds of Chapleau origin were irradiated with increasing doses from 250 r up to 32000 r of x-rays at the laboratories of Atomic Energy of Canada, Ltd., in Chalk River,Ont., with the aim of finding the L 50 dose and from then on to induce mutations causing increased heritable resistance to blister rust. The results of germination tests indicate that 2000 r constitute the L 50 dose. This is less than the 13000 r necessary to induce the same mortality in dry slash pine seeds and more than the 600-900 r needed for the same effect in Norway spruce and Scotch pine. Doses of 8000 r and above were completely lethal. Significant differences in frequency of weeviling were found in a test plantation of white pine in comparing a northern provenance (Temagami) with a southern (Rondeau) while this character exhibited an intermediate series between the two extremes in intermediate provenances (Petawawa, Gran Bend). This indicates that white pine in Ontario, at least from this standpoint, is

rather weakly differentiated into climatic races.

Poplars.

The production of aspen-like hybrids suitable for growing in southern Ontario continued to be the chief aim of this project. Cuttings and scions of 38 new clones, and seeds and scions of 19 new populations were obtained by means of exchange with other poplar breeders. In mass production for industrial use 14 new hybrid populations were obtained. The breeding for good rooting ability yielded 9 hybrid populations. It was possible to select for further testing 163 new seedlings, outstanding in respect to growth rate and form, from hybrid populations of previous years. A fungus causing dieback on hybrid aspens caused very severe attacks. All F1 hybrids of aspens and silver poplar are highly susceptible as are some hybrids between trembling and largetooth aspen. Hybrids of European and trembling aspen are free from attack. The Asiatic aspen P.davidiana is highly susceptible. A system of 3 major genes conditioning susceptibility is postulated, namely A (silver poplar), G (largetooth aspen) and T (trembling and European aspen) any 2 of which cause predisposition to attack by this fungus or fungus complex. This fungus is a very serious factor in all future aspen breeding and will have to be thoroughly studied. It is a weakness parasite and is found in all recent plantings of hybrid aspens. In a tally of 3-year old hybrid aspens in a plantation hybrids of good largetooth aspen and Hungarian silver poplar were found to be far superior to natural largetooth-silver poplar hybrids, and fully comparable to the

best cottonwood hybrids in form and vigour.

Hard Pines.

The development of new types, resistant to the European pine shoot moth and superior in growth form and growth rate, continued to be the aim of this project. New acquisitions comprised 72 clones and 17 populations, including red pine with very fine branching from northern Ontario. In addition, 54 seedlings were selected for further propagation and testing, from acquisitions of previous years. Thirteen interspecific crosses out of 47 made in 1957 yielded 548 seedlings in 1959. Out of 245 such crosses made in 1958, 30 yielded a total of 2554 full seeds and 53 new crosses were made in 1959. Of these, 2 were crosses between precocious Scotch pine, to determine the inheritance of this character and 31 were intraspecific red pine crosses for further studies of the breeding system of this species, started in 1958. It was found that the Japanese black pine, well known for its high resistance to shoot moth attacks, was not as resistant to shoot moth as some P.nigra materials recently acquired and tested. This greatly simplifies the problem of breeding shoot moth resistant hard pines.

White Cedar.

The production of improved types of this species and of western red cedar hardy in southern Ontario, is the aim of this project. Cuttings and scions of 4 new clones were obtained and established successfully. The cross between western red and eastern white cedar has been effected successfully in 1958. The resulting seedlings were somewhat chlorotic to at first but have later become green and now grow normally. The aim of this cross is to produce a hardy form of white cedar that will reach larger sizes than the native types.

Chestnut

The aim of this project is the production of hardy dwarf types, resistant to blight and suitable as dwarfing stocks in a breeding program with timber-type chestnuts. It was at last possible to obtain a seed lot of native chinkapin from Virginia in good time for fall storage. The seeds show good germination at present.

BIENNIAL REPORT

APRIL 1 1958 to MARCH 31 1960

FOREST TREE BREEDING AND GENETICS

AT THE

PETAWAWA FOREST EXPERIMENT STATION

M. J. Holst

GENERAL

This report gives a brief outline of the physical work accomplished by the tree breeding group at Petawawa Forest Experiment Station for the information of co-operators and fellow workers in the field of tree breeding.

As the number of established experiments is increasing, for the sake of brevity I have listed these in tables with titles sufficiently descriptive to convey the intent of the experiments (Tables 1 and 2).

WHITE SPRUCE

Our early collections start to bear fruit. Four single-tree progeny tests were established on the Station area. Some compare the progeny of elite trees, others the progeny of broad and slender trees. All tests were designed to yield information about the effectiveness of the field layout.

A provenance experiment including 32 races of white spruce, mainly from the middle part of the Great Lakes - St. Lawrence Forest Region, was established in 15 localities (Manitoba, Ontario, Quebec, Minnesota, Michigan, Maryland and Alaska). Nearly 85,000 plants were field planted. The pilot experiment located in the Petawawa Forest Experiment Station nursery indicated the existence of slow-growing inbred populations to the south of the range as well as the ecotypes developed on calcareous soils. (Rama Tp., Vankleek Hill, and Erin provenance) which show high mortality when planted on the acid sites at Petawawa. These provenances also showed pronounced yellowing which we interpreted as magnesium deficiency symptoms. Other provenances from limestone areas such as Essa Tp., Dalhousie Tp., and Hungerford Tp. were intermediate in mortality and developed a more normal colour. The most northern provenances were 20 per cent smaller than the local Petawawa stock and those from cooler areas than Petawawa were 5 to 10 per cent inferior to the control. Two provenances (Sand Lake and Sundridge) from the Haliburton area near Georgian Bay had suprinsingly poor growth (about 15 per cent poorer than the control).

While studying for his Master's Degree at the University of New Brunswick, Mr. Norman Jones investigated two old white spruce provenance experiments for wood density. There was a general relationship between growth rate and specific gravity; the slow growing trees had higher densities. However, in terms of dry wood production, growth seemed more important than density. Another interesting feature appeared from this investigation; the range in density is sometimes very narrow and sometimes very wide, indicating ecotypic variation as well as random distribution within ecotypes. Not ably, the Petawawa stock had a range of 0.155 within the open pollinated progeny of one tree, which was almost as great as the total range (0.163) in the material under test. Stock from Kananaskis in Alberta had the highest specific gravity (0.473) and that from Lake Edward in Quebec had the lowest (0.310). The high density (.468) white spruce from Petawawa, which is also superior in growth, is being propagated together with other high and low density trees of good growth. The specific gravities just mentioned refer to that at the 8th internode of 20-year-old trees. High correlation was also found between the specific gravity of adjacent branch samples of the 4th, 6th, and 8th whorl, and of the stem. Distal branch samples proved too difficult to work with and their specific gravity showed only slight correlation with that of the stem.

Three white spruces with rapid taper and acute branch angle (and therefore with a high proportion of knot wood) were crossed. The progenies from these crosses demonstrate that at least the acute branch angle is inherited and can be detected on 3-year-old seedlings.

Five white spruce plus trees were detected by our own crew in the immediate vicinity of the Station. We also grafted 13 white spruce plus trees selected in the boreal forest of northern Ontario by staff of the Ontario Department Lands and Forests.

Norway Spruce

Our interest in slender, fast-growing, hardy and weevil-resistant Norway spruce is still active. One experiment with intra-specific hybrids of the weevil-resistant trees growing on the Station was established (Exp. No. 6-B) and we added several new clones of apparently weevil-resistant selections to our graft arboretum.

Five provenance experiments and observation plots comprising 15,000 Norway spruce seedlings planted on 5.5 acres were established at the Petawawa Forest Experiment Station, and observation plots of many Norway spruce provenances were established in 8 locations in Ontario and Quebec with 32,000 plants on 25 acres. Some of these experiments include progenies from especially slender trees of European origin, others contain mostly carefully selected provenances which have been shown to be superior in Europe. Over the years, we have established a considerable acerage of Norway spruce experiments and observation plots of provenance material for which there is good information about origin and where eventually we can select weevil-resistant and winter-hardy trees for further breeding.

Red and Black Spruce

Seedlings of 32 red spruce provenances have been raised in the nurseries of the Acadia, Valcartier and Petawawa Forest Experiment Stations. Approximately 50,000 2-2 and 2-3 plants have been established in 20 locations in eastern Canada, the New England States and the Lake States. Some of these provenances showed introgression with black spruce and K. Morgenstern worked out a technique suitable for estimating the degree of introgression in nursery plants. One red spruce provenance from Bear Meadows, Penn., attracted particular attention because it had the upright plant form typical of black spruce while in all other taxonomic characteristics it was good red spruce. Many of the Canadian provenances had the blue-needled, pubescent and upright plants typical of introgressive populations.

The intent with these provenance experiments is not only to find fast growing and hardy red spruce provenances for eastern Canada, but also to establish gene pools of red spruce from its extreme southern range for producing hybrids between the southern red spruce and northern black spruce, which we suspect will be heterotic.

Many crosses between black spruce and red spruce have been studied and various F2's and back crosses have been made to investigate the taxonomic relationship and ecological preferences of the species.

In black spruce 3 small experiments including 8 provenances were planted.

Spruce Hybrization and Tree Crown Isolation Tents

Flowering was sparse in 1958 and 1959. However, we did manage to experiment intensively with the full crown isolation tents and to design improvements. Several selfings were made with the tents in white spruce, black spruce, red x black spruce hybrids and in Scots pine.

Seed obtained from a *Picea Koyamai* x *glauca* cross produced at Maple did not germinate. The tents promise to be very useful to effect self pollination (when both female and male flowers are enclosed in the tent) and cross pollination (female flowers isolated) in spruce in good flowering years, when several thousand female flowers may be found in the top 6 to 8 feet of mature white spruce.

