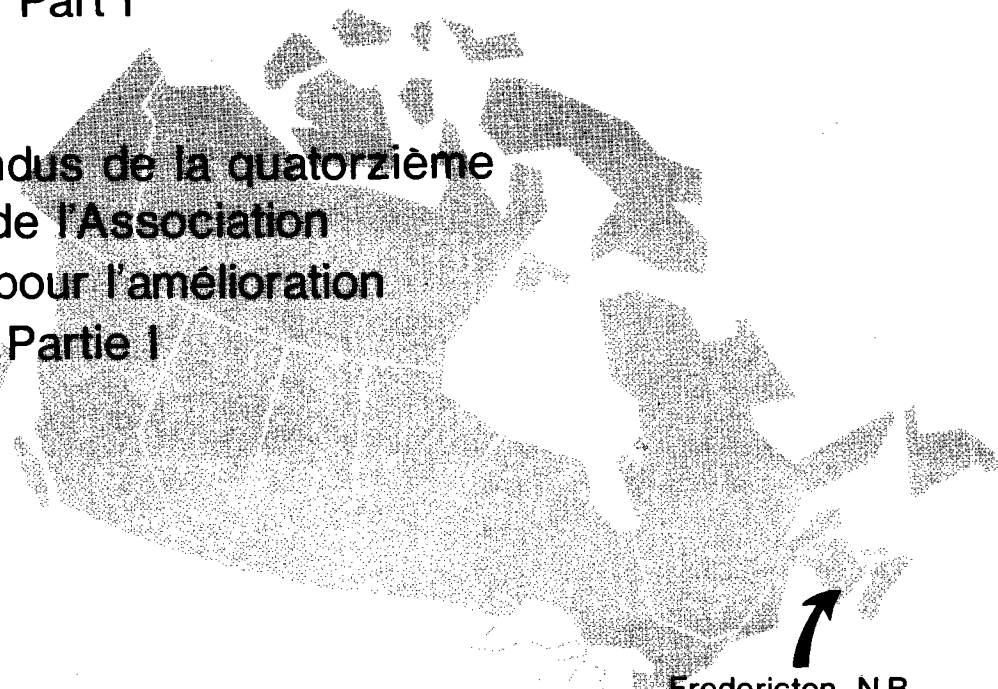
Proceedings of the fourteenth meeting of the Canadian Tree Improvement Association: Part I

Comptes rendus de la quatorzième conférence de l'Association canadienne pour l'amélioration des arbres: Partie I



Fredericton, N.B.
August 28-30, 1973

MINUTES AND MEMBERS' REPORTS
PROCÈS-VERBAUX ET RAPPORTS DE MEMBRES

PROCEEDINGS OF THE FOURTEENTH MEETING OF

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association.

Please file permanently in your institution library.

Enquiries may be addressed to the authors or to Mr. K. Illingworth, Executive Secretary, C.T.I.A., Research Division, British Columbia Forest Service, Victoria, B.C., Canada.

The Fifteenth Meeting of the Association will be held at the Petawawa Forest Experiment Station, Chalk River, Ont., in August 1975. Canadian and foreign visitors will be welcome. Detailed information will be distributed early in 1975 to all members and to others upon request.

If your name, title or address is incorrect or imcomplete, please complete and return this correction slip.

TO: Mr. K. Illingworth, Executive Secretary, Canadian Tree Improvement Association, British Columbia Forest Service, Victoria, B.C., Canada.

NAME: Prof.
Dr. Mrs.
Mr. Miss .... Title ....

INSTITUTION: ....

ADDRESS: ....

.... Postal Code ....

Please correct my name and address as above.

Signed ....

PROCEEDINGS OF THE FOURTEENTH MEETING OF THE CANADIAN TREE IMPROVEMENT ASSOCIATION*

Fredericton, New Brunswick, August 28-30, 1973

PART 1

Minutes and Members' Reports

COMPTES RENDUS DE LA QUATORZIÈME CONFÉRENCE DE L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES**

Fredericton (Nouveau-Brunswick), août 28-30, 1973

1re PARTIE

Procès-verbaux et Rapports de membres

Held jointly with the
Twenty-first Northeastern Tree Improvement Conference

Editors: K. Illingworth and C.W. Yeatman

* Formerly Committee on Forest Tree Breeding in Canada

** Précédemment le Comité canadien d'amélioration des arbres forestiers

Part 1	Minutes and Members' Reports was distributed to Association members and is available to others on request.
Part 2	Symposium, Interspecific and Interprovenance Hybridization of Forest Trees, received worldwide distribution to persons and organizations actively engaged or interested in forest genetics and tree improvement.
1re partie	Procès-verbaux et Rapports de membres distribués aux membres de l'association. Distribution générale sur demande.
2e partie	Colloque sur l'hybridation interspécifique et interprovenances des arbres forestiers. Distribution à l'échelle mondiale aux personnes et organisations activement engagées ou intéressées dans la génétique forestière et l'amélioration des arbres.

Produced by the Canadian Forestry Service
Department of the Environment for the
Canadian Tree Improvement Association
Ottawa, 1975

CONTENTS

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1974
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Dr. C.W. Yeatman	Canadian Forestry Service Petawawa Forest Experiment Station Chalk River, Ont.
Dr. L. Zsuffa	Ontario Ministry of Natural Resources Research Branch Southern Research Station Maple, Ont.

BUSINESS MEETING - MINUTES

Eighteen members attended the business meeting, which was convened on the afternoon of 29 August, 1973, Dr. D.P. Fowler in the chair.

154. MINUTES OF THE LAST MEETING

On a motion by C.H. Lee, seconded by C. Larsen, the minutes of the last meeting were adopted as published.

155. MEMBERSHIP

a) New Members. The following new members were duly elected:

Sponsoring:
Dr. B.B. Migikovsky, Canada Department of Agriculture
Mr. G.C. Warrack, British Columbia Forest Service
Active:
Mr. C. Hewson, British Columbia Forest Service
Dr. G. Murray, Lakehead University.
Mr. G.R. Powell, University of New Brunswick
Corresponding:
Mr. E.F. Bulley, Bowaters Mersey Paper Co.
Mr. N. Kreiberg, J.D. Irving Ltd.
Mr. D. Levey, Nova Scotia Department of Lands and Forests
Mr. T.S. Murray, New Brunswick Department of Natural Resources
Dr. J.B. Scarratt, Canadian Forestry Service

b) Change in Membership Status. Upon request, changes in membership status were recorded as follows:

Sponsoring to Corresponding - Dean J.W.B. Sisam
Corresponding to Sponsoring - Dr. R.E. Foster
- Dr. A. Lafond
- Dr. V.J. Nordin
- Mr. L.A. Smithers

c) Resignations:

R.K. Allen, J.A. Anderson, W.H. Brittain, L. Ebell, L. Holt, E.L. Howie, R.R. Lejeune, J.H. Mortimer, E. Porter, L. Roche, K.J. Roller, R.H. Spilsbury, J. van der Feyst, J.E.D. Whitmore.

Y. Lamontagne, seconded by A. Teich, moved the adoption of the membership report. *Carried.*

156. CHANGE OF NAME

Dr. Fowler announced that, in consequence of a ballot on the name change approved at its thirteenth meeting, the Committee on Forest Tree Breeding in Canada would, henceforth, be known as the Canadian Tree Improvement Association/Association canadienne pour l'amélioration des arbres.

157. CONSTITUTION AND BYLAWS

The draft constitution and bylaws was prepared by a subcommittee comprising Drs. A. Carlisle (Chairman), H.S.D. Swan, and A.L. Orr-Ewing. In their absence, D.P. Fowler presented it to the meeting for discussion and acceptance.

Speaking on behalf of A. Carlisle, E.K. Morgenstern expressed agreement with the bylaws excepting Article XII. After debate, H.G. MacGillivray, seconded by S.A.M. Manley, moved that Article XII be amended to read: "A quorum shall consist of a presiding officer conducting the meeting, a secretary and 15 members." *Carried.*

A motion by J.I. Klein, seconded by C.W. Yeatman, to amend Article III, objectives, was defeated.

M.A.K. Khalil expressed a need to debate further the need for a constitution or charter. What advantages did it confer and what were its attendant obligations? D.P. Fowler countered that these points had been debated exhaustively prior to acceptance of the "Report on the Committee on Forest Tree Breeding in Canada" at the thirteenth meeting, that it had been distributed to members for study, and that its acceptance, with or without amendment, was now the issue.

C.W. Yeatman, seconded by C.H. Lane, moved that the draft constitution and bylaws, as amended, be accepted as the constitution and bylaws of the Canadian Tree Improvement Association. *Carried.*

158. WORKING PARTY FOR THE CONSERVATION OF ENDANGERED ARBOREAL GERM PLASM

Dr. C.W. Yeatman reported for this subcommittee, which comprises C.W. Yeatman (Chairman), W.G. Dyer and K. Illingworth.

The C.T.I.A. policy statement on the conservation of forest gene resources, drafted at the thirteenth meeting, was presented and explained to the C.I.F. natural areas committee at the sixty-third annual meeting of the Canadian Institute of Forestry in October, 1971.

C.W. Yeatman tabled his paper, *Gene Pool Conservation for Applied Breeding and Seed Production* (Tokyo 1972), as a basis for the formulation of a national policy on gene pool conservation. Discussion of proposals for the implementation of such a policy was to have followed but was deferred for lack of time.

The subcommittee was, therefore, directed to prepare and submit their resolutions to the membership in the near future.

159. LOCATION OF NEXT MEETING

An invitation from the Canadian Forestry Service to hold the next meeting at Petawawa Forest Experiment Station in September 1975, was accepted.

After discussion on a suitable theme for the meeting, D.P. Fowler proposed that this should be left to the discretion of the incoming executive.

160. ELECTION OF OFFICERS, 1973-75

Moved by K. Morgenstern, seconded by C.H. Lane, that C.W. Yeatman be elected Chairman. *Carried.*

Moved by C.W. Yeatman, seconded by M.A.K. Khalil, that K. Illingworth be elected Secretary. *Carried.*

161. APPRECIATION

On behalf of all members of the Canadian Tree Improvement Association, C. Larsson thanked the Canadian Forestry Service for hosting the fourteenth meeting, and expressed special appreciation to D.P. Fowler, H.G. MacGillivray and their staff for their organizational efforts.

FOREST GENETICS RESEARCH IN NEWFOUNDLAND

M.A.K. Khalil

Canadian Forestry Service
Newfoundland Forest Research Centre
St. John's, Newfoundland

INTRODUCTION

This report deals with the period since the previous report, in August 1970. During this period the tree improvement research program was reviewed and a revised one finalized (Khalil 1972).

This program aims at acquiring basic knowledge of the genetics of selected local and exotic species so as to permit production of genetically superior seed and vegetative planting material in commercial quantities. The following broad objectives have been established.

1. To determine the degree and patterns of variation in local species, by provenance trials, for delineation of seed zones for various regions of the province.

2. To estimate genetic parameters of local species by progeny trials for their genetic improvement by selection hybridization.

3. To enrich the local resources by introducing suitable provenances of exotic species.

4. To improve the local and exotic species by hybridization and, possibly, by polyploidy.

5. To help forest managers in the selection and management of seed production areas, seed orchards and clone banks for commercial production of certified genetically superior seed and clonal material.

During the period under review research was in progress on four native species, viz. black spruce, *Picea mariana* (Mill.) B.S.P., white spruce, *Picea glauca* (Moench) Voss, balsam fir, *Abies balsamea* (L.) Mill. and trembling aspen, *Populus tremuloides* Michx. and on a number of exotics, viz. red spruce, *Picea rubens* Sarg., Sitka spruce, *Picea sitchensis* (Bong.) Carr. and hybrid and exotic poplars.

BLACK SPRUCE, *PICEA MARIANA* (MILL.) B.S.P.

The three studies in progress are summarized as follows:

Regional Provenance Trial

This study was started in 1968 and is based on 31 Newfoundland-Labrador and eight mainland provenances.

Cone length, cone width and their ratio for the 28 Newfoundland Island provenances were determined and the results were statistically analyzed. Cone length and cone width are highly correlated and the variation of these characters in Newfoundland is ecotypic.

Data collected on the phenology and growth of seedlings in the replicated nursery experiment at Pasadena in western Newfoundland were statistically analyzed and provide the following conclusions:

1. The variation in phenology and growth characters in Newfoundland is ecotypic. The mainland provenances form an ecotype different from the Newfoundland ecotypes. The ecotypes on the Island of Newfoundland correspond to Rowe's forest sections (Rowe 1972).

2. The provenances from the Northern Peninsula have the highest frequency of single leaders, and this gradually decreases southward. The mainland provenances have the highest frequency of multiple leaders.

3. The local provenances from forest section B.28a are the closest to the nursery mean in growth. Six of the mainland provenances have shown the best height and root-collar diameter growth, and those from Labrador, Northern Peninsula and northern parts of the Island have generally shown the poorest results. Three of the mainland provenances, viz. Petawawa, Ont., Farrington, P.E.I., and Valcartier, Que., exhibited consistently superior growth from 1969 to the fall of 1971. Provenances from Pistolet Bay, Plum Point and Harbour Deep, on the Northern Peninsula have shown the poorest growth. Table 1 shows the relative performance of these six provenances.