In 1959 thermo-couples were used to measure air temperatures in shade outside the tents and at different levels within tents erected on the tops of tall trees and on trees at ground level. Flowers of a 35-foot black spruce and a 20-foot red x black spruce hybrid were not injured by a maximum temperature of 102°F in the tops of the tents from 3 to 5 pm on 26th May; outside temperature was 88°F with a clear sky and no wind. The flowers aborted at the top and on the southern side of the crown of a man-high Scots pine enclosed in a tent. Here the maximum temperature in the top of the tent was 106°F at 2 p.m., 8th and 9th of June; outside temperature 89°F with a clear sky and negligable wind. Apparently lethal temperatures may develop within the tent when it is erected near the ground. Also Scots pine flowers appear to be more sensitive to heat injury than do spruce flowers. A tent fly has been constructed to shade the top of the tent to reduce insolation, but it has yet to be tested.

Red Pine

A provenance experiment was established comprising 18 races of red pine covering the east-west range of the species in Canada and the United States. Eleven experiments were included in this series; 29,000 experimental and 13,000 surround plants were planted in randomized and replicated field experiments.

Another experiment including 7 small lots of rare red pine provenances was planted at Petawawa Forest Experiment Station.

Three experiments were established in New York with 9 red pine provenances from the Petawawa seed bank; 10,630 seedlings were planted on 9.1 acres.

Four red pine provenance experiments including 7 races were planted in Wisconsin with seed from the Petawawa seed bank; 7,200 seedlings were planted on 6 acres.

In New Zealand 7 red pine provenances established in 5 localities are doing very well according to reports received from I. J. Thulin.

Red pine seems to behave strangely in western Europe. Several provenances have been on trial in Sweden, Denmark, Germany and France. Although the seed germinated well, the plants have subsequently faded away in seed beds and field experiments. Whether this is owing to lack of some specific mycorrhiza or to handling of red pine as one would Scots pine stock, or to cool summers, is hard to tell. It is indicative however of a narrow ecological amplitude.

Provenance hybridization in red pine seems a promising approach for increasing growth by breeding. We have therefore established a graft arboretum with population samples of mature red pine from all over the range. To this was added material from Manitoba and Newfoundland as well as 77 trees selected by Dr. C. Heimburger in northern Ontario where red pine has a disjunct occurrence and pronounced genetic drift.

Earlier provenance hybrids of red pine (Petawawa x Rochester N.Y. with pollen provided by Dr. C. Heimburger) were field planted at Petawawa.

Jack Pine

Jack pine provenance experiments established some years ago have been remeasured. They are:

Exp. No. 40	12 Ontario provenances
Exp. No. 82	6 Ontario and 3 Quebec provenances
Exp. No. 125	16 Lake State provenances

As these experiments are inadequate, seed has been gathered for a new series of provenance experiments covering the whole range of jack pine. We expect to sow 75 provenances in 1961.

Several population samples have been grafted. However, seedlings of jack pine produce flowers almost as quickly as do grafts, so planting seedlings may be the better technique for establishing gene pools and material for provenance hybridization.

Other Hard Pines

New selections of Scots pine suitable for Christmas trees have been made. Older selections were rated for winter browning during the 1958-59 winter when nearly all Ontario Christmas tree plantations suffered severe desiccation and needle drop. Two clones and two seedlings were found that withstood winter damage, and have been earkmarked for future breeding.

Crosses were made in an old Scots pine provenance experiment between trees selected as potential Christmas trees. The following provenance hybrids were made:

Checkoslovakia x Riga
x France
x Scotland

Seedlings and grafts of *Pinus nigra*, *P. Thunbergii*, *P. densiflora* were produced for our co-operative study of European pine shoot moth resistance.

This material was established in three locations:

1) Petawawa Forest Experiment Station,

2) Turkey Point in Southern Ontario
by Dr. C. Heimburger, Research Division,
Ontario Department of Lands and Forests,

3) Elmira Entomological Field Station in central Ontario
by P.J. Pointing,
Science Branch, Canada Department of Agriculture.

Attempts were made to cross P. resinosa with P. densiflora, P. thunbergii and P. nigra. If red pine cones are to survive in this area we must spray diligently in spring and fall.

Other Species

About 20,000 seedlings of larch, mainly European, Japanese and their hybrids, have been planted at Petawawa and distributed to various co-operators.

Larch may have merit in eastern Canadian forestry as an early pulp producer on hardwood sites, and may provide a cut before the hardwoods become merchantable. We have therefore introduced what appeared to be the best European provenances and used this material partly for formal provenance experiments and partly in clear-cut hardwood stands to observe whether the larch can keep ahead of the hardwood reproduction.

We are also conducting limited trials with Betula and have exchanged Canadian birch provenances with birch species from England, Norway, Sweden, Finland, Denmark, Germany, Korea and Japan.

PLANT FORCING AND FLOWER INDUCTION

Most plants must be a certain size before they will flower. It is important therefore to know something about the techniques for accelerating growth. While intolerant species such as birch or larch will grow continously when exposed to long days in a warm greenhouse, the pines, most spruces and firs seem to require a period of chilling. Although the pines we have tested under long day in a warm greenhouse seem healthy enough, they usually have difficulty in breaking bud dormancy. The spruces seem a little more plastic in reacting to long days, but eventually they suffer from continous heat, and flushing becomes sporadic and abnormal resulting in unsatisfactory growth and form.

We have therefore embarked on a program in which we pay particular attention to the chilling requirements in our plant forcing techniques. A growth cabinet in which chilling treatments or diurnal temperature variations, and short or long days can be given under high light intensity is being constructed for us by Engineering Research Section of Agriculture, Central Experimental Farm, Ottawa.

Many experiments have been made with flower induction. The most promising from a practical point of view was the application of ammonium nitrate fertilizer to red pine which gave a 50-100 per cent increase in female flowers but reduced male flowering by 80 per cent. The ammonium nitrate fertilizer should be applied before annual growth is completed. May and June applications were highly effective; July application was intermediate and in August and September applications had no flower-inducing effect. Ammonium nitrate also stimulated female flowering and reduced male flowering in jack pine.

Guanine hydrochloride and 2, 4 dichlorophenoxyacetic acid when sprayed on jack pine in concentrations of 20-160 ppm. stimulated male flowering but had no effect on female flowering.

In spruce a combination of early spring root pruning and ammonium nitrate fertilizer gave the highest flowering. The intolerant black spruce is easier to force than white and Norway spruce.

Experiments were carried out with branch girdling at two-week intervals during the growing season with black, Norway and white spruce, and red and jack pine, in an attempt to pinpoint when the flower primordia are formed.

Vegetative Propagation

A total of 4180 grafts were made in this 2-year period. An experiment with deep freezing of winter-collected scions gave the following survival percentages after 1 and 2 years of storage:

	One Year	Two Years
Red pine	100	30
Norway spruce	100	20
White spruce	75	6

Casual observation of an interspecific grafting experiment with white, Norway, red, and black spruce indicates that black spruce is a superior root stock. This experiment will get its last rating in the fall of 1960.

Nursery Work

The qulity of the nursery soil has improved considerably after many years of compost application. New experiments have been started to estimate the long range effect of seed-bed media. So far the Dunneman beds are most promising.

About 213,000 seedlings have been transplanted.

Plantation Work

Thirty-three experiments including 65,060 plants and covering an area of 35.3 acres were established at Petawawa.in the 1958-59 period (Table 1). Another 54 experiments including 210,780 plants and covering an area of 128 acres were planted with stock distributed from Petawawa, Acadia and Valcartier Forest Experiment Stations. (Table 2). Table 3 lists the seedlings, transplants and grafts shipped from the Petawawa Nursery during the 2-year period.

TABLE 1

SPRING PLANTING 1958 AND 1959

PETAWAWA FOREST EXPERIMENT STATION

EXP. NO.	DESCRIPTION	NO. OF PLANTS	AREA ACRES	PLANT AREA
	SEEDLINGS 1958			
6-B	Breeding of weevil resistant and weeveil susceptible Norway spruce by means of intraspecific hybridization of the Norway spruces on Hudsons Place, P.F.E.S.	338	0.33	P.A.114
7	Interspecific hybridization of Norway spruce, and white spruce from eastern, central and western Canada for transfer of weevil resistance from white spruce to Norway spruce, P.F.E.S. arboretum.	41	0.03	P.A.101
72	One-parent progeny test with red spruce, red x black spruce hybrids and black spruce, P.F.E.S.	31	0.01	P.A.103
80-B	Observation plots with 7 provenances of Norway spruce, P.F.E.S.	7880	2.90	P.A.114
85	Selection of early flowering Scots pine for root stock purposes, P.F.E.S.	500	0.27	P.A.106 P.A.115
86	Selection of the perfect Scots pine Christmas tree, P.F.E.S.	570	0.22	P.A.106 P.A.115
87	Investigation of jack pine, lodgepole pine and their hybrids for resistance to sweet fern blister rust, P.F.E.S.	1053	0.40	P.A.106 P.A.115
89	Controlled breeding of white spruces with brush and salami branch types for investigation of branch type variability, P.F.E.S.	19	0.10	P.A.114
90-B	Observation of 3 races of larch, 2 Austrian and 1 Polish, P.F.E.S.	1160	1.02	P.A.119
91-A	Comparison of wood production and growth behaviour of 18 selected broad and slender white spruces of various provenances by means of single-tree progeny tests, P.F.E.S.	4116	3.40	P.A.114

TABLE 1 (Cont'd)