4. The above three mainland provenances are, however, most susceptible to frost damage, and the three slowest-growing provenances from the Northern Peninsula are the least susceptible to this injury. The frost damage occurred only once in four years and only 30 percent of the seedlings of the mainland provenances had damaged leaders. The damage was not severe.

5. It appears that the three mainland provenances have so much advantage in terms of growth over the local and the Northern Peninsula provenances that, despite some frost damage, they can be tentatively accepted to be the most suitable for western Newfoundland unless subsequent field trials show different results.

6. Provenances with heavier seed produce more viable and faster-growing seedlings than those with lighter seed. The height growth patterns in different provenances are also maintained consistently from year to year.

TABLE 1. RELATIVE GROWTH OF THE THREE BEST AND THE THREE POOREST PROVENANCES OF BLACK SPRUCE IN WESTERN NEWFOUNDLAND IN 1971 FALL

Provenance	Height		Root-collar diameter	
	Actual (cm)	Percentage of the mean	Actual (mm)	Percentage of the mean
Petawawa Forest Experiment Station, Ont.	52.62	127	10.20	115
Queen's County, P.E.I.	51.22	123	10.55	119
Valcartier, Que.	53.02	127	11.20	127
Pistolet Bay, Nfld.	29.90	72	6.87	78
Plum Point, Nfld.	29.82	72	6.75	76
Harbour Deep, Nfld.	28.42	68	6.80	77

Nursery mean height = 41.62 cm.
Nursery mean root-collar diameter = 8.83 mm.

All-Range Provenance Trial

Seed of 102 provenances was sown in unreplicated nursery beds at Pasadena in May 1971, and 2 + 0 seedlings were transplanted in nursery beds in spring 1973. Twenty provenances have insufficient seedlings for field trial.

Progeny Trials

Individual tree seed collection from open-pollinated cones was carried out at seven locations from which seed for provenance trials was collected in 1967. Ten trees were selected at each location. Age, height and diameter at breast height of each tree were determined. Cones were kept separate by locations and by trees. Seed was extracted, dewinged and cleaned.

One control pollination was done, with three male and six female trees, one male tree being used for two female trees. Cones were collected and seeds were extracted, dewinged and cleaned. Open-pollinated cones from other areas will be collected this year, and all seed will be sown in replicated nursery beds in the spring of 1974.

WHITE SPRUCE, *PICEA GLAUCA* (MOENCH) VOSS

The Lake States-St. Lawrence region provenance experiment was continued. Information about precocious flowering of some provenances was furnished to the Petawawa Forest Experiment Station.

A new study was initiated in 1971 in the Exploits River Valley to determine whether the phenotypic superiority of some trees and stands was genetically controlled. Individual tree seed collected from "ordinary" and "plus" trees in the fall of 1971 in the Frenchman's Pond and Lake Douglas areas was stratified and sown in the laboratory and in the nursery at Pasadena. Statistically significant differences between locations were observed. The germination of seed from ordinary trees was significantly higher than that from plus trees from the Lake Douglas area in the laboratory experiment but not in the nursery experiment. There was no difference between these classes of trees from Frenchman's Pond in either experiment. The seed from the Frenchman's Pond area had statistically higher germination than that from the Lake Douglas area. Soil and foliage samples from each tree were also analyzed. These results indicate that the soils under ordinary trees were poorer, but not significantly so, than those under plus trees for organic carbon and total as well as available N, P, K, Ca and Mg. Similarly in most cases the needles of ordinary trees were lower, but not significantly so, than those of plus trees in N, P, K, Ca and Mg. This indicates possible genetic superiority of the plus trees over ordinary trees.

Repeatability and variation of the characters of cone morphology were studied to estimate their heritability and whether they can be used as criteria for selection of plus trees. The results indicate that, though most of these characters have high heritability, they cannot be used for selection of plus trees.

BALSAM FIR, *ABIES BALSAMEA* (L.) MILL

Two provenance experiments were started in 1961 to test the hypothesis that the characteristic of early fast height growth and its subsequent retardation observed on the Avalon Peninsula and adjoining areas is genetically controlled. These experiments, which are located at Salmonier in the Avalon Peninsula and at Cormack in western Newfoundland, were remeasured in the fall of 1970. Four provenances were used in each experiment, viz., those of the Avalon Peninsula and Sandy Brook in Newfoundland and Acadia and Saint John's County in New Brunswick. Though the Avalon Peninsula provenances have the best form at both locations, the differences in height growth are not statistically significant.

TREMBLING ASPEN, *POPULUS TREMULOIDES* (MICHX.) AND HYBRID AND EXOTIC POPLARS

An experiment was started in 1972 to determine the suitability of some selected hybrid and exotic poplars in Newfoundland in comparison with phenotypically superior clones of native trembling aspen, and to determine whether genetic differences exist among the selected phenotypically superior clones of local trembling aspen.

Cuttings of 40 hybrid and exotic poplars and some clones of native trembling aspen received from the Southern Forest Research Station of the

Ontario Department of Natural Resources, Maple, Ont., were planted in the Pasadena nursery in western Newfoundland on June 2, 1972. Survival in 1972 was very good. Only two clones, viz., A.547 (*Populus alba*) and DN.41 (*P. euramericana*), both originally from Grand Falls, completely failed. Only five of the remaining clones had less than 50 percent survival. These were CAG.25 and CAG.118 (*P. canescens*) x (*P. alba* x *grandidentata*) from Toronto, G.A. 87 and G.A. 88 (*P. grandidentata* x *alba*) and A.T. 42 (*P. alba* x *tremuloides*).

The 40 clones were grouped into five major classes, with mean heights after one growing season as follows:

Name	Mean height (in.)
Populus tremuloides	21.71
DN (*P. euramericana*, 7 cultivars and 2 clones	18.60
JACKII (*P. jackii* x *tacamahaca* x *deltoides* and *P. balsamifera* x *deltoides*)	18.41
IH (*P. euramericana*), Italian hybrid	13.86
CAG [*P. canescens* x (*alba* x *grandidentata*)]	11.92

On the basis of students' "t" test, all the classes except DN and *jackii* are significantly different from each other in height growth.

Root sections were collected from the phenotypically best tree in each of 23 selected phenotypically superior stands of native trembling aspen in Newfoundland. Age, height and dbh of each tree were measured. The root sections were kept separate, by trees, in polyethylene bags packed in wet peat moss after treatment with Captan. It had been planned to initiate experiments in 1972, but this was impossible owing to difficulties in preparing a greenhouse. It was therefore necessary to keep the sections in cold storage over winter.

RED SPRUCE, *PICEA RUBENS* SARG.

A 30-provenance, 10-replicate experiment in randomized complete-block design was laid out in 1964 in the North Pond Experimental Area in east-central Newfoundland. Of the 30 provenances used, 27 were obtained from the Maritime Provinces, two from West Virginia and one from Maine, in the United States. The planting stock of 2 + 2 seedlings supplied by the Maritime Forest Experiment Station was used. The results of the first measurements are being published in an information report and are summarized as follows:

Survival

1. Survival is very good and only occasional trees in the four-tree plots have died.

Height

2. The mean, maximum and minimum heights in the fall of 1972 were 111.2, 139.6 and 93.8 cm respectively. This height growth compares favorably with the average growth of 128 cm at the age of 12 years in the northeastern United States (Fowells 1965).

3. The four best provenances are from New Brunswick and the four poorest are from the southern sources, viz., southern New Brunswick, Nova Scotia, Maine and West Virginia. Table 2 shows the relative performance of these provenances.

TABLE 2. RELATIVE PERFORMANCE OF THE FOUR BEST AND THE FOUR POOREST RED SPRUCE PROVENANCES IN 1972 FALL

Provenance	Height (cm)	Percent of plantation mean
14. Upper Blackville, N.B.	139.63	126
16. East End, Maritime Forest Experiment Station, N.B.	138.88	125
17. Boyne Road, Sunbury County, N.B.	130.35	117
15. Rocky Brook, York County, N.B.	122.95	111
11. Cannaan Mountain, W.Va.	96.35	87
10. Economy River, Colchester County, N.S.	95.88	86
26. Penebscot Forest Experiment Station, Maine, U.S.A.	94.55	85
25. West of Great Salmon River, Saint John County, N.B.	93.78	84

Note: 1. Plantation mean height = 111.21 cm.
2. The four best and the four poorest provenances are not significantly different from each other.

4. Variance among provenances within replications is significant at the 0.01 level, indicating a strong provenance x replication interaction.

5. Though considerable within-plot variation is noticeable and has been found to be statistically significant in 12 plots, it does not appear to be caused by introgressive hybridization with black spruce. Trees in these plots, scored on the basis of the criteria of Manley (1971), did not show positive evidence of hybridization.

6. The following geographical patterns of growth are noticeable:

i. The New Brunswick provenances are faster-growing than Nova Scotia provenances.

ii. Within New Brunswick the inland provenances are faster-growing than those on the southern coast.

iii. There is no significant difference between the northern and the southern provenances within Nova Scotia. However, among the northern provenances those from the coast of the Bay of Fundy are faster-growing than those from the coast of the Gulf of St. Lawrence. This difference tends to be reduced with age.

iv. There is no significant difference between the provenances from the two coasts of the Bay of Fundy.

v. There is no significant difference between the provenances from the southern coasts of New Brunswick and Nova Scotia.

Root-collar Diameter

7. The mean, maximum and minimum root-collar diameters are 3.7, 4.2 and 3.0 cm respectively. Of the four best provenances two are from Nova Scotia and two from New Brunswick and, of the four poorest ones, one is from New Brunswick, two are from Nova Scotia and one is from Maine.

8. The only geographical pattern noticeable is that the provenances from inland New Brunswick are superior to those from its southern coast.

Phenology

9. The dates of commencement of bud setting of the four fastest-growing provenances are September 8-18 which are appreciably earlier than September 20, which is the mean date of fall frost for Gander, the nearest meteorological station. It therefore appears that these four provenances may be most suitable for east-central Newfoundland.

SITKA SPRUCE, *PICEA SITCHENSIS* (BONG.) CARR.

The Sitka spruce, *Picea sitchensis* (Bong.) Carr., provenance trial was continued at nine locations. The seedlings were tallied for damage due to winter desiccation in the 1970-71 and 1971-72 winters in locations where this damage was appreciable. Where present, the damage was always observed on the portion of the seedlings above the show, but no seedlings were killed. Tables 3 and 4 show the percentage of seedlings damaged in the 1970-71 and 1971-72 winters respectively.

TABLE 3. SUMMARY OF WINTER DAMAGE TO SITKA SPRUCE IN 1970-71 WINTER

Test location	Latitude (N)	Longitude (W)	Percent seedlings damaged	Provenances with highest percentage of damaged seedlings
Roddickton	50°56'	56°12'	20.4	54(74%), 18(59%), 30(39%)
Sandy Brook	48°46'	56°01'	12.5	3(55%), 18(45%), 31(25%)
Crabbes River	48°08'	58°38'	7.2	18(73%), 54(60%), 30(25%)
Sheffield Lake	49°21'	56°35'	6.3	54(54%), 18(48%), 30(34%)
New Bay Pond	49°13'	55°34'	15.5	18(56%), 54(47%)
Big Falls	49°16'	57°09'	16.1	54(34%), 18(24%)
Little George's Lake	48°46'	58°01'	11.9	3(41%), 18(25%)

TABLE 4. SUMMARY OF WINTER DAMAGE TO SITKA SPRUCE IN 1971-72 WINTER

Test location	Latitude (N)	Longitude (W)	Percent seedlings damaged	Provenances with highest percentage of damaged seedlings
Roddickton	50°56'	56°12'	>75.0	Most provenances damaged
Sheffield Lake	49°21'	56°35'	57.7	18(92%), 54(81%), 30(66%)
New Bay Pond	49°13'	55°34'	56.8	38(84%), 18(82%), 30(80%), 32(76%)
Sandy Brook	48°46'	56°01'	56.2	31(88%), 3(81%), 32(77%), 18(77%)
Big Falls	49°16'	57°09'	39.8	18(71%), 38(65%), 54(59%), 30(56%)
Crabbes River	48°08'	58°18'	35.7	18(59%), 32(47%), 54(43%), 30(42%)
Little George's Lake	48°46'	58°01'	Negligible	-

The four provenances most severely damaged in the 1970-71 winter were nos. 3, 18, 30 and 54. They are all from the states of Washington and Oregon, with latitudes between 48°50' N and 44°46' N. These and three additional provenances, viz., nos. 31, 32 and 38, suffered the highest damage in the 1971-72 winter. These three provenances originated on the Queen Charlotte Islands, where they were adjusted to maritime climate, albeit in the more northern latitudes of 53° to 54° N.

The mean temperatures from December to March were 1 to 6 degrees lower than the average at all these locations except Roddickton in the 1970-71 winter and 3 to 9 degrees lower than the average in the 1971-72 winter. All locations had several days with temperatures above 42°F when the parts of the seedlings above the snow cover suffered from winter desiccation.

Though Roddickton did not have an unusually severe winter in either of these 2 years, the normal winter there is perhaps too severe for all these provenances. In this area the temperature falls below 42°F about October 4 and winter minima range from -10°F to -25°F.

Mortality due to *Armillaria mellea* (Vahl. ex Fr.) Kummer root rot was noticed and tallied at five locations in fall 1972. The results are summarized below:

Location	Percent mortality
Sandy Brook	15.0
Crabbes River	13.7
Big Falls	7.4
Sheffield Lake	4.5
New Bay Pond	6.6

Analyses of variance and Duncan's multiple range tests showed that all provenances were equally affected at all locations except at New Bay Pond, where provenance 4 from Bella Coola, B.C., suffered the highest mortality, - 20 percent. The effects of this disease will be kept under observation.

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TREE BREEDING AT THE MARITIMES FOREST RESEARCH CENTRE, 1971 AND 1972

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INTRODUCTION

The objectives of the tree improvement work at the Maritimes Forest Research Centre are:

1. To determine the level of genetic improvement possible with promising native and exotic genera and to provide the provincial governments and industries of the region with the information and breeding materials required to attain a realistic level of improvement in materials used for reforestation.

2. To assist the provincial governments and industries to establish and execute programs leading to the use of genetically superior trees for reforestation.

3. To provide information on the role of genetic variations in the behavior of wild stands, particularly as it relates to such problems as the spruce budworm.

Since 1970, the Maritimes Forest Research Centre has participated in a number of contracts in applied aspects of tree improvement with the provincial governments of New Brunswick and Nova Scotia. The objective of these contracts is to stimulate the provincial organizations to undertake meaningful programs in applied tree improvement. With the aid of these contracts in 1970 and 1971, the Province of New Brunswick started a program of plus stand selection in black spruce (*Picea mariana*). About 40 very good stands have been located and reserved as seed production stands. As soon as it is possible to obtain seeds, progeny tests will be established to determine which stands are genetically superior. These stands will be used as general purpose seed sources for reforestation.

In 1972, a contract with the Province of New Brunswick was undertaken for the selection of plus trees of black spruce. Seeds from these trees will be used to establish a seedling seed orchard. To date, 37 plus trees have been selected. Since the first contracts were undertaken, the province has retained the services of a professional forester and provided him with technical assistance to work on applied tree improvement. These programs now include similar stand and tree selection work on jack pine (*Pinus banksiana*) and white spruce (*Picea glauca*).

In 1971, Dr. S.S. Sidhu accepted a contract to develop criteria and methods for the selection of white spruce stands in Nova Scotia. A report (Sidhu 1972) was prepared on the work. The work on stand selection was continued, under contract, in Nova Scotia in 1972. The 1972 contract assisted in stand selection with nine important native and exotic species. A total of 101 stands were selected for further evaluation. A report on this work is being prepared for publication by R.E. Bailey of the Nova Scotia Department of Lands and Forests.

A position for a reforestation and applied tree improvement consultant has been approved and it is hoped that it will be filled during the summer of 1973.

BREEDING AND BREEDING SYSTEMS OF FOREST TREES
D.P. Fowler

The objectives of this study are: (a) to determine the existing potential genetic variability of promising native and exotic species and (b) to provide information and breeding material that will make possible the mass production of genetically improved trees for the region.

Because of the present importance of *Picea* species and the potential importance of *Larix* species and hybrids for reforestation, work has been concentrated on these genera. Some work on *Pinus* species has also been undertaken.

Picea

The hybrid *Picea omorica* x *P. mariana* (and reciprocal) has proved to be the most promising spruce hybrid thus far under test in the region. Early field tests indicate that this hybrid has the good juvenile characteristics of black spruce and considerably better diameter growth. In 1972, an attempt was made to propagate selected individuals of this hybrid by stem cuttings for wider testing in the region. In addition, the cross *P. mariana* x *P. omorica* was made on a large scale in 1971 and 1972 for this same purpose. The success of this cross, on the basis of past experience, was much poorer than expected - possibly because of pollen of low viability. A number of exploratory crosses were also attempted in 1971 and 1972. This work is summarized in Table 1.

A second attempt was made in 1971 (see Fowler *et al.* 1971) to assist J.D. Irving Ltd. develop a clonal seed orchard of *P. mariana*. Cuttings from 48 young trees, selected in Irving plantations were rooted. About 1,800 rooted cuttings are at present in the nursery and will be ready for planting in the fall of 1973.

Forty plus trees of Norway spruce (*Picea abies*), which range from 11 to 17 in. dbh and 70 to 90 ft high at age 55 were selected. These will be grafted in 1973 and will be used to establish a clonal seed orchard of this species.

TABLE 1. RESULTS OF CONTROLLED *PICEA* POLLINATIONS 1971 AND 1972

Female parent	Male parent						
	P. abies	*P. glauca*	*P. glenhii*	*P. omorica*	*P. pungens*	*P. rubens -mariana*	*P. smithiana*
P. abies	1						
Selfing	1(2)						
	4.5(9)						
P. glauca	4	11	4	18	10	4	3
	0(750)	11(380)	3(893)	4(2,662)	10(724)	0(756)	3(443)
	-	8.0(3,051)	0.1(73)	.01(34)	3.3(2,390)	-	.3(144)
P. mariana				10			7
				8(1,264)			2(107)
				.3(318)			.2(24)

11 Number trees pollinated

11(380) Number crosses yielding full seeds (number cones)

8.0(3,051) Number full seeds/cone (number full seeds)

Larix

The objective of the larch improvement work is to select or develop superior strains of species or hybrids for use in the region.

Most European larch (*L. decidua*) and Japanese larch (*L. leptolepis*) and their hybrids are susceptible to early fall frosts when raised in nurseries in central and northern New Brunswick. Native larch (*L. laricina*) and Siberian larch (*L. siberica*) are more tolerant of fall frost. Between 1968 and 1970, many attempts were made to cross *L. laricina* with *L. decidua* and *L. leptolepis*. These crosses proved fairly difficult although by no means impossible to make. The hybrids from these crosses are being tested at present. In 1971 and 1972, *L. siberica* was used as pollen parent on selected *L. decidua*, *L. leptolepis* and *L. laricina* in an attempt to produce frost-resistant species hybrids. In addition, a number of exploratory species crosses were attempted. The results of this work are presented in Table 2.

TABLE 2. RESULTS OF CONTROLLED *LARIX* POLLINATIONS 1971 AND 1972

Female parent	Male parent			
	L. decidua	*L. occidentalis*	*L. siberica*	*L. gemelini*
L. decidua	7 8(223) 22(4,912)	3 3(192) 1.5(286)	14 30(1,106) 21.1(23,340)	1 1(29) 22.3(647)
L. laricina		18 13(1,338) .2(222)	20 4(1,545) .01(13)	
L. leptolepis	4 4(78) 3.7(292)	2 1(69) .4(28)	11 11(189) 5.8(1,102)	
L. laricina x *leptolepis*	2 2(30) 8.5(254)		3 4(31) 1.7(53)	

7 Number trees pollinated
8(223) Number crosses yielding full seeds (number cones)
22.1(4,912) Number full seeds/cone (number full seeds)

One of the most promising larch hybrids being tested in the region is (*L. laricina* x *L. leptolepis*) x *L. decidua*. Seed-set from this cross has been fairly high and seedling growth has been exceptional. The phenology of flowering of the hybrid and that of *L. decidua* are similar enough to produce the three-way hybrid in seed orchards. Materials are at present being propagated for the establishment of such an orchard. In this orchard, one clone of the hybrid will be established with several selected populations of *L. decidua*, which will serve as the pollen parent.

Pinus

Red pine (*Pinus resinosa*) has proved to be extremely difficult to cross with other species. *P. resinosa* and *P. tropicalis* are the only two American species of the *Lariciones* group of pines. No attempts to cross these species have been reported.

Dr. P.W. Garrett, U.S. Forest Service, provided pollen to make this cross in the spring of 1972. A total of 433 ovulate flowers on nine *P. resinosa* were pollinated with *P. tropicalis* pollen.

PROVENANCE AND PROGENY STUDIES

H.G. MacGillivray

Trees for two studies in Norway spruce were spring-planted in 1972. The first consisted mostly of provenances and single-tree progenies from Yugoslavia and Bulgaria. This material was established in randomized blocks at the Acadia Forest Experiment Station in New Brunswick and in a milder climatic region in southwestern Nova Scotia. In the former location, the progenies were kept separate, but in the Nova Scotia plantation the progenies from each general area were mixed and treated as provenances. Surplus trees were planted in Nova Scotia by the provincial Department of Lands and Forests in unreplicated observation plots.

The second Norway spruce study consisted mostly of trees from seed collected in plantations along the New Brunswick coast of the Bay of Fundy and from one plantation at the Petawawa Forest Experiment Station in Ontario. The main purpose was to learn if the plantations in the relatively mild coastal climate along the Bay of Fundy would be suitable as seed sources for central New Brunswick. A replicated test was planted at Acadia, and surplus trees were planted in observation plots in the west-central part of the province. Native white, red (*P. rubens*), and black spruces were included in both Norway spruce studies as controls.

The all-range black spruce nursery study, spring-sown in 1971, was measured for first- and second-year tree heights in October 1972. These data, with weights for full-clean seeds and cotyledon numbers, are being compiled. Preliminary compilations indicate that the most northern provenances within each of 10 bands of longitude were generally the slowest growers in the nursery test. In the band of longitude including most of Labrador, eastern Quebec, the Maritime Provinces, and most of Maine (60° - 70° longitude), the height growth pattern appears to be more or less random. Besides this, when ranked according to average 2-year heights, most of the Nova Scotia provenances placed in the lower half. Hybridization with red spruce may be a factor in the growth of some New Brunswick provenances. The poorness of the seed years when many Nova Scotia and New Brunswick cone collections were made suggests that inbreeding, caused by self-pollination, may be another factor.

Survival and tree heights were recorded for two seed-source studies in balsam fir (*Abies balsamea*) and one each in white spruce, Norway spruce, red pine, and Douglas-fir (*Pseudotsuga menziesii*). Damage caused by the European pine shoot moth was recorded for one of the red pine test plantations on Prince Edward Island.

Trees with bluish green foliage and good natural density and profile, factors desirable in Christmas trees, were produced by some Newfoundland provenances of balsam fir that were outplanted in New Brunswick in 1961. Since then, other seed collections have been made from these same general areas. To date, the 2+2-year-old trees in the nursery from these collections have not exhibited any striking color differences from the controls. Greater maturity may be required before the bluish green of foliage develops. The differences in foliage color occurring in the 1961 plantations were not noticed until the trees had been outplanted for at least 2 years.

GENECOLOGY OF RED AND BLACK SPRUCE

S.A.M. Manley

Although the present distribution, ecology, and physiology of red and black spruces suggest that each species evolved in distinct niches, hybrid colonies are considered to be common in their overlapping range. Preliminary analysis of the genecology of the two species indicated that hybrids were restricted to intermediate habitats, while parental species were maintained as pure phenotypes in their preferred niches.

The objectives of the research are to determine the nature and relative importance of factors (i.e. isolating mechanisms) that prevented the formation of a species complex in the zone of sympatry.

Incompatibility barriers, even weakly developed, could restrict gene exchange. Controlled pollinations were used to evaluate the cross-compatibility among red spruce, black spruce, and natural hybrids. The actual frequency of natural hybridization, before selective adjustment at the seedling stage, was estimated by analysis of progeny grown from seed collected in adjacent populations of pure red and black spruces. Hybrids were identified from measurement of growth responses and morphology and from comparative enzymology.

Natural selection may also enforce species differences through ecological isolating mechanisms that operate after the formation of hybrids. Progeny obtained from controlled pollinations were grown under uniform conditions in growth chambers and in the field to compare the fitness of hybrids relative to parental species. Controlled environment experiments were directed at partitioning the effect of important growth variables such as light, temperature, and moisture. In the field, replicated samples of the progeny were established in each parental habitat. Field experiments indicate the synergistic effect of the environment and provide a realistic measure of natural selection.

In addition to determining the strength of reproductive isolating mechanisms in controlled experiments, a field survey was undertaken to determine the effectiveness of the isolation in natural populations. The presence of an intermediate habitat may result in hybridization because of a breakdown in ecological isolation. The field survey was conducted in New Brunswick, Nova Scotia, and Prince Edward Island, where the admixture of boreal and temperate environments permits extensive sympatry of the two species. Natural populations were analyzed by means of hybrid index techniques with the objective of quantifying the frequency of natural hybridization.

A unique contribution to evolutionary theory will be made if the role of the various isolating mechanisms contributing to sympatric coexistence are quantified by these data.

TISSUE AND ORGAN CULTURE

J.M. Bonga

The production of homozygous lines and the subsequent crossing of these lines to produce heterotic hybrids has been successfully used as a breeding technique with agricultural crops. Because of the long period between generations, this method has been avoided by most tree breeders.

For some agricultural crops, in particular tobacco, haploid tissue culture is being used routinely to develop new homozygous lines. With this technique, haploid adventitious embryos are obtained from immature pollen. By colchicine or other treatment, these embryos are then turned into homozygous diploid plants. If this technique could be applied to forest trees, the long period required to produce homozygous diploid trees through inbreeding could be circumvented.