EXP NO	DESCRIPTION	NO. OF PLANTS	AREA ACRES	PLANT AREA
91-B	White spruce single-tree progeny test with 8 provenances.	2411	0.89	P.A. 119
92-A	Single-tree progeny test including 16 Petawawa white spruces, P.F.E.S.	4496	1.65	P.A. 114
92-B	Single-tree progeny test including 10 Petawawa white spruces, P.F.E.S.	2376	0.87	P.A. 114
93-B	Provenance experiment including 25 races of Ontario and Quebec white spruce provenances, P.F.E.S.	13464	4.85	P.A. 119
94-A	Black spruce provenance experiment including 8 provenances, P.F.E.S.	935	0.35	P.A. 119
95-G	Provenance experiment including 16 races of red spruce, P.F.E.S.	3776	1.38	P.A. 119
96-G	Red pine provenance experiment including 16 races of Canadian and U.S.A. red pines, P.F.E.S.	5599	2.00	P.A. 106
97	Observation plots with red pine originated from small stands of various origin, P.F.E.S.	211	0.36	P.A. 106
98	Interspecific hybridization in the group _Lariciones_ for production of a hard pine type resistant to European shoot moth, P.F.E.S.	21	0.10	P.A. 106
174	Selfing of early flowering white spruce of Maritime origin, P.F.E.S.	26	0.10	P.A. 114
207	Provenance hybridization in red pine, with 3 provenances, P.F.E.S.	308	0.25	P.A. 106
213-B	Observation of growth of _Picea omorika_ P.F.E.S.	190	0.25	P.A. 114
237	Collection of miscellaneous birch species for breeding purposes, P.F.E.S.	43	0.06	P.A. 106
	TOTAL 1958	49564	21.79	

TABLE 1 (Cont'd)

EXP NO	DESCRIPTION	NO. OF PLANTS	AREA ACRES	PLANT AREA
	SEEDLINGS 1959			
140	Polish and German provenances of Norway spruce, and selected slender Finnish plus trees on trials for weevil resistance, at P.F.E.S.	4730	1.70	P.A. 114
141	Comparison of branch types of Swedish Norway spruce from Hedesunda planted at P.F.E.S.	1500	0.55	P.A. 114
183-A	Testing of single-tree progenies of high resin yield Austrian pine for shoot moth resistance, at P.F.E.S.	135	0.50	P.A. 115
215-A	Single-tree progeny test in Lake State red pine conducted in co-operation with the University of Wisconsin, planted at P.F.E.S.	3768	0.08	P.F.E.S. Nursery II
216-A	Red pine provenance experiment including 18 Lake States and Canadian provenances in co-operation with University of Wisconsin, planted at P.F.E.S.	2168	0.04	P.F.E.S. Nursery II
	Total 1959	12301	2.87	
	Total 1958-59	61865	24.66	

TABLE 1 (Cont'd)

EXP NO.	DESCRIPTION	NO. OF PLANTS	AREA ACRES	PLANT AREA
	GRAFTS 1958			
10	Norway spruce grafts for weevil resistance breeding, planted at P.F.E.S.	723	2.39	P.A. 117
130	Single-tree and population samples of jack pine intended for provenance hybridization (Planted at P.F.E.S., Young's Creek Rd.).	144	0.47	P.A. 106
130	Single-tree and population samples of jack pine, planted at P.F.E.S. Pine graft arboretum.	254	0.84	P.A. 115
P.140	Jack pine grafts, single-tree and population samples, planted at P.F.E.S.	165	0.66	P.A. 106
P.149	Tamarack grafts from trees selected near Mattawa, planted at P.F.E.S.	17	0.01	P.A. 119
	Spruce graft arboretum (var. species)	767	2.54	P.A. 116
	Spruce graft arboretum (var. species)	261	0.86	P.A. 114
	Pine graft arboretum (Comp. I, Scots pine)	193	0.63	P.A. 115
	Pine graft arboretum (Comp.II, Red pine)	148	0.49	P.A. 115
	Pine graft arboretum (Comp.III, Lariciones hybrids)	18	0.06	P.A. 115
	TOTAL 1958	2690	8.95	
	GRAFTS 1959			
10	Norway spruce clones selected for weevil resistance, planted at P.F.E.S.	464	1.53	P.A. 117
P.144	Population samples.	51	0.17	P.A. 106
	Total 1959	515	1.70	
	Total 1958-59	3205	10.65	

[redacted]

PLANTATIONS ESTABLISHED IN 1958 AND 1959 OUTSIDE PETAWAWA FOREST EXPERIMENT STATION

EXP. NO.	TITLE	NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION
	SEEDLINGS 1958			
44-A	Provenance experiment with 9 races of red pine planted at the Star Lake Ranger School, N.Y. U.S.A.	3150	2.60	N.Y. State College of Forestry Star Lake, N.Y. U.S.A.
44-B	Provenance experiment with 9 races of red pine planted at the Pack Forest N.Y. U.S.A.	2860	2.80	N.Y. State College of Forestry Pack Forest, N.Y. U.S.A.
44-C	Provenance experiment with 10 races of red pine planted at Tully Forest N.Y. U.S.A.	4620	3.70	N.Y. State College of Forestry Tully Forest, N.Y. U.S.A.
55-A	Provenance experiment with 7 races of red pine planted by University of Wisconsin.	2304	2.00	Un. of Wisconsin Vilas County, Wisc. U.S.A.
55-B	Provenance experiment with 7 races of red pine planted in Waukesha County, Wisc. U.S.A.	2304	2.00	Un. of Wisconsin Waukesha County, Wisc. U.S.A.
55-C	Provenance experiment with 7 races of red pine planted in Juneau County, Wisc. U.S.A.	1296	1.00	Un. of Wisconsin Juneau County, Wisc. U.S.A.
55-D	Provenance experiment with 7 races of red pine planted in Burnett County, Wisc. U.S.A.	1296	1.00	Un. of Wisconsin Burnett County Wisc. U.S.A.
56-A	Provenance experiment with 5 races of Norway spruce planted in Vilas County, Wisc. U.S.A.	768	1.12	Un. of Wisconsin Vilas County, Wisc. U.S.A.
56-B	Provenance experiment with 5 races of Norway spruce planted by Un. of Wisconsin in Sawyer County, Wisc. U.S.A.	960	1.40	Un. of Wisconsin Sawyer County, Wisc. U.S.A.
56-C	Provenance experiment with 5 races of Norway spruce planted in Waukesha County, Wisc. U.S.A.	640	0.94	Un. of Wisconsin Waukesha County Wisc. U.S.A.
59-B	Provenance experiment with 7 races of Norway spruce planted at Harrington Forest Farm, Que.	13711	8.62	International Paper Co., Harrington Forest Farm, Que.

TABLE 2 (Cont'd)

EXP. NO.	TITLE	NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION
60	Provenance experiment with 10 races of norway spruce, planted at Harrington Forest Farm, Que.	1551	1.50	International Paper Co., Harrington Forest Farm, Que.
61-A	Provenance experiment with 11 races of norway spruce, planted in Wainfleet Twp. Ont.	12000	9.90	Ontario Paper Co., Wainfleet Twp. Ont.
80-C-1	Observation plots of norway spruce provenances planted in Papineau County, Que.	2100	1.26	James MacLaren Co., Papineau County, Que.
80-C-2	Observation plot of Polish norway spruce provenances planted in Val De Bois, Que.	600	0.70	James MacLaren Co., Val De Bois, Que.
90-C	Observation of Austrian larch planted at Valcartier F.E.S. Que.	2000	1.65	Forestry Branch, Valcartier F.E.S. Que.
90-D	Observation of Austrian larch planted at Grand Mere, Que.			Forestry Branch, Grand Mere, Que.
93-C	Provenance experiment with 25 races of white spruce mainly from the central part of the Great Lakes - St. Lawrence Forest Region, planted in Artemisia Twp.	13464	4.85	Ont. Dept. Land and Forests, Artemisia Twp. Grey County, Ont.
93-D	White spruce provenance experiment with 25 races planted in Fauquier Twp. Ont.	13464	4.85	Spruce Falls Pulp and Paper Co., Fauquier Twp. Ont.
93-E	White spruce provenance experiment with 25 races planted in Drummondville, Que.	12325	5.50	South Canada Power Co., Drummondville, Que.
93-F	White spruce provenance experiment with 25 races planted at Harrington Forest Farm, Que.	8387	3.10	Canadian International Paper Co., Harrington Forest Farm, Que.
93-G-1	White spruce provenance experiment with 25 races planted at Toumey Nursery, Watersmeet, Mich., U.S.A.	476	0.40	Lake States F.E.S. Toumey Nursery, Mich., U.S.A.

TABLE 2 (Cont'd)

EXP. NO.	TITLE	NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION
93-G-2	White spruce provenance experiment with 22 seed lots of white spruce, 1 seed lot of Norway spruce, 1 seed lot of balaam fir and 1 seed lot of black spruce.	2883	1.70	Minn. School of Forestry, Prarie Lake, Grand Rapids, Mich., U.S.A.
93-J	White spruce provenance trial with 17 races planted at Harrington Forest Farm, Que.	9097	3.24	Canadian International Co., Harrington Forest Farm, Que.
94-D	Comparison of 4 provenances of black spruce of various origin planted in Papineau County, Que.	1800	1.38	James MacLaren Co., Papineau County, Que.
95-M	Provenance experiment with 6 provenances of red spruce planted in Papineau County, Que.	1850	1.46	James MacLaren Co., Papineau County, Que.
96-A	Provenance experiment with 8 provenances of red pine covering the east-west range in Canada and the U.S.A.	2885	1.10	Mersey Paper Co., Liverpool, N.S.
96-B	Red pine provenance experiment with 16 seed lots planted at Chignecto Game Sanctuary, N.S.	5599	2.07	Forestry Branch, Chignecto Game Sanctuary Cumberland County, N.S.
96-C	Red pine provenance experiment with 12 seed lots planted at Valcartier F.E.S. Que.	4287	1.57	Forestry Branch, Valcartier F.E.S. Que.
96-D	Red pine provenance experiment with 9 seed lots planted on Canadian International Paper "Girard" lots in Que.	3305	1.20	Canadian International Paper Co., Chatham Twp. Argenteuil County, Que.
96-E	Red pine provenance experiment with 16 seed lots planted in the Game Sanctuary, Norfolk County, Ont.	5599	2.07	Ont. Dept. of Lands and Forests, Norfolk County, Turkey Point, Ont.
96-F	Red pine provenance experiment with 9 seed lots planted at Dorset, Forest Ranger School, Ont.	3225	1.20	Un. of Toronto, Dorset, Ont.