These considerations have led to the following experiments:

Tissue cultures were prepared of haploid microgametophytes of *Pinus resinosa* and megagametophytes of *Pinus austriaca*, *Pinus mugo*, and *Picea abies*. Rapidly growing haploid callus masses were obtained, which are being subcultured at regular intervals. Some of these calluses formed proembryo-like structures. Attempts are being made to grow these into seedlings.

Vegetative propagation of conifers is often difficult with conventional techniques. New techniques should therefore be developed. At present, we are attempting to root conifer buds on nutrient media under aseptic conditions. Aseptic techniques have the advantage of allowing application of root-stimulating organic chemicals, which would decompose under non-aseptic conditions.

Buds of *Abies balsamea* have grown into short shoots with a good callus at the base. However, they have not produced roots so far.

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NEW BRUNSWICK TREE IMPROVEMENT PROGRAM

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INTRODUCTION

The purpose of this report is to give a general outline of the progress of the program since its inception in 1970.

PROGRAMS BACKGROUND AND DEVELOPMENT

Information from provenance tests and existing plantations suggest that black spruce (*Picea mariana*) is one of the most adaptable and versatile species for reforestation in New Brunswick. Both the province and industry are planning major increases in their planting programs in the next few years. Sufficient variability exists in the species to justify considerable effort toward locating the best sources of seed and cultivating them.

In view of these considerations the federal and provincial governments, during 1970 and 1971, cooperated under an agreement to identify, locate and map superior stands of black spruce for seed production areas. In 1972, they cooperated under an additional agreement to select and tabulate pertinent information of individual plus trees in the selected black spruce stands. Aid was supplied to the provincial government in the form of funds, training and guidance throughout the project.

The project work described under the previous contracts will be continued and expanded to other important species such as jack pine (*Pinus banksiana*) and white spruce (*Picea glauca*).

PROGRAM PROGRESS

To date, 41 stands of black spruce and 13 stands of better-than-average jack pine are reserved from cutting. From within the 41 stands of black spruce, 37 plus trees have been selected and duly tabulated. This work will continue in 1973. During a year of a moderate to good seed crop, seed will be collected to establish a progeny test from which a seedling seed orchard can be established.

STUDIES IN TREE BREEDING AT THE FACULTY OF FORESTRY UNIVERSITY OF NEW BRUNSWICK

G.R. Powell

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ACADEMIC

James F. Coles is working toward a M.Sc.F. degree in forest genetics under the supervision of Dr. D.P. Fowler (Honorary Research Associate) and Dr. G.R. Powell. His thesis topic is "Population structure of white spruce".

REPRODUCTIVE DEVELOPMENT OF BALSAM FIR

Research aimed at elucidating the relationship between reproductive and vegetative development in the upper crown of mature balsam fir (*Abies balsamea* [L.] Mill.) has been under way at the University of New Brunswick since 1964. Seed years occurred in 1964, 1966 and 1968 and provided many data. Since 1968 the increasing incidence of spruce budworm (*Choristoneura fumiferana* [Clem.]) defoliation and resultant loss of crown have led to the curtailment of work on this project. The spruce budworm has not only an indirect effect on megastrobilus production through destruction of foliage and young shoots but also a direct effect, killing large numbers of megastrobili by girdling them at their bases before vegetative buds burst (Powell 1973).

Early work was concentrated on strobilus development (Powell 1970a), seed production, seed maturation and strobilus color. This was followed by emphasis on intrinsic morphological, developmental, positional and concurrent growth factors affecting seed production and seed-year periodicity (Powell 1970b). This involved study of lateral-bud initiation and development and, particularly, formation of latent buds that have been shown to be important in the periodicity of flowering in *Pseudotsuga menziesii* (Mirb.) Franco (Owens 1969, Allen and Owens 1972).

Balsam fir has a tendency toward biennial bearing. There is a distinct separation of megasporangiate and microsporangiate zones in the crown (Morris 1951, Powell 1972). Megasporangiate, microsporangiate and vegetative lateral buds are readily distinguishable by morphology, numbers per shoot and position on the shoot. For these reasons the species appears to be ideal for the study of physiological factors associated with the seed-production process. Such study will form the main thrust of future work in this project.

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FOREST TECHNICAL EDUCATION IN FINLAND

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My visit to Finland in the summer of 1972 had two phases. The *raison d'être* for the trip - an assignment from the FAO/IAEA to teach radio-isotope techniques in forestry to an international group and to act as the agency's representative to the course - occupied most of the time during the first part of my trip.

During the second part, I was given special opportunity by the Finnish Forestry Service to examine their government-sponsored technical training program (some of these schools had been visited during the training course). The schools are located in all sections of Finland, but their courses vary in purpose and intensity. Of particular interest were the two programs specializing in the operation of heavy equipment. One of these, at Rovaniemi on the Arctic Circle, has had students from foreign countries, e.g., Algeria. This is possible because of the use of both French and English as languages of instruction and it is understood that some Quebec companies may avail themselves of these services.

TREE IMPROVEMENT AT THE BERTHIERVILLE, QUEBEC, FOREST TREE NURSERY

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INTRODUCTION

This is the first biennial report presented to the Committee by the personnel of the Provincial Forest Tree Nursery, located at Berthierville, Que. Since most tree improvement work is just beginning here, only a short description of the materials and methods used and some preliminary results are given. More detailed results will be presented in future reports.

PROVENANCE TRIALS

Norway Spruce (*Picea abies* [L.] Karst.)

Eleven provenances from France were outplanted at four different locations in Quebec in the spring of 1972. Observations will be made in the fall of 1973 on survival and growth. The seeds were obtained through Dr. Louis Parrot of Laval University. The planting was done by the Research Branch of the Department of Lands and Forests.

In another trial, seeds from 26 provenances were sown in the fall of 1971 with four replications. Twenty-two provenances were provided by Mark Holst (Exp. No. 349-D), and four provenances from Quebec were included as checks. The number of cotyledons and the total height at 1-0 were recorded from 10 seedlings per replication. It was found that number of cotyledons was negatively correlated to latitude (r= -.817**) and to longitude (r= -.558**) of the seed source. Also, seedlings having more cotyledons were taller after 1 year of growth. The mean number of cotyledons varied from 7.0 to 8.5, and total height from 20 to 79 mm. Other observations on growth will be recorded during the two coming years in the nursery. Outplanting is planned for at least four locations in the province.

Black Spruce (*Picea mariana* [Mill.] B.S.P.)

Eight provenances from Quebec were outplanted at three different locations in the spring of 1972. Observations on survival and growth in the field are planned for the fall 1973. The planting was done by the Research Branch. At age 5 (2-3) in the nursery, total height was measured but could not be related significantly to any geographic data of the seed source.

White and Engelmann Spruces (*Picea glauca* [Moench] Voss and *P. engelmannii* Parry)

Seeds from 24 provenances from British Columbia and 1 from Quebec as a check were sown in the fall of 1971 in four replications. The British Columbia seeds were provided by Dr. Larry Roche. The number of cotyledons and the total height growth at 1-0 were recorded from 10 seedlings per replication. Computations are being completed.

Blue and Engelmann Spruces (*Picea pungens* Engelm. and *P. engelmannii* Parry)

Dr. James W. Hanover sent us 44 sources of blue and Engelmann spruces for a trial in Quebec. The seedlings, received as 2-0, were transplanted in four replications in May 1972. No observations have been made yet. When large enough, the seedlings will be transplanted to selected areas in Quebec.

Scots pine (*Pinus sylvestris* L.)

A test with four sources from France, one from Spain and one from Poland was outplanted in the spring of 1973 at three locations in Quebec by the Research Branch. Observations will be made in the fall of 1973 on survival, growth and color of needles.

Douglas-fir (*Pseudotsuga taxifolia* [Poir.] Britt.)

Seeds from 12 sources in British Columbia and the western United States were sown at the Berthierville nursery. At age 5 (2-3) all seedlings from Washington, Oregon and Colorado had frozen. Some seedlings from California also suffered from frost. The resistant sources were outplanted in the spring of 1972 by the Research Branch, at six locations throughout Quebec. Observations are planned in the fall of 1973 on survival, growth and color of foliage.

PROGENY TESTING OF WHITE SPRUCE

Seeds were collected from five individual trees in each of 26 locations throughout the range of white spruce in Quebec. The weight of 600 seeds was recorded and the number of cotyledons counted, and total height at 1-0 was measured for 10 seedlings in each of the four replications. Computations are not yet all completed. Preliminary results indicate that the mean weight of 600 seeds is negatively correlated with longitude and positively with the mean number of cotyledons. Seedlings from higher latitudes had more cotyledons, and those from southern latitudes were taller when grown at Berthierville.

These seedlings will be outplanted in selected locations in Quebec, and the best families will be vegetatively propagated in seed orchards.

SEEDLING SEED ORCHARDS

In the fall of 1972, superseedlings were selected from the beds of 12 provincial nurseries. To be accepted, the candidate had to be $1\frac{1}{2}$ times higher than the mean of the eight tallest seedlings found in a circle 24 inches in diameter around the selected seedling. Depending on the provenance of the seeds, the 1,614 selected seedlings will be outplanted with their checks at five locations in Quebec. We plan to make observations in these plantations until the trees begin to flower and then to thin them out to keep only the original selected seedling for seed production. The screening of nursery beds for superseedlings will continue in the fall of 1973. The selection is made for all conifer species grown in the nurseries.

PLUS-TREE SELECTION

It is hoped that a plus-tree selection program will be started this year. Pertinent instructions have been written and will be distributed to the personnel in the various regions of the province. Crews will be organized to screen selected stands and search for plus-trees. Both scions and cones will be collected from these trees and grafted or sown at the Berthierville nursery.

GLOSSARY

A glossary of technical terms used in tree improvement has been prepared for distribution to the personnel in the administrative regions who will collaborate in this work. A French definition is given and is followed by an English equivalent.

AMÉLIORATION DES ARBRES FORESTIERS AU SERVICE DE LA RECHERCHE DU MINISTÈRE DES TERRES ET FORÊTS DU QUÉBEC

G. Vallée, C. Chouinard,
A. Stipanicic et D. Robert,
de la Section de génétique

INTRODUCTION
(G. Vallée)

Depuis 1970, la Section de génétique du Service de la recherche du ministère des Terres et Forêts a consolidé l'infrastructure de son organisation, surtout dans la mise en place du réseau de secteurs expérimentaux pour l'amélioration des arbres forestiers (arboreta), tel que prévu dans le programme présenté en 1969 (1)[1]. Ainsi, 13 secteurs ont été ouverts pour les plantations comparatives et déjà des organismes tels que le Service canadien des forêts et la Faculté de foresterie et de géodésie y ont installé des dispositifs.

Des contacts ont été établis avec des organismes canadiens pour des échanges de matériel biologique afin de bénéficier de l'expérience acquise. Nous remercions tous ceux qui ont coopéré et nous ont conseillés dans nos travaux.

Les efforts de la Section ont porté surtout sur l'amélioration des peupliers, l'introduction d'espèces exotiques, l'amélioration du genre *Larix* et l'établissement des secteurs expérimentaux (2). Dans le cas des peupliers, la Section a joué un rôle clé en participant très activement aux travaux de recherche et de développement en populiculture (3) réalisés au Service de la recherche du ministère des Terres et Forêts et en distribuant les clones qu'elle a sélectionnés à la suite des plantations comparatives clonales qu'elle a réalisées depuis 1969.

MM. C. Chouinard (4) et A. Stipanicic (5) ont fait des stages de perfectionnement à la Station d'amélioration des arbres forestiers du Centre national de recherches forestières, France, en 1971 et 1972 respectivement. La Section continue de recevoir les graines des espèces de la côte ouest américaine récoltées par le Working Group on Procurement of Seed for Provenance Research de l'International Union of Forest Research Organization (IUFRO).

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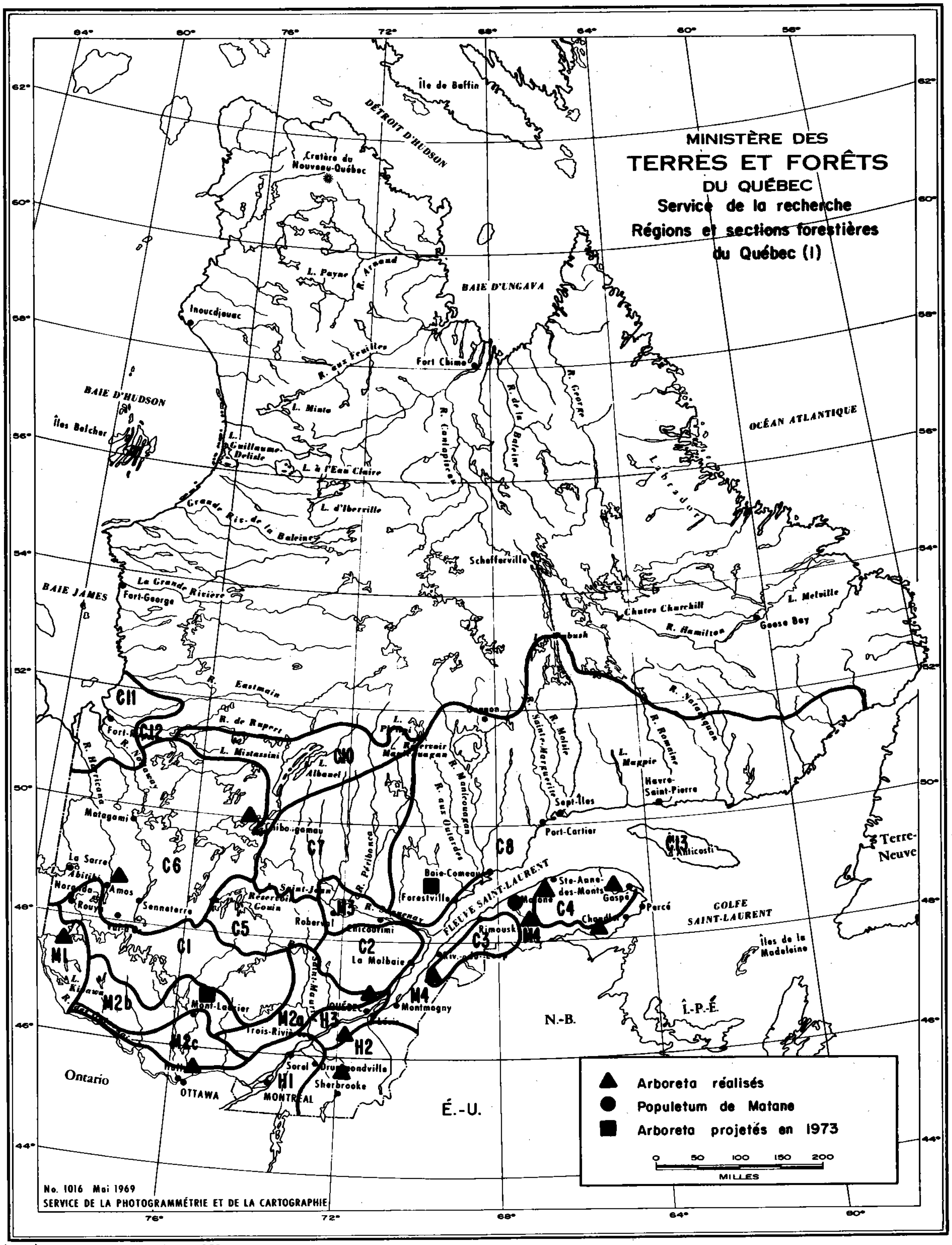
[1]Les numéros entre parenthèses renvoient à la Bibliographie, page 70.



(1) D'après Villeneuve 1946 et Rowe 1959

COMITÉ DE RECHERCHE EN GÉNÉTIQUE FORESTIÈRE
(G. Vallée, président)

Le Conseil de la recherche et du développement forestiers du ministère des Terres et Forêts a formé, en novembre 1970, un comité de recherche en génétique forestière dont le premier mandat était de préparer un rapport sur la populiculture au Québec (6), qui a été publié en 1971. Par la suite, le Conseil a confié au Comité la préparation de rapports (7) sur "L'amélioration du pin gris", qui sera publié au début de 1975, et sur "L'état actuel de la recherche et du développement en génétique forestière au Québec", en voie de réalisation.

Le Comité est formé de représentants du Centre de recherche forestière des Laurentides, de la Faculté de foresterie et de géodésie, de l'industrie forestière du Service de la recherche et du Service de la restauration forestière du ministère des Terres et Forêts. Il invite aussi tous les spécialistes qui peuvent l'aider dans ses tâches à collaborer avec lui. À date, cette initiative du Conseil s'est avérée très fructueuse, tant sur le plan échange d'idées entre les membres et les invités du Comité que pour l'étude d'un sujet particulier.

POPULICULTURE
(G. Vallée)

Projet Sg 68-1 Sélection de clones de peuplier des sections *Aigeiros* et *Tacamahaca* et leurs hybrides

Projet Sg 69-4 Sélection de clones de peuplier des sections *Leuce* et *Leucoides* et leurs hybrides

Collection de clones

Au cours des deux dernières années, nous avons continué la collection de clones de peuplier (*Populus*) par l'obtention de matériel éprouvé dans des peuplements naturels. Ainsi, quelque 707 clones ont été réunis à la pépinière de Duchesnay, comprenant les espèces et hybrides suivants:

1 *P. alba*
2 *P. alba x P. grandidentata*
3 *P. alba x P. x Jackii*
4 *P. alba x P. sieboldii*
5 *P. balsamifera*
6 *P. x berolinensis*
7 *P. cv. candicans*
8 *P. x canescens*
9 *P. x canescens x (alba x grandidentata)*
10 *P. cathayana*
11 *P. deltoides*

12 *P. deltoides cv. angulata x P. simonii*
13 *P. deltoides x P. trichocarpa*
14 *P. x euramericana*
15 *P. grandidentata*
16 *P. x Jackii* et *x rollandii*
17 *P. maximowiczii x P. trichocarpa*
18 *P. nigra*
19 *P. cv. Oxford x P. cv. Androscoggin*
20 *P. cv. Roxbury*
21 *P. simonii cv. fastigiata*
22 *P. tremula*
23 *P. tremuloides*
24 *P. trichocarpa*
25 *P. trichocarpa x P. balsamifera*

Les sections *Aigeiros* et *Tacamahaca* sont représentées par 641 clones, les autres clones appartenant à la section *Leuce*.

Quelque 89 clones de *P. balsamifera*, 150 de *P. deltoides*, 105 de *P. x Jackii* et *x rollandii* et 40 de *P. tremuloides* ont été sélectionnés dans des peuplements ou des régénérations naturelles au Québec. Pour ces espèces, des variations morphologiques (formes des feuilles et des rameaux) ont été constatées. Ainsi, deux clones de *P. balsamifera*, l'un provenant des environs du parc des Laurentides au nord de Québec et l'autre de Port-Daniel en Gaspésie, présentent des rameaux munis de crêtes comme le *P. trichocarpa*. D'ailleurs, parmi les clones de *P. balsamifera* que nous avons, toute la gamme de formes est représentée, des rameaux ronds aux rameaux anguleux et munis de crêtes. *P. deltoides* est aussi très variable, tant dans la morphologie des feuilles (8 et 9) que dans la forme des tiges des arbres. Ainsi on a constaté que certains sujets de *P. deltoides*, croissant à découvert, fourchent dès qu'ils atteignent une hauteur de 20 à 25 pieds environ, tandis que chez d'autres, ce phénomène apparaît à une hauteur de 50 à 60 pieds. Ce caractère est très important dans la sélection de clones pour les plantations.

Tous ces clones sont actuellement observés en pépinière sur les plans développement, résistance aux maladies foliaires et des tiges, phénologie et rusticité. La pépinière est située à la Station forestière de Duchesnay à 27 milles au nord-ouest de Québec.

Plantations comparatives

Quatre plantations comparatives comprenant de 150 à 175 clones seront installées au printemps de 1973, ce qui portera à 30 le nombre de dispositifs de peupliers établis à travers le Québec.

Deux plantations de collection de clones seront mises en chantier: l'une en 1973 à l'arboretum de Lotbinière à 40 milles au sud-ouest de Québec et l'autre en 1974 au populetum de Matane avec les clones présentant une rusticité suffisante.

Autres acquisitions

À la suite d'une récolte de 45 lots de graines sur 31 *P. deltoides*, 7 *P. x euramericana*, 5 *P. balsamifera*, 2 *P. x Jackii*, selon un axe sud-ouest à nord-est dans la vallée du Saint-Laurent (de Beauharnois à Québec), quelque 50,000 plants ont été obtenus et plantés en dispositifs de descendance à quatre endroits différents.

De plus, 27,000 plants ont été obtenus de 26 lots de graines de peupliers exotiques au Québec, dont 13 lots proviennent d'Europe, 3 du Japon et 10 de l'Ontario et du Manitoba. Les espèces suivantes y sont représentées: *P. x canescens, P. nigra, P. deltoides, P. trichocarpa, P. tremula, P. tremuloides, P. alba, P. maximowiczii.*

On prévoit recevoir les graines des provenances de *P. trichocarpa* qui seront récoltées à l'été de 1973 par le Working Party on Provenance of Poplars de l'IUFRO.

Hybridations

En 1971, en collaboration avec M. R. Joennoz (10), coopérant français, 464 croisements ont été réalisés entre 12 espèces ou hybrides de peupliers dont 140 ont réussi, fournissant 57,000 plants. Les croisements ont été faits sur des rameaux floraux bouturés en pot selon la méthode dite du "plançon en pot" pour les espèces de peupliers se bouturant bien. La liste des espèces et des croisements réalisés se trouve aux tableaux 1, 2, 3 et 4. Les points suivants sont à noter en ce qui regarde le succès des croisements:

1) Le croisement *P. balsamifera x P. deltoides* est difficile; 1 famille a été obtenue sur 38 possibles, ce qui laisse présager que les *P. x Jackii* que l'on trouve en forêt naturelle originent surtout du croisement *P. deltoides x P. balsamifera*. Notons que *P. deltoides* a bien réussi comme pollinisateur de *P. cathayana* en donnant 7 familles sur 7.

2) Parmi les croisements interspécifiques et intersections présentant de l'intérêt, il y a celui de *P. alba x P. x Jackii* dont les descendants montrent en pépinière un développement remarquable et une bonne résistance aux maladies foliaires.

3) Le croisement *P. balsamifera x P. nigra cv. italica* a produit des descendants dont le développement est très bon et dont la résistance aux maladies foliaires est excellente.

Une autre série de croisements a été réalisée au début de 1973 en mettant l'accent sur les hybridations infraspécifiques chez *P. balsamifera* et *P. deltoides* résumées au tableau 5.

TABLEAU 1 Espèces et nombre de sujets utilisés comme parents

Espèces	Abréviations	Nombre de sujets utilisés	
		Mâles	Femelles
Populus alba L.	*Poa*	-	2
Populus grandidentata Michx.	*Pog*	2	2
Populus tremuloides Michx.	*Pot*	1	4
Populus cathayana Rehd. (nº 13)	*Pocat*	-	1
Populus balsamifera Du Roi	*Pob*	5	8
Populus simonii cv. fastigiata Carr.	*Posi*	1	-
Populus deltoides Marsh.	*Pod*	7	12
Populus nigra cv. italica L.	*Poniit*	1	-
Populus canescens Sm.	*Poc*	2	1
Populus x Jackii	*PoJ*	4	2
Populus x euramericana (Dode) Guinier	*Poe*	2	1
Populus cv. Roxbury (P. nigra x P. trichocarpa)	*Porox*	-	1
Total		25	34

Cette série de croisements n'a pas été un succès car les rameaux floraux femelles ont été récoltés trop tard à la fin de février et au début de mars, ce qui a favorisé un débourrement rapide en serre des bourgeons floraux et foliaires. Les rameaux n'ayant pas le temps de s'enraciner selon la méthode du plançon en pot, les feuilles et les fleurs ont séché.

Développement de la populiculture

Au printemps de 1972 et de 1973, quelque 75 et 80 acres, respectivement, de peupliers ont été plantées sur deux fermes populicoles en voie de réalisation dans la région de Cabano, comté de Témiscouata. Ces travaux ont été entrepris dans le cadre de la coopération technique franco-québécoise dans le but de développer un mode de populiculture pour cette région (9).

Les plantations ont été réalisées à partir de boutures de 12 pouces plantées mécaniquement à l'aide d'une planteuse "Tractor-Mounted" ayant un disque de 24 pouces de diamètre et un socle d'environ 18 pouces de

TABLEAU 2 Synthèse des croisements infraspécifiques

Espèces	Nombre de croisements		Qualité des capsules et des inflorescences				Plants obtenus
	Total	Réussis	C	Cmd	Is	PI	
Poc x Poc	1	0	-	-	1	-	0
Pot x Pot	4	1	3	-	1	-	22
Pog x Pog	3	2	2	-	1	-	479
Pob x Pob	7	7	7	-	-	-	4,731
Pod x Pod	27	10	20	1	3	3	1,787
PoJ x PoJ	8	5	6	-	-	2	732
Poe x Poe	1	0	-	-	-	1	0

Légende:

C: capsules dans un état de développement satisfaisant.
Cmd: capsules mal développées.
Is: inflorescences séchées encore attachées au rameau.
PI: pas d'inflorescences, elles ont séché et sont tombées.

hauteur. Les terrains plantés ont été préalablement défrichés et essouchés. Les boutures sont plantées obliquement, afin de mieux résister au déchaussement provoqué par le gel du sol, et à un espacement d'environ 10 pieds x 10 pieds.

Une vingtaine de clones ont été plantés. Ils comprenaient les meilleurs clones sélectionnés par le Centre de recherche forestière des Laurentides et le Service de la recherche du ministère des Terres et Forêts. Dès la mise en terre des boutures, une fertilisation est appliquée selon les meilleurs traitements définis par les recherches faites au Québec dans ce domaine.

Un des principaux problèmes rencontrés est celui de réaliser une plantation de qualité avec une planteuse mécanique. Vu l'enrochement des terrains, le socle ne pénétrait pas dans la terre, ou bien le faisait difficilement, empêchant une plantation profonde des boutures. Au printemps de 1973, l'équipe en charge de la plantation a modifié la planteuse en remplaçant le disque par un "ripper" (dent-sous-soleuse) qui ouvre le sol en poussant les roches ayant jusqu'à 24 pouces de diamètre, défonçant les couches de cailloux et coupant les racines. Avec ce système, une plantation de très bonne qualité a été réalisée.