TABLE 2 (Cont'd)

EXP. NO.		NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION
96-H	Red pine provenance experiment with 12 seed lots planted at Ingram, Ont.	4280	1.50	Ont. Dept. of Lands and Forests, Ingram Twp., Ont.
96-I	Red pine provenance experiment with 12 seed lots planted at Dryden, Van Horne Twp., Ont.	4280	1.50	Ont. Dept. of Lands and Forests, Van Horne Twp., Dryden, Ont.
96-J	Red pine provenance experiment with 9 seed lots planted on Sandilands Forest Reserve.	3225	1.20	Forestry Branch, Sandilands, Man.
96-K	Red pine provenance experiment with 6 seed lots for shoot moth tests.	600	0.22	Ont. Dept. of Lands and Forests, Turkey Point, Ont. Comp. H.
136	Comparison of Danish white spruce, sitka × white spruce, Alaska sitka and white spruce, and local Newfoundland white spruce, planted in Newfoundland.	1530	1.00	Forestry Branch, Deer Lake, Newfoundland.
138	Comparison of Danish white spruce and sitka × white spruce hybrids with Ontario white spruce and local New York white spruce, planted in New York on Atomic Energy Commission Land.	10400	8.60	N.Y. Conservation Dept., West Milton N.Y., U.S.A.
189	Trial of Polish larch at Harrington Forest Farm, Que.	1420	0.60	Canadian International Paper Co., Harrington Forest Farm, Que.
	Total, 1958	166541	92.50	

TABLE 2 (Cont'd)

EXP. NO.	TITLE	NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION
	SEEDLINGS 1959			
93-G-4	White spruce provenance experiment with 15 races planted at Savage River State Forest.	600	1.10	Dept. of Forests and Parks, Garrett County, Maryland, U.S.A.
93-H	White spruce provenance experiment with 17 races, establ. in 2 plantations at Indian Head.	a) 1190 b) 136	1.20	Canada Dept. Agriculture Indian Head, Sask.
93-I	White spruce provenance experiment with 16 races (14 E. Canada, 2 W. Canada).	5068	4.50	Forestry Branch Riding Mountain, Man.
93-K	White spruce provenance experiment with 4 races.	200	0.07	Brooks Range, Alaska U.S.A. Un. of Tennesee
95-A	Red spruce provenance experiment with 16 seed lots planted in New Brunswick.	10349	3.80	Forestry Branch, Acadia F.E.S., N.B.
95-D	Red spruce provenance experiment with 14 races planted by Forestry Branch, Que.	5605	4.64	Forestry Branch, Valcartier F.E.S., Que.
95-E	Red spruce provenance experiment with 15 races planted on land owned by Southern Canada Power Co.	5605	4.64	Southern Canada Power Co., Drummondville, Que.
95-F	Red spruce provenance experiment with 14 races planted on land owned by Megantic Manufacturing Co., Lake Megantic, Que.	5605	4.64	Forestry Branch, Lake Megantic, Que.
95-I	Red spruce provenance experiment with 4 seed lots.	714	0.24	Forestry Branch, Acadia F.E.S., N.B.
135-A	Comparison of Danish white spruce and sitka × white spruce hybrids, and local Quebec white spruce.	1681	1.40	Forestry Branch, Valcartier F.E.S., Que.
135-B	Comparison of Danish white spruce sitka × white spruce and local Quebec white spruce planted at Southern Canada Power Co. land in Drummondville, Que.	1681	1.40	Forestry Branch, Drummondville, Que.

TABLE 2 (Cont'd)

EXP. NO.	TITLE	NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION
135-C	Comparison of Danish white spruce, sitka x white spruce and local Quebec white spruce	500	0.41	Forestry Branch, Lake Megantic, Mount Louise, Que.
183-B	Testing of single-tree progenies of high resin yielding Austrian pine for shoot moth resistance.	400	0.33	Canada Dept. Agriculture, Elmira Field Station, Ont.
183-C	Testing of single-tree progenies of high resin yielding Austrian pine for shoot moth resistance	800	0.66	Ont. Dept. Lands and Forests, Turkey Point, Ont.
202-B	Polish larch observation plots with 4 seed lots, planted in Saratoga County, N.Y., U.S.A. on the property of Atomic Energy Commission Limited	3906	5.73	N.Y. Conservation Dept., West Milton N.Y., U.S.A.

Total 1959	44040	34.76
Total 1958-59	210581	127.26

TABLE 2 (Cont'd)

EXP. NO.	DESCRIPTION	NO. OF PLANTS	AREA ACRES	AGENT AND LOCATION OF PLANTATION
	GRAFTS 1958			
186-A-2	Seed orchard of grafts from selected Scots pine Christmas trees, 12/v. lots of grafts.	150	0.50	W. E. Nordwell Courtland, Ont.
186-B	Seed orchard of grafts from selected Scots pine Christmas trees, 4/v. lots of grafts.	38	0.12	J. McDonald of Forest Insect Lab., Sault St. Marie, Ont. Kirkwood Twp. Ont.
186-C	Grafts of selected Scots pine Christmas trees 1/v. lot of grafts.	11	0.04	A. Reinke, Cedar Valley, Ont.
	Total	199	0.66	

TABLE 3

DISTRIBUTION OF SEEDLINGS AND GRAFTS TO OUTSIDE AGENTS, SPRING 1958 AND 1959

EXP. NO.	AGENT AND PLANTING SITE	NO. OF SEED LOTS	NO. OF SEEDLINGS
	SEEDLINGS 1958		
90-C 90-D	Forestry Branch At Valcartier F.E.S. At Grand Mere } Larch seedlings	4	2000
P.144 P.151	Dept. of L. & F., Maple, Ont. 6 seedlots of Pinus nigra x sylvestris, P.rigida, P. densiflora)	6	1622
96-A	Mersey Paper Co, N.S. at Liverpool, N.S. (Red Pine, 2-2 stock)	8	2000
96-B	Forestry Branch at Cumberland County N.S. (Red Pine, 2-2 stock)	16	4000
96-C	Forestry Branch at Valcartier F.E.S., P.Q. (Red Pine, 2-2 stock)	12	3000
96-D	Canadian Inter. Paper Co, at Argenteuil County Chatham Twp. Que.(Red Pine, 2-2 stock)	9	3350
96-E	Ontario Dept. of L. & F. at Turkey Point, Ont., Game Sanctuary (Red Pine 2-2, stock)	15	3750
96-F	Univ. of Toronto, at Dorset, Ont. (Red Pine, 2-2 stock)	9	2250
96-H	Ontario Dept. of L. & F. at Ingram Twp. North. Ont. (Red Pine, 2-2 stock)	12	3000
96-I	Ontario Dept. of L. & F., at Dryden, Ont. (Red Pine, 2-2 stock)	12	3000
96-J	Forestry Branch Man. at Sandilands Man. (Red Pine, 2-2 stock)	9	2250
96-K	Ontario Dept. of L. & F., at Turkey Point, Ont. (Red Pine, 2-2 stock)	6	600
	TOTAL 1958 SEEDLINGS	118	30822

TABLE 3 (Cont'd)

EXP. NO.	AGENT AND PLANT SITE	NO. OF SEED LOTS	NO. OF SEEDLINGS
	SEEDLINGS 1959		
183-B	Division of Forest Biology Field Station, Elmira, Austrian Pine, 2-2 stock	2	400
183-C	Ont. Dept. of L. & F., Turkey Point (Austrian Pine, 2-2 stock)	2	800
200	Univ. of New Brunswick at Univ. Arboretum (Norway Spruce, 2-0 stock)	2	60
201	Univ. of New Brunswick at Univ. Arboretum (Scots Pine, 2-0 stock)	2	60
202-C	Mersey Paper Co, Liverpool, N.S. at Durling Fields (Larch, 1-1 stock)	6	3400
202-D	Univ. of Toronto at David Dunlop Observ. and Glendon Hall Arboretum, Ont. (Larch, 1-1 stock)	7	670
202-E	Forestry Branch, N.B. at Acadia F.E.S, N.B. (Larch, 1-1 stock)	7	210
202-F	Univ. of New Brunswick, at Univ. Arboretum N.B. (Larch, 1-1 stock)	4	120
202-G	Canadian International Paper Co. at Harrington Forest Farm, Que. (Larch, 1-1 stock)	6	12650
	Total 1959 seedlings	38	18370
	Total 1958 - 59 seedlings	156	49192

TABLE 3 (Cont'd)

EXP. NO.	AGENT AND PLANT SITE	NO. OF CLONES	NO. OF SEEDLINGS
	GRAFTS 1958		
186-A-2	W.E. Nordwell, Courtland, Ont. (Scots Pine grafts)	12 V/L	150
186-B	J. McDonald, Kirkwood Twp. Thessalon, Ont. (Scots Pine grafts)	4 V/L	38
186-C	A. Reinke, Cedar Valley, Ont. (Scots Pine grafts)	1 V/L	11
	Total Grafts 1958	17	199