Dès la première année de croissance et malgré un retard de la plantation de trois semaines sur la saison de végétation, une pousse moyenne en hauteur de 25 pouces a été enregistrée pour le meilleur clone. Plusieurs

TABLEAU 3 Synthèse des croisements interspécifiques et infrasections

Sections	Espèces	Nombre de croisements		Qualité des inflorescences				Plants obtenus
		Total	Réussis	C	Cmd	Is	PI	
Leuce	*Poa x Poc*	2	0	-	-	2	-	-
	Poa x Pot	2	0	-	1	1	-	-
	Poa x Pog	3	1	2	1	-	-	2
	Pot x Pog	4	1	4	-	-	-	30
	Poc x Pot	1	0	-	-	1	-	-
	Pot x Poc	4	0	-	-	2	2	-
	Poc x Pog	1	1	1	-	-	-	2
	Pog x Poc	3	0	1	-	2	-	-
	Pog x Pot	1	0	-	-	1	-	-
Tacamahaca	*Pob x Posi*	6	0	1	1	1	3	-
	Pocat x Pob	3	3	3	-	-	-	10,841
	Pocat x Posi	1	1	1	-	-	-	799
Tacamahaca-Aigeiros	*Porox x PoJ*	4	4	4	-	-	-	765
Aigeiros	*Pod x Poniit*	6	5	5	-	-	1	428
	Pod x Poe	8	3	3	-	1	4	919
	Poe x Poe	1	0	-	-	-	1	-
	Poe x Poniit	1	1	1	-	-	-	1,178

autres clones ont atteint une moyenne de 20 à 24 pouces et des hauteurs maximales de 3 à 4 pieds ont été observées.

La Section de génétique a installé à la pépinière de Duchesnay un quartier de 13,000 pieds-mères pour la production de boutures à partir des 18 meilleurs clones expérimentés au Québec. De plus, la Section a distribué des boutures de ces mêmes clones à deux autres pépinières du Ministère pour la réalisation de quartiers de pieds-mères à la ferme de Caplan dans la Baie-des-Chaleurs et à la pépinière de Saint-Louis-du-Ha! Ha!, comté de Témiscouata.

L'auteur a participé à deux sessions d'information pour des propriétaires forestiers, dans l'est du Québec; ceux-ci se sont montrés très intéressés par la populiculture et déjà des demandes de plants et de boutures sont parvenues au Ministère.

TABLEAU 4 Synthèse des croisements interspécifiques et intersections

Sections	Espèces	Nombre de croisements		Qualité des inflorescences				Plants obtenus
		Total	Réussis	C	Cmd	Is	PI	
Leuce et *Tacamahaca*	*Poa x Pob*	4	0	1	2	1	-	-
	Poc x Pob	1	0	-	-	1	-	-
	Pob x Poc	7	0	-	-	2	5	-
	Pog x Pob	3	0	-	-	2	1	-
	Pob x Pog	7	0	-	1	4	2	-
	Pot x Pob	4	0	2	-	1	1	-
	Pob x Pot	2	0	-	-	-	2	-
	Poa x Posi	2	0	1	-	-	1	-
	Poc x Posi	1	0	1	-	-	-	-
	Pog x Posi	1	0	-	-	1	-	-
	Pot x Posi	4	1	3	-	1	-	3
	Pocat x Poc	1	0	-	-	1	-	-
	Pocat x Pog	2	0	2	-	-	-	-
	Pocat x Pot	1	0	1	-	-	-	-
Leuce et *Tacamahaca-Aigeiros*	*Poa x PoJ*	8	1	4	2	2	-	11
	Poc x PoJ	4	0	2	1	1	-	1
	PoJ x Poc	2	0	-	-	-	2	-
	Pog x PoJ	4	0	-	1	3	-	-
	PoJ x Pog	2	0	1	-	-	1	-
	Pot x PoJ	16	1	10	2	3	1	42
	PoJ x Pot	2	1	1	-	-	1	6
	Porox x Poc	1	0	-	-	1	-	-
	Porox x Pot	1	0	-	-	-	1	-
	Porox x Pog	2	0	1	1	-	-	-
Leuce et *Aigeiros*	*Poa x Pod*	13	0	7	4	1	1	-
	Poa x Poniit	2	0	2	-	-	-	-
	Poa x Poe	4	0	2	-	1	1	-
	Poc x Pod	5	0	2	-	3	-	-
	Pod x Poc	10	0	-	-	4	6	-
	Poc x Poniit	1	0	1	-	-	-	-
	Poc x Poe	2	1	2	-	-	-	1
	Pog x Pod	7	0	1	2	2	2	-
	Pod x Pog	9	2	6	2	-	1	65
	Pog x Poniit	1	0	-	1	-	-	-
	Pog x Poe	2	0	-	-	2	-	-
	Poe x Pog	1	0	1	-	-	-	-
	Pot x Pod	22	1	8	1	8	5	2
	Pod x Pot	5	0	-	-	-	5	-
	Pot x Poniit	4	1	2	-	1	1	2
	Pot x Poe	8	2	5	-	3	-	76
	Poe x Pot	1	0	-	-	1	-	-

TABLEAU 4 (suite)

Sections	Espèces	Nombre de croisements		Qualité des inflorescences				Plants obtenus
		Total	Réussis	C	Cmd	Is	PI	
Tacamahaca et *Tacamahaca-Aigeiros*	*Pob x PoJ*	13	7	9	–	1	3	2,948
	PoJ x Pob	1	1	1	–	–	–	76
	Pocat x PoJ	4	4	4	–	–	–	3,015
	PoJ x Posi	2	1	1	–	1	–	34
	Porox x Pob	3	2	3	–	–	–	3,415
	Porox x Posi	1	0	–	–	1	–	–
Tacamahaca et *Aigeiros*	*Pob x Pod*	38	1	13	4	4	17	2
	Pod x Pob	31	18	26	–	2	3	3,756
	Pob x Poniit	5	5	5	–	–	–	7,888
	Pob x Poe	12	4	7	2	2	1	853
	Poe x Pob	1	1	1	–	–	–	70
	Pocat x Pod	7	7	7	–	–	–	376
	Pocat x Poniit	1	1	1	–	–	–	759
	Pocat x Poe	2	1	2	–	–	–	1,061
	Pod x Posi	6	5	5	–	–	1	1,127
Tacamahaca-Aigeiros et *Aigeiros*	*PoJ x Pod*	12	0	3	3	2	4	–
	Pod x PoJ	25	16	22	–	1	2	2,205
	PoJ x Poniit	2	2	2	–	–	–	4,262
	PoJ x Poe	4	2	2	–	1	1	913
	Poe x PoJ	4	3	4	–	–	–	708
	Porox x Pod	7	1	6	1	–	–	3
	Porox x Poniit	1	0	–	–	1	–	–
	Porox x Poe	2	1	1	–	–	–	3

AMÉLIORATION DU MÉLÈZE
(A. Stipanicic)

Projet Sg 70-3 Amélioration du mélèze laricin (*Larix laricina*)

Projet Sg 70-4 Amélioration du mélèze d'Europe (*Larix decidua*)

Projet Sg 70-5 Amélioration du mélèze du Japon (*Larix leptolepis*)

Larix laricina (Du Roi) K. Koch

Méthode

Le programme de travail sur cette espèce a été élaboré et commencé en collaboration avec la Station d'amélioration des arbres forestiers du Centre national de recherches forestières, France (Y. Birot, chargé de recherche).

Étant donné qu'il existe peu d'informations actuellement disponibles sur *L. laricina*, deux approches ont été planifiées:

1) Tests de provenances et de descendances pour identifier les sources de graines les plus intéressantes et pour la formation de vergers à graines.
2) Étude de la structure génétique de *L. laricina* pour en connaître les caractères héritables et les lois d'héritabilité.

Travaux prévus

Test de provenances et de descendances

Au début du programme, nous avions prévu un test de provenances-descendances qui serait une combinaison de test de provenances et de test de descendances et qui devrait se faire selon un transect sud-nord partant du sud de Montréal, en passant par la région de Trois-Rivières, la vallée du Saint-Maurice, la région du lac Saint-Jean, le parc de Chibougamau et en allant vers le lac Mistassini. Nous espérions ainsi pouvoir définir de 10 à 12 endroits, dans lesquels deux stations seraient échantillonnées, une station sèche et une station humide. Dans chaque station, 20 arbres seraient sélectionnés en tenant compte des caractères suivants: une tige droite, des branches horizontales, une vigueur égale ou supérieure à la moyenne, approximativement du même âge (la différence ne devrait pas dépasser 20 ans). Pour éviter la parenté entre les individus sélectionnés, il était nécessaire que ces derniers soient assez éloignés les uns des autres. Nous considérons qu'il ne faut pas sélectionner plus d'un arbre par demi-acre de superficie (environ 2,000 m^2). Nous avions prévu aussi de mesurer pour chaque arbre sélectionné la densité du bois à l'aide d'un torsiomètre, mais pour ce caractère, la sélection ne peut encore être faite, vu que nous ne connaissions pas encore la relation entre l'accroissement et la densité du bois dans le cas de *L. laricina*. Des études plus approfondies dans ce sens seraient nécessaires.

À la suite de notre première tournée de reconnaissance pour la réalisation du transect prévu, nous avons modifié notre projet de test de provenances-descendances, parce que nous avons réalisé que *L. laricina* forme très rarement des peuplements étendus et réguliers, de sorte qu'il est difficile de pratiquer une sélection d'individus telle que prévue initialement. Au début du siècle, les peuplements de *L. laricina* ont été à plusieurs reprises ravagés par la tenthrède du mélèze (*Pristiphora erichsonii* (Htg.)). Les dernières attaques importantes sont survenues dans les années 1960-1964. Si les attaques de ce défoliateur se répètent pendant quelques années consécutives, cela mène à un dépérissement complet de l'arbre. Pour cette raison, la répartition de *L. laricina* à l'intérieur de son aire naturelle est très irrégulière. Cette espèce forme plutôt de petits groupes ou bouquets éparpillés, surtout dans les zones tourbeuses ou mal drainées, et l'on peut considérer que les individus d'un même bouquet proviennent de quelques arbres-mères qui ont résisté à l'attaque de la tenthrède et qu'en définitive ils sont tous demi-frères. D'autre part, ces bouquets sont souvent trop éloignés les uns des autres pour qu'on puisse les considérer comme une provenance unique. Nous prévoyons maintenant ne sélectionner qu'un seul arbre par bouquet et réunir ce matériel sous forme de greffes ou de boutures dans les parcs à clones qui pourront servir de vergers à graines clonaux. De cette façon, nous espérons éviter la manifestation de gènes récessifs défavorables, qui est due à la consanguinité prolongée (inbreeding depression), et aussi profiter de la combinaison des caractères génétiques favorables dont les arbres sélectionnés sont porteurs et sur lesquels nous allons aussi récolter les graines pour le test de descendances en vue de vérifier la supériorité génétique de ces individus.

Sur le plan du test de provenances, nous pensons réunir une collection de lots de graines qui nous permettrait de mettre en marche un test de provenances qui couvrira les différentes zones écologiques de l'aire naturelle du mélèze laricin, principalement au Québec.

Dans le cas de peuplements suffisamment étendus, où nous serons en mesure de sélectionner 20 arbres, nous prévoyons réaliser un test de provenances-descendances. En réunissant en dispositifs quelques provenances représentées par une vingtaine d'arbres sélectionnés, nous espérons obtenir en même temps la réponse sur la valeur d'une région comme source de graines et sur la valeur génétique des arbres échantillonnés.

Étude de la structure génétique de Larix laricina

Pour cette étude, nous avons prévu de choisir un peuplement assez grand pour pouvoir sélectionner au minimum 15 arbres avec un des quatre

TABLEAU 5 Les croisements réalisés en 1973

Nombre d'arbres femelles	Nombre d'arbres mâles													
	5 *Pod*		11 *Pob*		3 *PoJ*		1 *Posi*[2]		1 *Poniit*		1 *Poe*[3]		1 *Pot*	
	Nombre de croisements													
	T[1]	r[1]	T	r	T	r	T	r	T	r	T	r	T	r
13 *Pod*	50	1	132	6	36	0	13	0	13	0	13	0	8	0
1 *Poni*[2]	5	0	11	0	3	0	1	0	1	0	1	0	1	0
6 *Pob*	-	-	54	40	13	0	3	0	6	4	6	0	1	0
1 *Porox*	-	-	3	0	2	0	-	-	-	-	1	0	-	-
1 *Poe*	-	-	11	4	3	0	1	0	1	0	1	0	1	0
3 *Poa*	6	0	-	-	6	0	-	-	-	-	3	0	3	0
1 *Pog*	-	-	-	-	2	0	-	-	-	-	1	0	1	0
1 *Pot*	-	-	-	-	2	0	-	-	-	-	1	0	1	0

[1]T: total.
r: réussis.
[2]Arbres fastigiés.
[3]C'est le clone Q-36-Q sélectionné dans la région de Québec et montrant un très beau développement dans les plantations comparatives.

caractères principaux qui nous semblaient très importants pour la qualité technologique du bois de mélèze laricin. Ces caractères sont:

- tige droite
- tige flexueuse
- branches horizontales
- branches fastigiées

Les observations ultérieures sur les descendances de ces arbres choisis devraient vérifier l'héritabilité de la flexuosité de la tige et de l'horizontabilité des branches, ainsi que d'autres caractères qui seront observés lors de l'échantillonnage.