TABLE 4

SUMMARY OF GRAFTING DURING SPRING AND FALL 1958 AND 1959

SPRING 1958		
P-139 & 142 EXP. NO. 128		
10 clones of *P. resinosa* from Manitoba	160	
1 population of *P. resinosa*, Newfoundland	100	260
P-144		
1 population of *P. thunbergii*, Long Island, N.Y.	100	
2 clones of *P. densiflora*, Midhurst, Ont.	40	140
P-137		
1 population and 30 clones of exotic spruce species from east Asia		348
Grafting course. Jan and Oct 1958		
5 clones of spruce		270
FALL 1958		
P-133		
2 clones of *P. glauca* from Mattawa, Ont.		75
Exp. No. 248 Cold storage of scions		350
Total grafting		1443
SPRING 1959		
P-139		
39 clones of *P. resinosa* from northern Ontario		913
P-145		
10 clones of early flowering *P. sylvestris* from Germany		225
P-147		
8 clones of *P. sylvestris* (Christmas tree selection)		237
P-133		
17 clones of *P. glauca* from northern and western Ontario		345
P-137		
33 clones of exotic spruce species from east Asia, Europe and Oregon		637
FALL 1959		
P-139 & P-142, EXP. NO. 238		
38 clones of *P. resinosa* from Petawawa F.E.S.		380
Total grafting		2737

TABLE 5

TRANSPLANTING OF TREE BREEDING MATERIAL

SPRING 1958

EXP. NO.	MATERIAL	NO. PLANTED
202	Larix from Canada, Denmark, Poland and Japan	32600
98	Pinus nigra austriaca, high resin yielders	845
183	Pinus nigra from Corsica, Italy and Spain	1072
188	Pinus sylvestris from France, Belgium, Scotland and Ont.	22230
-	Pinus hybrids	264
-	Betula from Finland	87
	Total transplant	57098

SPRING 1959

EXP. NO.	MATERIAL	NO. PLANTED
209	Larix from Europe, Japan and British Columbia	35430
201	Pinus sylvestris from Finland, european Russia and Siberia	45910
200	Picea abies from Finland, Poland, Sweden, european Russia and Siberia	51080
-	Picea hybrids	16115
-	Rootstocks e.t.c.	7160
	Total transplanting	155695

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REPORT TO THE COMMITTEE ON FOREST TREE BREEDING IN CANADA

UNDER A GRANT FROM THE NATIONAL RESEARCH COUNCIL OF CANADA

AND THE AUSPICES OF THE UNIVERSITY OF BRITISH COLUMBIA

A GENETIC EVALUATION OF TREE GROWTH THROUGH AN ANALYSIS OF THE PROGENIES OF INDIVIDUAL TREES, FILIOTYPES AND REGIONAL POPULATIONS

BY A. H. HUTCHINSON

Vancouver, B. C.,

June 28, 1960

A GENETIC EVALUATION OF TREE GROWTH THROUGH AN ANALYSIS OF THE PROGENIES OF INDIVIDUAL TREES, FILIOTYPES AND REGIONAL POPULATIONS

By A. H. HUTCHINSON

INTRODUCTION

The immediate problem of forest maintenance and improvement associated with a system of utilization involves the adequate production of ecologically adapted rapidly growing, structurally suitable and economically located trees. These requirements are paramount in the current system of utilization, and consequently must receive commensurate attention. Essentially these requirements are problems of reproduction and growth.

In the natural system, genetic mutation, selection and hereditary transmission have provided a variety of growth forms from which natural selection has perpetuated adapted, adaptive, regional filiotypes. From the environmental point of view, these adapted filiotypes may be called ecotypes.

In the economic system the conditions of growth of a selected area must be satisfied in order to obtain optimum growth. The relatively slow progress of natural selection extending over thousands of years in the case of trees must be speeded up by means of directed selection to attain the adapted type in a single tree generation.

EXPERIMENTAL METHODS

<u>SOIL</u> An original Douglas fir stand on the University of British Columbia lands was cleared leaving a six inch top soil over hard pan. Sods of three grass crops were removed and an inch of forest soil rich in humus was added. The soil was tile drained, and cultivated.

<u>SEEDING AND SEED BEDS</u> The seed beds are on a slope of 2.5 per cent and elevated six inches. Four rows of seeds are planted five inches apart and the seeds in the row one and one half inches; that is, all possible care is taken to insure uniform soil and seeding. Plots are in replicate.

<u>TRANSPLANTING:</u> The seedlings are transplanted, at age two or three years, in rows three feet apart and spaced regularly at one foot intervals.

<u>WATERING AND EVAPORATION PROTECTION</u> During the first summer after seeding or transplanting, water is uniformly applied and during dry periods the seedlings are protected by a covering of cotton, supported by wires. Two year old seedling transplants are treated similarly for one month. Otherwise atmospheric conditions as recorded by the weather station are used.

<u>IDENTIFICATION OF PLANTS</u> Each growing plant is regarded as an individual and is identified by a number registering the section, row, plot and subrow. Dead seedlings are collected and examined for lethal characters.

SUMMARY - CONDITIONS OF GROWTH

All plants were grown under uniform or similarly variable conditions. It follows that impingement of ecological factors was uniform, in so far as that may be attained in field experiments, and consequently any variability in growth may be attributed to individual genetic sensitivity and response, within these limits.

ANALYSIS OF GROWTH CHARACTERS AND EVALUATION OF DATA - DOUGLAS FIR

SEED SOURCES AND DISPOSITION OF SEED Qualified foresters selected three trees from each of three locations on the eastern slopes of Vancouver Island. From each location a superior, an intermediate and an inferior mature "lumber type" tree was marked. From a fourth location, two second growth trees, side by side, were marked, tall and straight, and shorter and branched, respectively. One hundred cones were collected from each of the "lumber type" trees at the time of felling. The best of the seed was selected from each seed tree, layered and planted, in 1956, under the prepared conditions, as above. Seeds were planted in 44 plots: that is, four plots per seed tree and 256 seeds in each plot, that is 1024 seeds from each seed tree and a total of 11,264 seeds for eleven seed trees (less 192 seeds in one case of insufficient seeds..ST9, R9, P4). Plots were arranged in five and one half parallel rows, with eight plots per row.

In late November 1956 alternate plots in each row were covered with coarse straw as an experiment in protection against winter and spring freezing. Contrary to expectation the result of covering was harmful to the extent of killing due largely to hypocotyl injury and less notably to leaf defoliation. On the contrary, seedlings of Picea glauca and of Betula allegheniensis of the same age were favorably protected.

GROWTH RESPONSES AND CYCLES

THE INTERACTION OF THE PLANT AND ENVIRONMENT One side of this equation is expressed in terms of the life sensitivity and reaction to ecological conditions, climatic, edaphic and biotic; the other approach is the conditional effect of the environmental factors as conditioners of life processes; one or the other may be emphasized; both must be recognized. Successful growth is attained when the range of tolerance includes an optimum within the limits of environmental variants. Survival is conditional. Survival is conditioned by a parallelism in the organism's hereditary range of telerance and the limits of the environmental variability. This co-ordinated range of interaction requirement applies specifically to diurnal and seasonal responses and involves cyclic changes of comparative activity and dormancy, alternately of food manufacture or supply and of storage, of stem elongation and bud formation or seed production, of nuclear or cytoplasmic activity; of nucleic acid or protein metabolism. Sensitivity of genes control the phase and rate of the periodic changes within the limits of supply and demand.

THE NATURE OF GROWTH GENES

GENES AS UNITS The activities of growth genes are expressed essentially through the agency of specific enzymes, which in turn are subject to the laws of mass action or supply in addition to definite conditional requirements of particular temperature, pH, and available energy conditioners. Growth involves a multiplicity of reactions and a correspondingly multitudinous quota of specifically controlling genes. -- Recent research reveals that mutation consists, primarily, in changes of molecular configuration such as a change in the position of side chain oxygen or hydrogen bond within a purine or pyrimidine base, of which there are thousands in the nucleic acid molecule.

Secondarily, a mutation may involve a change in relative position of one of 13 or more proteins forming a group essential for a specific metabolic process. Finally, there are the Mendelian genetic entities which are expressed as tall or dwarf; round or wrinkled; green or grey. What are genes? What are the determinate units which are basic to the operation of life and to the perpetuation of species, races, or individual kinds? Recognizing the units of atomic structure similarly the units we call "Mendelian genes" consist of subgenic units which have attained a complexity level with the power of specific and measurable expression in growth and activity of an organism. The latter may be regarded as "effective genes".

MULTIPLE GENES (FACTORS) OR POLYGENES. It is conceded generally that "quantitative characters" which give a gradation size, shape, metabolic products, rates of chemical or physical change or other measurable activity are determined by the action of several primary genes which contribute to a common result, varying in degree of expression according to the number and co-ordinate action of the genotypic complex. Growth in all its phases is dependent upon the action and expression of multiple genes. These genes may be active or inactive, supplementary or complementary, stimulatory or depressive, reversible or accelerative in their expression. The primary character is that they contribute as a group to a common vital cycle or progression.

MULTIPLE ALLELES AND THE FREQUENCY DISTRIBUTION CURVE OF GROWTH VARIABLES

THE GENETIC BASIS OF VARIATION Mendel's terms "tall and dwarf" are based on the observation that the height characteristic may be used to designate mutually distinct classes, without overlap or marginal contact. Schoedinger* gives Mendel credit for adoption of the quantum concept antedating Planck and Einstein. The quantum principle is basic to the multiple factor system of genetic classes. These specific entities are prerequisite to the frequency distribution system which applies to multiple genes.

MUTATION Mutation provides new genes and these result in heterozygosity. The number of genetic classes is correspondingly increased. These variants are perpetuated in the same proportion according to the Hardy and Weinberg Law, i.e. provided mutation and selection do not disturb the balance, and the scope of free interbreeding is not restricted. In addition, the Hardy-Weinberg Law applies to the frequency of genes only and does not apply directly to effective genotypes or phenotypes except in cases where the genes are multiple and additive in their expression. There is generally accepted evidence, however, of frequent mutation and selection, reproduction and isolation, which by the addition or deletion of effective genes change the genetic system in populations. These are generally recognized as the "peaks and valleys" of frequency distribution. Actually there is evidence of mutation and of marked selection in Douglas fir in our results. Favourable mutation is added to the complement of growth promoting factors.

* In: "What is Life".

THE DISTRIBUTION OF MULTIPLE FACTORS FOR GROWTH, AND OTHER QUANTITATIVE CHARACTERS

The distribution of multiple factors for growth and other quantitative characters has been considered in an earlier paper presented to the X Genetic Congress of Genetics, Montreal, August, 1958. A copy of the abstract follows:

"Hutchinson, A. H. The Principles Involved in Polygenic Selection from a Polyzygous Population of Douglas Fir. Department of Biology and Botany, University of British Columbia, Vancouver, Canada.

"A genotypic evaluation of wind pollinated Douglas fir populations is premised on polygenic segregation involving various growth rates, frost sensitivity, and cyclic bud activity. In each case three or four allelic factors are required to satisfy the polyzygous states, which are evident from more than 80,000 readings. Simple equations in terms of N, the number of polygenic alleles, and n, the degree of parental heterozygosity, relate the phenotypes and genotypes of the progenitors to the class frequency distribution coefficients of the progenies $(1 + I)^n \times 2^{2N-n}$. All population curves are reduced to the common base, 2^{2N}.

"Each controlled biparental class frequency polygon of a specific polyzygous population is balanced and includes (n + 1) phenotypic classes from a possible (2N + 1) classes, each of which belongs to one of (factorial (N + 1)) effective genotypic classes. These genotypes may combine to produce factorial 2N + 1 class frequency series, as progenies. Wind pollinated, multiparental stocks are characterized by class frequency polygons which show predictable skewness, multiple peaks and extended plateaus.

"Selection may be controlled genotypically on these bases. Examples of natural selection are presented."

THEORETICAL FREQUENCY DISTRIBUTION OF PHENOTYPES. From the abstract above, and from other considerations the orderly operation of multiple additive genes is readily anticipated as an expression related entirely to the number of contributary alleles and the combined heterozygosity of the two progenitors as in Table I.

Table I. Frequency Distribution of Phenotypic Classes for Heterozygous Progenies on Least Number Basis.

Biparental Heterozygosity	Class Frequencies of Progeny	Number of Classes
0	1	1
1	1 1	2
2	1 2 1	3
3	1 3 3 1	4
4	1 4 6 4 1	5
5	1 5 10 10 5 1	6
6	1 6 15 20 15 6 1	7
H		H + 1

Bringing the expression to a common denominator of 64 individuals (progeny) as in Table II, a relative scale of frequencies for the various heterozygosities is obtained.

Table II. Frequency Distribution of Three Alleles on Least Number Basis.

Biparental Heterozygosity	Relative Class Frequencies	Number of Classes
0	64	1
1	32 32	2
2	16 32 16	3
3	8 24 24 8	4
4	4 16 24 16 4	5
5	2 10 20 20 10 2	6
6	1 6 15 20 15 6 1	7
H		H + 1

EVALUATION OF THE EXPERIMENTAL DISTRIBUTION OF HEIGHT CLASSES IN A THREE YEAR OLD DOUGLAS FIR NURSERY POPULATION OF KNOWN PROGENITORS

The 11,264 Douglas fir seeds planted as described above produced 2,378 three year old plants. The 22 plots which were covered with straw during the first winter contain 915 young trees and the 22 alternative plots, not covered, contain 1,454 plants, the ratio is 1:1.6.

The progeny of any two parents is theoretically balanced about the mean according to the multiple factor frequency distribution principle.

Table III. Frequency Distribution of Height Classes in 3 yr. Douglas Fir

CLASS	7	6	5	4	3	2	1	TOTALS	FEATURES
	HIGH						LOW		
Total Population	38	102	374	691	669	398	108	2378	(Pollen (Inferior
Theoretical	37	223	557	744	557	223	37	2378	(Skew, low
T 10 Cov.	1	3	16	17	11	1	0	49	(Self pollinated
T 10 Exp.	0	0	12	12	12	12	2	40	(Low viability
Total	1	3	28	29	23	13	2	89	
Theoretical	1+	8	21	28	21	8	1+	88+	(Skew, high
T 11 Cov.	(1)	3	18	45	34	15	3	119	(Het 5
T 11 Exp.	0	7	30	62	74	47	7	227	(Hardy
Total	(1)	10	48	107	108	62	10	346	
Theoretical	-	11	54	108	108	54	11	346	(Balanced
T 1 Cov.	1	9	20	28	31	32	4	125	(Het 6
T 1 Exp.	2	2	20	49	57	37	4	171	(Frost Sens.
Total	3	11	40	77	88	69	8	296	(Pollen Inf.
Theoretical	4	28	70	92	70	28	4	296	(Skew, low
T 4 Cov.	0	0	10	25	18	9	2	64	(Het 5
T 4 Exp.	0	5	15	32	23	12	1	89	(Pollen
Total	0	5	25	57	41	21	3	152	(Inferior
Theoretical	2	15	36	48	36	15	2	153	(Skew, low
T 7 Cov.	1	6	7	14	18	10	6	62	(Het. 6
T 7 Exp.	9	8	27	35	15	8	0	102	(Superior
Total	10	14	34	49	33	18	6	164	(Pollen
Theoretical	3	15	38	51	38	15	3	163	(Balanced

DESCRIPTION OF TABLE III: A GENETIC ANALYSIS OF THE HEIGHT CLASS FREQUENCY DISTRIBUTION FOR 2378 PROGENIES, GROWN FROM ELEVEN WIND POLLINATED SEED TREES:

Five tree samples are charted and the aggregate population is shown. Three multiple alleles are postulated as sufficient to satisfy the frequency distribution. Then the maximum combined biparental heterozygosity is 6 (Het. 6) Seven genetic classes are present and the expected frequency distribution is 1,6,15,20,15,6,1. When the heterozygosity is 5 the coefficient frequency distribution series is 1,5,10,10,5,1. The total population shows lower class coefficients for the higher classes, 7 and 6, and higher coefficients for the lower classes as compared with the expected distribution. This skewness is explained chiefly on the basis that the seed progenitors were selected trees while the wind distributed pollen is "inferior", on the average.

A secondary consideration is the killing of frost sensitive plants during the first winter. The proportion of survival varies greatly as between covered (cov.) and exposed (exp.) plants. The low numbers indicate high frost sensitivity since the record is for survivors. Trees 1 and 4 are similar to the general population, above, in varying degree. Trees 11 and 7 however show a well balanced parallelism with multiple factor curve of frequency distribution (theoretical). However, for tree 7, the tallest of the expected, both the pollen and seed progenitors are regarded as superior, especially tree 7, which forms the tallest class of the actual and is in excess of the theoretical. This would imply a higher degree of heterozygosity in the seed plant and also, in a proportion of the pollen, giving homozygosity in the tallest class.

Tree 10 is very exceptional. High frost sensitivity is shown and in addition there is evidence of general deficiency expressed as low seed viability and high frost sensitivity. The frequency distribution also suggests a degree of self pollination. Parent trees 10 and 11 are situated side by side.

The evidence obtained from this analysis gives ample data which may be used in the selection of superior trees with respect to the characters tested. This analysis gives a basis of selection. Tree 7 for instance is superior as a progenitor since its progeny contains 10 times the number of trees of the highest superior class, as compared to the general population, and 3.3 times that of the balanced frequency expectation, in this case, and Tree 11 shows the highest proportion of viability accompanied by a "high" mode.

GENERAL CONSIDERATIONS OF FREQUENCY DISTRIBUTION APPLYING TO ACTUAL DATA PRESENTED IN TABLE III.

In Table III Class 7 is the "highest" class and Class 1 is the "lowest". The superior height classes are 7 and 6, and the inferior classes are 1 and 2. The mode lies between and varies in relative position for actual readings. From a genetic selection point of view, the classes superior and inferior and modal classes are of primary interest.

Table I contributes samples of frequency distribution data as follows. The range of height was from 245 mm. to 1050 mm. with one mutant exception which was outstanding. The height scale was divided equally into seven sections representing seven effective phenotypic classes. Three alleles, or a maximum of 6 effective genes were regarded as sufficient to satisfy the genetical data pertaining to height growth.

The data represents a high degree of heterozygosity. The progeny of these trees with one exception has representatives in at least five of the seven height classes and the theoretical frequency distribution is followed generally. Digressions are reasonably attributable to the effect of the variable pollen contribution, by wind. It would appear that the pollen, not being selected contributed to skewness curve giving higher frequencies in the region of low height classes. This is particularly notable in the case of the curve of the total population. In the total population the tallest class is according to expectation, while the other "high" classes are not fully represented.

SUMMARY, CONCLUSIONS AND CURRENT PROJECTS

1. In order to evaluate the genetic factors of growth and survival, it is essential that the variability of the environment be in minimum and that the degree of variability be known, and included in the equation.

2. An analysis of the genetic system involving multiple factors is basic to the evaluation of quantitative character inheritance. A system of this type is presented here, in part, and the publication of further basic considerations is planned.