Travaux en voie de réalisation

Tests de descendances et de provenances

Durant l'été de 1972, nous avons sélectionné 10 arbres de *L. laricina* dans un peuplement près de Saint-Bernard-de-Lacolle, canton de Lacolle, et 13 arbres dans un peuplement près de Weedon, canton de Weedon.

Cette année, nous allons continuer les travaux dans ces peuplements où nous comptons sélectionner 20 arbres et aussi commencer la sélection dans les peuplements déjà repérés. Selon nos possibilités, nous pensons aussi commencer la sélection dans des petits groupes et bouquets.

Au printemps de 1972, nous avons installé un dispositif dans la pépinière de Duchesnay avec 13 provenances différentes de *L. laricina*. La pépinière provinciale de Berthierville nous a fourni des graines pour cette expérience. De la Station forestière expérimentale de Petawawa, nous avons reçu une collection de 13 provenances de l'est de l'Ontario, et, avec 3 autres acquisitions de la pépinière provinciale de Berthierville, nous possédons au total 16 provenances de la province de Québec qui seront conservées pour le test de provenances sur l'ensemble de l'aire de *L. laricina*.

Nous participons aussi à l'expérience n° 376 de la Station forestière expérimentale de Petawawa. Une collection de 20 descendances a été repiquée au printemps de 1973 dans la pépinière de Duchesnay et sera probablement installée en dispositifs au printemps de 1974.

Étude de la structure génétique de L. laricina

Un peuplement de *L. laricina* assez étendu, près de Sainte-Catherine, comté de Portneuf, a été choisi. Présentement, il y a un total de 53 arbres déjà sélectionnés (13 arbres avec la tige droite, 13 avec la tige flexueuse, 15 avec les branches horizontales et 12 avec les branches fastigiées). Le premier essai de greffage a été fait au printemps de 1973 et cette année nous allons terminer la sélection et compléter une description précise des arbres choisis.

Larix sp. exotiques et hybrides

Méthode

1) Test de provenances en utilisant les graines récoltées dans les plantations déjà établies au Québec et les graines des provenances recommandées de l'étranger.

2) Test de descendances des arbres sélectionnés au Québec et à l'étranger pour vérifier la supériorité des arbres sélectionnés, en vue de réaliser des vergers à graines.

3) Test clonal des arbres sélectionnés afin d'examiner leur aptitude au bouturage et de vérifier la supériorité des clones sélectionnés.

4) Pollinisation contrôlée interspécifique et infraspécifique entre les clones intéressants pour obtenir les hybrides qui correspondraient le mieux à nos conditions écologiques.

Travaux prévus

Test de provenances

Nous envisageons de récolter les graines dans les plantations de *Larix sp.* qui sont déjà installées au Québec et ainsi de profiter du matériel de base qui s'est montré satisfaisant dans nos régions. Aussi, les démarches sont faites pour obtenir les graines de provenances qui sont déjà reconnues supérieures à l'extérieur du Québec.

Test de descendances et test clonal

Une sélection à l'intérieur des plantations déjà existantes est prévue. Les critères de sélection ne sont pas encore complètement définis, mais nous pensons que la rectitude de la tige sera le facteur le plus important.

Pollinisation contrôlée

Le programme dans ce sens n'est pas encore élaboré en détail, mais nous prévoyons greffer les arbres que nous avons sélectionnés ainsi que ceux sélectionnés par les autres organismes de recherche, afin d'établir un parc à clones qui servira de base pour la production des hybrides.

Travaux réalisés

Test de provenances

Présentement, nous possédons les provenances suivantes:

Espèces	Pays d'origine	Nombre de provenances
L. decidua	Allemagne fédérale	2
	Autriche	2
	Canada—Québec	4
	France	1
	Hongrie	1
	Italie	2
	Pologne	1
	Suisse	2

Espèces	Pays d'origine	Nombre de provenances
L. eurolepis	Danemark	1
L. leptolepis	Canada—Québec	1
	France	1
	Japon	8
L. occidentalis	Canada—Québec	1
L. sibirica	Finlande	1
	URSS	1

La majorité de ces lots a été semée et toutes les provenances se comportent de façon satisfaisante en pépinière.

De plus, nous participons aux expériences n^{os} 377 et 378 de la Station forestière expérimentale de Petawawa. Nous avons reçu et semé 9 provenances de *L. sibirica* pour l'expérience n^{o} 377 et 27 lots différents de *L. decidua*, *L. leptolepis* et des hybrides pour l'expérience n^{o} 378.

Test de descendances et test clonal

À l'intérieur de la province de Québec, nous avons sélectionné au total 37 individus de *L. decidua* et 4 de *L. leptolepis*. Les critères de sélection n'étaient pas toujours assez sévères et nous serons obligés d'annuler quelques sélections.

Présentement, nous avons dans la pépinière un test qui regroupe au total 47 descendances provenant d'arbres sélectionnés à l'intérieur de la province de Québec. Sur les arbres sélectionnés, des boutures ont été prélevées et, durant l'hiver de 1970-1971, plusieurs expériences de bouturage ont été réalisées. Ces études comprennent également 14 arbres sélectionnés par le Centre de recherche forestière des Maritimes (15).

Au printemps de 1972, nous avons essayé de greffer les 14 arbres sélectionnés. Nous avons également reçu les greffons de 14 clones de la North Central Forest Experiment Station (Wisconsin, États-Unis) et 1 clone du Centre de recherche forestière des Maritimes.

Au printemps de 1973, nous avons reçu les greffons de 105 clones de la Station forestière expérimentale de Petawawa, et de nouveau, le clone n^{o} St 368 du Centre de recherche forestière des Maritimes du Nouveau-Brunswick. Ce matériel, avec les 10 clones du Québec, a été en partie greffé et en partie bouturé.

INTRODUCTION D'ESPÈCES
(A. Stipanicic)

Projet Sg 68-2 Introduction d'espèces exotiques ou indigènes au Québec

Buts

1) Trouver de nouvelles espèces aptes au reboisement de façon à accroître la rentabilité des plantations et à diversifier la production (1).

2) Orienter des études plus précises de provenances.

3) Créer des hybrides interspécifiques présentant des caractères propres à différentes fins.

4) Évaluer les possibilités d'adaptation et de croissance de ces espèces en relation avec les conditions écologiques de diverses stations.

Travaux réalisés

Les premiers travaux d'ensemencement ont été faits au printemps de 1969 à la pépinière provinciale de Berthierville. Nous avons semé 25 espèces différentes représentées par un total de 61 provenances.

Le deuxième ensemencement a été fait à l'automne de 1969 à la pépinière de Duchesnay. Dans ce dernier cas, 10 espèces avec au total 15 provenances ont été semées.

L'ensemencement suivant a été fait au printemps de 1970, alors que nous avons semé 57 espèces comprenant un total de 133 provenances.

À l'automne de 1970, 14 espèces avec 80 provenances ont été semées, dont 59 provenances de *Pseudotsuga sp.* (collection IUFRO), ce qui représente la première partie de l'ensemencement pour un test de provenances sur le sapin de Douglas.

Au printemps de 1971, 13 espèces réparties en 21 provenances ont été semées, puis, à l'automne, 6 autres espèces réparties en 8 provenances. Une provenance d'*Abies balsamea* comprenait 36 descendances, et deux provenances d'*Abies sachalinensis* étaient représentées par 10 descendances chacune.

À l'automne de 1972, nous avons semé 24 espèces avec au total 198 provenances, dont 131 provenances de *Pseudotsuga sp.* (collection IUFRO). C'était la deuxième partie, plus complète, de l'ensemencement pour le test de provenances sur le sapin de Douglas.

Pinus lambertiana était représenté par une collection de 17 provenances, obtenue aussi de l'IUFRO.

Au printemps de 1973, nous avons semé 8 espèces avec au total 45 provenances, dont 11 provenances d'*Abies lasiocarpa* (collection IUFRO).

Les plants issus de ces ensemencements sont destinés à être introduits en plantations comparatives dans le réseau de nos secteurs expérimentaux (arboreta)—projet Sg 68-SE.

Toutes les provenances semées sont régulièrement observées, ce qui nous donne les renseignements nécessaires sur le comportement des espèces exotiques au niveau de la pépinière. Pour certaines espèces, dès le premier hiver, une forte sélection est faite au niveau des sujets et entre les provenances, et dans certains cas des provenances sont complètement endommagées par le froid. Les lots partiellement atteints, ou complètement exempts de dommages causés par l'hiver, seront repiqués après deux saisons de végétation, et finalement la plupart des plants seront expédiés de la pépinière à l'âge de quatre ans (plants 2 - 2).

Le tableau 6 montre les travaux d'ensemencement réalisés jusqu'au printemps de 1973.

<u>Observation des semis</u>

Durant chaque été, les semis sont observés régulièrement afin de déterminer l'époque du débourrement, l'importance des dégâts causés par le gel et le froid, le développement durant l'été et l'aoûtement. Toutes ces observations nous permettent de connaître le comportement juvénile des semis. Dans la plupart des cas, sous nos conditions climatiques, les semis 2 - 2 ne dépassent pas le niveau de la neige et ne sont pas exposés au vent et au froid sec de l'hiver. C'est seulement après que la cime aura dépassé le niveau de la neige et donc après quelques années dans les arboreta que nous serons en mesure de donner un jugement plus valable sur la résistance et les autres qualités d'une espèce ou d'une provenance.

Nous donnons ci-après un bref résumé des observations de rusticité faites sur les semis des années 1969, 1970 et du printemps de 1971.

Genre *Abies*: La plupart des espèces de ce genre ont démontré une résistance complète ou satisfaisante aux conditions de la pépinière. Il faut cependant souligner un taux de germination très faible ou nul chez plusieurs lots ainsi qu'un développement juvénile lent pour toutes les espèces. *Abies balsamea* montre le meilleur comportement alors qu'*Abies firma* et *Abies homolepis* sont partiellement endommagés et ne semblent pas adaptés à nos conditions.

Genres *Cedrus* et *Cryptomeria*: Tous les plants ont été fortement atteints par le froid, et la majorité des plants sont morts après le premier hiver.

TABLEAU 6 Liste et nombre de provenances ensemencées

Espèces \ Pépinière	Berthierville printemps de 1969	Duchesnay automne de 1969	Duchesnay printemps de 1970	Duchesnay automne de 1970	Duchesnay printemps de 1971	Duchesnay automne de 1971	Duchesnay automne de 1972	Duchesnay printemps de 1973
Résineuses								
Abies alba	6	-	7	2	6	-	2	-
Abies balsamea	-	-	1	-	-	1	6	-
Abies bornmülleriana	-	-	1	-	-	1	1	-
Abies cephalonica	-	-	-	-	-	1	-	-
Abies concolor	-	-	1	-	-	-	-	-
Abies firma	1	-	1	-	-	-	-	-
Abies fraseri	-	-	1	-	-	-	-	-
Abies grandis	-	-	2	-	-	-	1	-
Abies holophylla	-	-	-	-	-	1	-	-
Abies homolepis	1	-	3	-	-	-	-	-
Abies lasiocarpa	-	-	-	-	-	-	11	-
Abies magnifica	-	-	1	-	-	-	-	1
Abies mariesii	-	-	3	-	-	-	-	-
Abies nobilis	-	-	-	-	-	-	1	-
Abies nordmaniana	-	-	1	-	-	2	1	-
Abies procera	-	-	1	-	-	-	-	-
Abies sachalinensis	3	-	7	-	-	2	-	-
Abies veitchii	-	-	2	-	-	-	-	-
Cedrus libani	-	-	1	-	-	-	1	-
Chamaecyparis lawsoniana	2	-	2	-	-	-	-	-
Cryptomeria japonica	-	-	2	-	-	-	-	-
Cupressus sempervirens	-	-	-	-	-	-	1	-
Larix decidua	2	-	5	-	-	-	-	11
Larix eurolepis	-	-	-	-	1	-	-	-
Larix leptolepis	1	-	5	-	-	-	5	1
Larix occidentalis	-	-	-	-	1	-	-	-
Larix sibirica	1	-	1	-	-	-	1	2
Picea breweriana	-	-	1	-	-	-	-	-
Picea glauca	-	-	2	-	1	-	-	-
Picea glehnii	1	-	5	-	-	-	-	-
Picea hondoensis	-	-	1	-	-	-	-	-
Picea jezoensis	1	-	6	-	-	-	-	-
Picea mariana	-	-	1	-	-	-	-	-
Picea orientalis	-	-	-	-	1	-	-	-
Picea pungens	-	-	1	-	-	-	-	-
Picea rubens	-	-	2	-	-	-	-	-
Picea sitchensis	6	-	7	-	-	-	-	-
Pinus cembra	1	-	3	-	-	-	-	-

TABLEAU 6 (suite)