3. In general the quantitative characters for growth may be analyzed on a basis of "effective additive genes", which segregate and combine to produce a series of phenotypic classes, having frequency coefficients in agreement with "normal distribution curves". The number of "alleles" (N) and the degree of contributing parental heretozygosity (H) determines the number of progeny classes (N + 1) and the standard serial frequency. The converse is true. Deviations from this system may be interpreted and adjusted or utilized, provided the environmental or other limiting factors are known and evaluated. A paper is in process.

4. This report deals with the height growth in Douglas fir. An analysis of the progenies of eleven trees, 2378 in all, shows marked individual ranges of variability and of the level of heterozygosity with concomitant class frequencies. This analysis gives a basis for the selection of progenitor trees.

5. The inheritance of frost sensitivity as dependent upon multiple factors (polygenes) has been analyzed and will be reported. Douglas fir trees from nine subregions of the Pacific Coastal area which were exposed to the record breaking November frosts of 1954, '55 and '57 have been recorded for growth and frost injury, including 100% killing. The data gives ample basis for analysis and definitive results. The frequency curves are highly modified by frost sensitivity selection, according to an orderly system.

6. The six year old progeny grown from seed from seven regions throughout the Pacific Northwest have been analyzed for growth characters and frost sensitivity. The heights at six years vary from six inches to eight feet six inches, and the progeny from each region has its own mode and growth limits. These variations are interpreted as the result of selections from the heterozygous coastal type which have been naturally selected to produce widely varying and adapted filiotypes and races. A paper on this subject is in process.

7. The progenies of ten trees of yellow birch, *Betula allegheniensis* 1,431 trees are being analyzed. The height growth at age three years varies from four inches to six feet three inches and various limits and modes characterize the individual progenies. Other significant characters are being evaluated.

8. The progenies of six fourteen year old white spruce, Picea glauca, 814 trees are under study. Seed of spruce species from many regions have been sown this year.

9. Many other quantitative characters, particularly those related to metabolic processes, are matters of record and are being analyzed.

10. The genetic analysis of progenies on a basis of multiple gene factors makes controlled selection feasible.

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A.H.H.

REPORT ON TREE IMPROVEMENT
1958 - 1960

by

H. G. MacGillivray[1]

Tree improvement undertaken by the Forestry Branch in the Maritime Provinces from the spring of 1958 to the spring of 1960 is dealt with in this report, and is chiefly concerned with *Picea rubens*, *Abies balsamea*, *Pinus resinosa*, and various exotics, particularly species of *Abies*.

PICEA RUBENS

Provenance Studies:

(a) Seed from Eastern Canada and United States

The *P. rubens* provenance experiments and observation plots established during 1959 and 1960 (Table 1) are part of a larger project conceived and directed by M. Holst, Petawawa Forest Experiment Station, Chalk River, Ontario. The main objects of this study are to introduce, and test fast growing southern races in Canada. The seed lots were assembled by Mr. Holst. In the spring of 1955, some seed from each lot was sown at the Acadia Forest Experiment Station in central New Brunswick. Severe winter burn damaged many seedlings during the winter of 1956-57 and it was decided that the trees should spend three years in the transplant beds instead of two, to allow time to recover from the winter burn. Recovery was good and they were large enough to plant in 1959. In the spring of 1959 one provenance experiment and some observation plots using these trees were established at the

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Experiment Station (Table 1). All other plantings were made in 1960.

In the spring of 1960 one experiment was established at Fundy National Park in southern New Brunswick and one experiment and one observation plot were established at Grimmer Settlement in northwestern New Brunswick. The locations, Fundy National Park, Acadia Forest Experiment Station, and Grimmer Settlement have maritime, more or less intermediate, and continental climates respectively. The designs for the experiments were 4 x 4 lattice square (Cochran and Cox, 1950, pp. 346-369). These experiments and observation plots were bordered by two rows of surround trees. A row of division trees separates each plot (Table 1). In addition observation plots were established in the University of New Brunswick Woodlot, Fredericton, N. B. by Mr. H. W. Blenis; at Acadia University, Wolfville, N. S. by Dr. E.C. Smith; in the north of Yarmouth County, N. S. by Mr. H. J. Grant, Nova Scotia Department of Lands and Forests; and at one or more locations in Queens County, N. S. by the Bowaters Mersey Paper Company, Limited, Liverpool, N. S. One experiment was established in the Nicolet National Forest, Wisconsin by Dr. Hans Nienstaedt, Lake States Forest Experiment Station; one experiment was planted at the Coleman State Forest, Stewartstown, N. H., and one at the Franklin Pierce State Forest, Hillsboro, N. H. by Dr. H. I. Baldwin of the New Hampshire Forest and Recreation Commission; in addition Dr. Hans Nienstaedt, in turn supplied Prof. S. S. Pauley of the University of Minnesota with about 100 trees from each lot.

Phenological data on leader growth of this P. rubens stock was collected from trees in the nursery at the ACADIA FOREST Experiment Station in 1959. As yet it has not been compiled but there was considerable variation in height of the 2-2 trees, both within and between lots. Variation may be greater than that shown, as the data (Table 2) were from trees having healthy, dominant

Table 1. DISTRIBUTION AND PLANTING OF PICEA RUBENS PROVENANCE MATERIAL

Provenance	Experiments						Number Trees in Observation Plots					
	N. B.			Wisc.	N. H.		N. B.			N. S.		
	Acadia F.E.S.	Grimmer	Fundy Nat. Pk.	Nicolet Nat. For.	Stowartstown	Hillsboro[1]	Acadia F.E.S.	Grimmer	U.N.B.	Acadia Univ.	Yarmouth County	Queens County
Great Smoky Mts., N. C.	x	x	x	x	x	x(3)	–	–	(94 (91	1000	1400	1700
Glade River, Monongahela Nat. For., W. Va.	x	x	x	x	x	x(3)	–	–	95	1200	1600	500
Bear Meadows, Centre Co., Penn.	x	x	x	x	x	x(1)	–	–	92	1000	–	100
October Mts., Berkshire Co., Mass.	x	x	x	x	x	x(2)	–	–	(95 (95	–	–	1200
Paul Smith, Franklin Co., N. Y.	x	x	x	–	–	–	–	–	–	–	–	–
Essex and Clinton Co., N. Y.	x	x	x	x	x	x(3)	–	–	90	–	700	–
Mt. Monadnock, 2300 to 2600 ft., Cheshire Co., N.H.	x	–	–	–	–	–	–	200	–	–	–	–
Mt. Monadnock, 3150 ft., Cheshire Co., N.H.	–	–	–	–	–	–	170	–	–	–	–	–
Pillsburry State Forest, 1550 ft., Sullivan Co., N.H.	x	x	x	x	x	x(2)	–	–	99	–	–	1200
Pillsburry State Forest, 1800 ft., Sullivan Co., N.H.	–	–	–	–	–	–	100	–	–	–	–	–
Mt. Firescrew, 3000 ft., Grafton Co., N.H.	–	–	–	–	–	–	70	–	–	–	–	–
Amherst, Handcock Co., Maine	x	x	x	x	x	x(2)	–	–	100	800	–	100

(Cont'd.)

Table 1. (Continued)

Provenance	Experiments						Number Trees in Observation Plots					
	N. B.			Wisc.	N. H.		N. B.			N. S.		
	Acadia F.E.S.	Grimmer	Fundy Nat. Pk.	Nicolet Nat. For.	Stewarts-town	Hillsboro[1]	Acadia F.E.S.	Grimmer	U.N.B.	Acadia Univ.	Yarmouth County	Queens County
Andorra Forest, 1700 ft., Cheshire Co., N.H.	x	x	x	x	–	x(5)	–	–	96	750	1000	1200
Valcartier, Quebec	x	x	x	x	x	x(2)	–	–	98	–	–	1000
St. Charles, Quebec	x	x	x	–	–	–	–	–	–	–	–	–
Halifax Co., N. S.	x	x	x	x	x	x(2)	–	–	101	–	–	500
Digby Co., N. S.	x	x(x)	x	x	x	x(2)	–	(x)	99	–	–	–
St. John Co., N. B.	x(x)	x	x(x)	x	–	–	(x)	–	139	–	–	–
Central Acadia F.E.S., Sun. Co.,N.B.	x	x	x	x	x	x(2)	–	–	(96 (96	2250	–	100
East Acadia F.E.S., Sun. Co., N.B.	–	x	x	x	x	x(3)	100	–	93	–	–	1200
Year established	'59	'60	'60	'60	'60	'60	'59	'60	'60	'60	'60	'60
Spacing in feet	4x4	4x4	4x4	8x8	5x5	5x5	4x4	4x4	5x6[2]	6x6	?	?
Trees per plot	100	100	100	2	25	20–25						
Replications	5	5	5	25	3	1–5						

x Provenance trees plantcd in plots.

(x) Provenance trees used in division and surround rows.

[1] The number of replications are shown in brackets.

[2] Two rows per plot, 10 feet between plots, six feet between rows, and five feet between trees.

Table 2. VARIATION IN HEIGHTS OF 2-2 PICEA RUBENS IN THE NURSERY[1]

Provenance	Mean Height (cm.)	Coefficient of Variation (%)
Great Smoky Mts., N. C.	19.6	23.3
Glade River, Monongahela Nat. For., W. Va.	22.2	19.9
Bear Meadows, Centre Co., Penn.	29.0	31.6
October Mts., Berkshire Co., Mass.	21.6	26.1
Paul Smith, Franklin Co., N. Y.	22.7	33.4
Essex & Clinton Co.'s, N. Y.	27.4	28.6
Mt. Monadnock, 2300-2600 ft., Cheshire Co., N.H.	22.2	26.3
Pillsburry State Forest, 1550 ft., Sullivan Co., N. H.	28.9	23.5
Amherst, Handcock Co., Maine	26.6	20.7
Andorra Forest, 1700 ft., Cheshire Co., N. H.	25.8	22.3
Valcartier, P. Q.	27.1	30.4
St. Charles, P. Q.	27.1	33.6
Halifax Co., N. S.	28.5	29.6
Digby Co., N. S.	28.8	22.4
St. John Co., N. B.	25.8	21.4
Central Acadia F.E.S., Sunbury Co., N.B.	29.0	33.4
East Acadia F.E.S., Sunbury Co., N.B.	27.7	25.4

[1]Measured in mid-August, 1959.

leaders only. Forty such trees, randomly chosen, were measured from each lot.

(b) Seed from Maritime Provinces and Vicinity

Seed from 29 seed sources from Nova Scotia, New Brunswick and Maine were sowed in the Acadia nursery in the spring of 1959.

Selecting and Progeny Testing

The two best trees, and one of the poorest seed bearing trees, in each of 11 superior stands located in Nova Scotia and New Brunswick were selected. Scions from these trees were propagated by grafting. This material will be set out in the breeding garden and used in crossing experiments. Seed collected from the standing trees was sown in the nursery this spring to produce material for progeny tests.

ABIES BALSAMEA

Provenance Studies

(a) Provenances from the Maritime Provinces

An *A. balsamea* provenance experiment was planted at the Experiment Station in the autumn of 1958 using 2 - 3-year-old trees (the seed was sown in the spring, 1954). The site was level and fairly well drained. The trees were planted under an overstory that averaged about 50 square feet basal area per acre. The overstory was pruned to make planting easier. Slash from a previous cutting was burned. The overstory will be reduced by girdling and herbicide treatments.

The experiment consists of trees from eight provenances from within the Maritime Provinces. These were planted in six randomized blocks. Small observation plots of trees from five other provenances were also planted. The spacing is 4 x 4 feet. No division or surround rows were used. About 13,320 trees were planted.

(b) Provenances from the Atlantic Provinces, Quebec, Manitoba and New York

Seed lots from 16 sources in the Atlantic Provinces, Quebec, Manitoba and New York were sown in the spring of 1956. The establishment of a provenance experiment in New Brunswick, using this material was planned for the spring of 1960 but it was necessary to postpone it until the autumn. In the meantime the planting stock will be root pruned to reduce its growth.

(c) Provenances from Newfoundland (and Labrador) and New Brunswick

The purpose of this study is to determine whether heredity is a major factor in the reported (Wilton and Lewis, 1956 and Rowe, 1959) premature loss of vigor of A. balsamea in the southeastern part of the Island of Newfoundland: the Avalon, Burin and Bonavista Peninsulas. Seed for this study was sown in the spring of 1957. Plantings will be established in 1961 in New Brunswick and Newfoundland.

A nursery study showed that very significant differences (at .01 level) exist between the average number of cotyledons of different provenances (Table 3). There is a strong tendency for the averages to form two overlapping groups: one from New Brunswick having less cotyledons and one from Newfoundland (and Labrador) having more. There may be a relationship between this grouping and the relative abundance of A. b. var. phanerolepis in Newfoundland. No explanation is offered at this time for the difference (at the .05 level) between the averages for lots 5 and 11 (Table 3). Seed lots 5 and 11 were collected in the same area but in different years, 1956 and 1955 respectively.

No relationship was shown to exist between the cotyledon numbers in lots from seed sources where A. balsamea is reported to suffer a premature loss of vigor (lots 5, 9 and 11). Provenances from Newfoundland tend to have a greater number of cotyledons than those from New Brunswick and the differences were highly significant in some cases. Further study would be necessary to determine if factors other than geographic origin influence the number of cotyledons.

Table 3. AVERAGE NUMBER OF COTYLEDONS IN ABIES BALSAMEA

Provenance	Average[1]	± Least Significant Difference			
		0.05 Level		0.01 Level	
		- 0.09	+ 0.09	- 0.12	+ 0.12
1. Acadia F.E.S., N. B.	3.89	3.80	3.98	3.77	4.01
2. Green River, N. B.	3.95	3.86	4.04	3.83	4.07
3. McGivney, N. B.	3.96	3.87	4.05	3.84	4.08
4. Beaver Harbour, N. B.	3.99	3.90	4.08	3.87	4.11
5. Avalon Peninsula, Nfld.	4.02	3.93	4.11	3.90	4.14
6. Salmon River, N. B.	4.05	3.96	4.14	3.93	4.17
7. Sandy Brook, Nfld.[3]	4.05	3.96	4.14	3.93	4.17
8. Lake Melville, Labrador	4.06	3.97	4.15	3.94	4.18
9. Burin Peninsula, Nfld.[2]	4.11	4.02	4.20	3.99	4.23
10. Victoria Lake, Nfld.[2]	4.11	4.02	4.20	3.99	4.23
11. Avalon Peninsula, Nfld.[2]	4.14	4.05	4.23	4.02	4.26

Average for all samples - 4.03

Average for New Brunswick provenances - 3.97

Average for Newfoundland provenances - 4.08

[1] Based on nine samples of 20 seedlings each from each provenance.

[2] Seed from *Abies balsamea* var. *phanerolepis*.

[3] Seed from mixture of *A. balsamea* and *A. balsamea* var. *phanerolepis*.

Breeding

The breeding with Abies is aimed at producing hybrids suitable for use in the Maritime Provinces. Such hybrids should not be susceptible to attack by Adelges piceae. The spring of 1960 was the first time that freshly produced exotic Abies pollen was available at the proper time for pollination. Pressure of other work made it impossible to get the isolation tents up before a few male flowers on exposed trees had begun to shed their pollen. Abies alba, A. amabilis and A. homolepis pollen were each used to pollinate the female flowers on two A. balsamea. A. koreana pollen was used on two additional A. balsamea that had been exposed to wind-borne pollen.

No crosses were made in 1959. In 1958, crosses were attempted on nine trees using old A. grandis, A. cephalonica, A. nobilis and A. nordmanniana pollen that had been kept in cold storage. The control indicated that some pre-isolation pollination may have taken place. Besides this, four tents were loosened by high winds. All trees produced some viable seed. Examination of the one-year-old seedlings showed that they resembled Abies balsamea. However, further observations may reveal the presence of some hybrids.

EXOTICS

Abies

In the spring of 1959, the establishment of exotic Abies observation plots at Acadia Forest Experiment Station was initiated. These plots are intended to serve as preliminary tests of exotic Abies in the Maritimes, and as a source of breeding material. In 1959 small lots of Abies ernestii, A. homolepis, A. koreana, A. koreana x A. veitchii, A. vilmorinii, A. nordmanniana and A. balsamea, totalling about 2000 trees, were planted.

The A. balsamea was included for comparison. In 1960 A. alba, A. koreana, A. grandis, A. concolor and also A. balsamea plots were added with a row of A. balsamea between each exotic species. A total of about 3900 trees were planted at this time. The spacing is 4 x 4 feet. Specimen trees of Abies alba, A. concolor, A. ernestii, A. grandis, A. homolepis, A. koreana, A. koreana x A. veitchii, A. nobilis, A. nordmanniana, A. pinsapo, A. veitchii and A. vilmorinii spaced 25 x 25 feet were planted in the arboretum during the spring of 1959.

Larix

Three small lots of Larix decidua, two of these from known seed sources and three lots of L. d. var. polonica along with one lot of L. kurilensis, all of known seed sources were planted in the arboretum in the spring of 1960. A few L. laricina x L. leptolepis, L. laricina x L. laricina, L. leptolepis x L. leptolepis and progenies of two L. decidua and one L. leptolepis that may have crossed naturally with each other were also planted here. L. laricina was planted along at least one side of each of the above plots for comparison. Spacing in these plots is 10 x 10 feet. About 624 Larix, all three years old, were planted in the arboretum.

Other Exotics

Other exotics added to the arboretum include specimen trees of Picea pungens, P. pungens argentea, and P. pungens pendula[2], Pinus mugo, P. mugo rotundata, P. nigra, P. ponderosa, P. rigida, P. sylvestris, P. sylvestris argentea, and P. thumbergii; and Pseudotsuga taxifolia. A small lot of Picea orientalis was also added.

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[2] Status unknown, listed in Index Seminum (1954).

PINUS RESINOSA

Provenance Study

The Pinus resinosa provenance experiment, established in the spring of 1958 on the Chignecto Game Sanctuary in Nova Scotia was visited in 1959. Mortality was less than four per cent. The dead trees were replaced. Fifty-nine per cent of the trees had been damaged by browsing. The experiment will be re-examined in 1960 to determine whether deer or rabbits caused the damage.

NURSERY

There were, according to estimates made in August, 1959, about 99,000 three-year-old transplants in the nursery of which, some 24,000 were Abies balsamea for the Newfoundland and New Brunswick provenance study mentioned earlier; 2,000 A. balsamea for progeny trials of superior Christmas trees; 48,000 Picea abies from 12 seed sources; and the remainder was made up of miscellaneous lots of Abies, Larix and Picea. The 2-0 stock consisted of about 340,000 seedlings for the Province of New Brunswick and about 45,000 for research in tree-improvement and reforestation. The 1-0 seedlings numbered between 600,000 and 700,000. These were made up of about 100,000 trees for the Province, 400,000 or 500,000 Picea rubens from 30 seed sources; about 100,000 Larix leptolepis, L. decidua and L. laricina; and 28,000 Abies. All surplus seedlings will go to the Province after research needs have been met. Early frost in September, 1959 greatly reduced the Larix leptolepis. L. decidua was damaged to a lesser extent. This frost browned the tops of many Picea rubens. Frost heaving in the spring of 1960 was noticeable. The losses in the L. leptolepis were the most serious as this material came from 22 defined seed sources in Japan.

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