Espèces \ Pépinière	Berthierville printemps de 1969	Duchesnay automne de 1969	Duchesnay printemps de 1970	Duchesnay automne de 1970	Duchesnay printemps de 1971	Duchesnay automne de 1971	Duchesnay automne de 1972	Duchesnay printemps de 1973
Pinus cembroides	-	-	1	-	-	-	-	-
Pinus contorta	-	-	1	-	-	-	-	-
Pinus echinata	-	-	2	-	-	-	-	-
Pinus flexilis	-	-	1	-	-	-	-	-
Pinus Jeffreyi	-	-	2	-	-	-	-	-
Pinus koraiensis	-	-	-	-	1	-	-	-
Pinus lambertiana	-	-	2	2	-	-	-	15
Pinus leiophylla	-	-	1	-	-	-	-	-
Pinus leucodermis	-	-	-	-	1	-	-	-
Pinus massoniana	-	-	1	-	1	-	-	-
Pinus montana	2	-	5	-	-	-	-	-
Pinus monticola	-	-	1	-	-	-	-	-
Pinus nigra	10	-	3	-	-	-	-	-
Pinus parviflora	-	-	3	3	-	-	-	-
Pinus peuce	-	-	-	1	-	-	-	-
Pinus ponderosa	-	-	5	-	-	-	-	-
Pinus pseudostrobus	-	-	1	-	-	-	-	-
Pinus rigida	-	-	1	-	-	-	-	-
Pinus rigida x echinata	-	-	-	-	1	-	-	-
Pinus rudis	-	-	1	-	-	-	-	-
Pinus strobus	-	-	2	-	-	-	-	-
Pinus thunbergii	-	-	-	-	1	-	-	-
Pinus virginiana	-	-	1	-	-	-	-	-
Pseudotsuga flahaulti	-	-	-	1	-	-	1	-
Pseudotsuga macrolepis	-	-	-	1	-	-	1	-
Pseudotsuga menziesii	5	-	6	57	1	-	129	3
Sequoiadendron giganteum	-	-	2	-	-	-	-	-
Thuja occidentalis	-	-	2	-	-	-	-	-
Thuja plicata	3	-	4	-	-	-	-	-
Feuillues								
Acer pseudoplatanus	3	-	-	-	-	-	-	-
Acer rubrum	-	-	-	-	-	-	-	7
Acer saccharinum	-	-	-	-	-	-	-	9
Acer saccharum	-	1	-	-	-	-	-	-
Aesculus hippocastanum	-	-	1	1	-	-	-	-
Alnus glutinosa	1	4	2	-	-	-	8	-
Betula alleghaniensis	-	1	-	-	-	-	-	-
Betula pendula	1	-	-	-	-	-	-	-

TABLEAU 6 (suite)

Espèces \ Pépinière	Berthierville printemps de 1969	Duchesnay automne de 1969	Duchesnay printemps de 1970	Duchesnay automne de 1970	Duchesnay printemps de 1971	Duchesnay automne de 1971	Duchesnay automne de 1972	Duchesnay printemps de 1973
Betula pubescens	1	-	-	-	-	-	-	-
Catalpa sp.	-	-	-	-	2	-	1	-
Fagus sylvatica	2	-	-	-	-	-	-	-
Fraxinus excelsior	-	-	1	-	-	-	1	-
Fraxinus nigra	-	1	-	-	-	-	-	-
Fraxinus pennsylvanica	-	3	-	-	-	-	1	-
Juglans cinerea	-	1	-	3	-	-	2	-
Juglans nigra	-	-	-	-	-	-	1	-
Platanus orientalis	-	-	-	-	3	-	1	-
Populus alba	1	-	-	-	-	-	-	-
Populus maximowiczii	2	-	-	-	-	-	-	-
Populus nigra	1	-	-	-	-	-	-	-
Populus tremula	1	-	-	-	-	-	-	-
Prunus serotina	-	1	-	1	-	-	-	-
Quercus macrocarpa	-	1	-	1	-	-	-	-
Tilia americana	-	1	-	-	-	-	-	-
Tilia cordata	-	1	-	1	-	-	5	-
Tilia japonica	-	-	3	3	-	-	-	-
Tilia mandshurica	-	-	-	-	-	-	1	-
Tilia maximowicziana	-	-	3	3	-	-	-	-
Tilia platyphyllos	-	-	-	-	-	-	3	-
Tilia tomentosa	-	-	-	-	-	-	2	-

Genre *Chamaecyparis*: Les plants ont été partiellement atteints par le froid et un certain nombre sont morts après le premier hiver. Cependant, nous avons remarqué une bonne résistance au froid et un fort accroissement en hauteur chez les plants qui n'ont pas été endommagés.

Genre *Larix*: Tous les lots ensemencés montrent une résistance complète au froid. Dans certains cas le taux de germination était très faible.

Genre *Picea*: La résistance complète au froid est remarquée chez les espèces indigènes et aussi chez *Picea glehnii*, *Picea jezoensis* et *Picea pungens*. Toutefois, les pousses terminales de plus de 10 pouces de longueur (environ 25 cm) chez les plants 2 - 2 de *Picea glehnii* ont été partiellement touchées par le froid de l'hiver de 1972-1973. Nous avons noté le même comportement chez quelques provenances de *Picea sitchensis* (deux provenances du

Danemark). Une provenance danoise de *Picea sitchensis* (Meilgård, Overskov compt. 210) se montre plus faible par rapport aux deux autres (Rye Nørskov compt. 10 et Frijsenborg Tinning compt. 3a), l'accroissement est plus lent et les dommages causés par le froid plus visibles. Les deux provenances d'Alaska montrent en général une résistance complète au froid, mais leur vigueur est inférieure aux provenances danoises. Une provenance de Washington (Crescent Lake, États-Unis) n'était pas adaptée à nos conditions: les plants avaient une bonne croissance mais étaient endommagés par le froid. *Picea hondoensis* montre une faible résistance au froid, les pousses terminales ont été touchées par les gelées précoces et l'accroissement était très faible. Le seul lot de *Picea breweriana* que nous avons semé a eu un taux de germination très faible; *Picea orientalis* n'a pas germé du tout.

Genre *Pinus*: Nous avons observé une résistance complète au froid chez: *Pinus cembra*, *Pinus contorta* (graines récoltées sur quelques arbres dans la pépinière provinciale de Grandes-Piles, au Québec), *Pinus flexilis* (provenance du Montana, États-Unis), *Pinus lambertiana* (provenance de la Californie, États-Unis), *Pinus montana spp. mughus* et *uncinata* (provenances de France, d'Italie et de Suisse), *Pinus nigra spp. austriaca* et *calabrica* (provenances d'Italie et du Danemark) et *Pinus peuce* (provenance de Bulgarie).

Nous avons remarqué une résistance partielle chez *Pinus Jeffreyi* (deux provenances de la Californie), *Pinus nigra spp. corsicana* (provenances d'Angleterre et de France), *Pinus ponderosa* (provenances du Colorado, du Montana, de l'Oregon et de Washington, États-Unis), *Pinus rigida* (provenance du Québec) et *Pinus rigida x echinata* (hybride obtenu de la Corée du Sud).

Nous avons remarqué une faible résistance au froid entraînant un pourcentage élevé de mortalité chez *Pinus echinata* (provenances du Kentucky et de la Georgie, États-Unis), *Pinus monticola* (provenance de l'Idaho, États-Unis), *Pinus ponderosa* (provenance de la Californie) et *Pinus virginiana* (provenance du Kentucky).

Les autres espèces n'ont montré aucune résistance au froid et nous avons constaté un très fort pourcentage de mortalité après le premier hiver.

Quelques espèces ont eu un taux de germination faible ou nul (*Pinus parviflora*, *Pinus strobus*, *Pinus koraiensis*, *Pinus leucodermis*, *Pinus thunbergii*).

Genre *Pseudotsuga*: Les provenances situées à l'intérieur des montagnes Rocheuses (*Pseudotsuga menziesii* var. *glauca*) et les provenances de la zone d'introgression des variétés *glauca* et *menziesii* montrent une résistance satisfaisante au froid (collection IUFRO, provenances n^os^ 1001, 1003, 1005, 1006, 1008, 1019, 1020, 1035, 1052, 1105, 1106, 1107, 1109, 1110, 1111, 1112).

Une provenance récoltée au Québec (Rivière-du-Loup) n'a subi aucun dommage par le froid.

Les provenances de *Pseudotsuga menziesii* var. *menziesii* ont été, en général, atteintes par le froid, mais l'intensité des dommages est très variable selon les provenances.

Nous avons également observé le comportement du sapin de Douglas sur un dispositif comprenant 59 provenances, installé dans la pépinière au printemps de 1971.

Genre *Sequoiadendron*: Les deux provenances de la Californie étaient fortement touchées par le froid.

Genre *Thuja*: Les quatre provenances de *Thuja plicata* (Danemark, Idaho et Washington) étaient partiellement endommagées par le froid, mais nous avons observé un accroissement très intéressant chez les semis de cette espèce.

Thuja occidentalis montre une résistance complète.

Genres *Acer, Aesculus, Alnus, Betula, Fagus, Fraxinus, Prunus* et *Quercus*: Tous les lots ensemencés montrent une résistance complète. Il faut souligner l'accroissement très intéressant et la très bonne adaptation constatés chez toutes les provenances d'*Alnus glutinosa*. *Acer pseudoplatanus* semé au printemps de 1969 n'a pas germé.

Genre *Juglans*: Une provenance de *Juglans cinerea* (Portneuf, Québec) était partiellement atteinte par le froid.

Genre *Tilia*: Tous les lots que nous avons semés ont eu un taux de germination très faible ou même nul. Toutefois, les semis montrent une résistance satisfaisante, mais l'accroissement est très lent, ce qui démontre une inadaptation de ces provenances.

Genres *Catalpa* et *Platanus*: Tous les plants étaient fortement endommagés par le froid après le premier hiver et le taux de mortalité, surtout chez *Platanus sp.*, était très élevé.

BANQUE DE SEMENCES
(D. Robert)

Le principe de la banque de semences est de conserver dans des conditions optimales d'entreposage à longue durée, des lots de semences désirés. L'entreposage des semences pour de grandes périodes est quelque peu délicat du fait que les conditions varient suivant l'espèce concernée. Les facteurs limitatifs se résument au degré hygrométrique de l'air ainsi qu'à sa température. Les espèces comme telles se classent grossièrement en deux groupes: celles qui nécessitent un fort pourcentage d'humidité afin de conserver leur faculté germinative et celles (la majorité) pour lesquelles le pourcentage d'humidité peut être très réduit. Suivant la haute ou la faible teneur en humidité, les semences pourront être conservées à des températures supérieures ou inférieures au point de congélation, respectivement.

Le but premier de la banque de semences, en ce qui nous concerne, est de conserver des gènes. L'utilité de cette perspective se fait principalement valoir dans le cas où certaines espèces se trouvent menacées d'extinction ou lorsqu'on veut avoir la possibilité de reproduire, avec un certain délai, un peuplement particulièrement remarquable appelé à disparaître pour quelque raison. La banque de semences nous permet de plus d'accumuler le nombre voulu d'espèces et de provenances nécessaires à la réalisation des projets envisagés. C'est le cas principalement de la disponibilité des semences concernant les introductions d'espèces.

Ce mode d'entreposage permet donc de disposer sans cesse d'un matériel dont l'aspect génétique présente une valeur certaine, sans être à la merci des périodes de faible production de semences intervenant entre les années semencières.

La banque de semences de la Section de génétique forestière du Service de la recherche fait l'objet d'accords avec le Service de la restauration, principalement avec M. Yves Lamontagne de la pépinière provinciale de Berthierville, qui veut bien nous fournir une certaine quantité de semences pour chacun des lots récoltés annuellement et présentant un certain intérêt du point de vue conservation et amélioration. Quant aux provenances exotiques, les semences s'obtiennent par l'entremise des divers organismes internationaux et centres de recherche à la suite d'accords et d'échanges mutuels.

La Section de génétique envisage d'effectuer sa propre récolte de semences pour entreprendre des essais au niveau des espèces indigènes feuillues, des tests d'introduction chez ces mêmes espèces à l'intérieur du Québec ainsi que des plantations conservatoires pour les espèces à faible représentation ou menacées de disparition. Ce dernier cas se présente pour le pin dur (*Pinus rigida*) dont l'îlot de Saint-Chrysostome, au sud de Montréal, ne possède aucune protection et peut subir une destruction inattendue. Il est impératif de préserver cette population isolée située à la limite septentrionale de dispersion de l'espèce et de prendre ainsi les moyens de la reproduire.

Les récoltes visent également d'autres espèces puisque pour ce qui est des feuillus, nous n'en sommes qu'à envisager l'approche sur le plan amélioration tout en conservant à l'esprit leur grande importance. La nécessité de la banque de semences s'impose dans ce dernier cas, puisqu'elle permettra d'accumuler le matériel nécessaire à la mise en marche des expériences à proprement parler. Les espèces dont nous disposons dans la banque de semences sont énumérées au tableau 7 avec leur nombre respectif de provenances.

La banque se compose ainsi de deux parties: les espèces représentées par un nombre assez important de provenances et sur lesquelles sont envisagés de futurs tests de provenances ou autres (par exemple *Picea*

TABLEAU 7 Liste des espèces indigènes ou exotiques composant la banque de semences et leur nombre de provenances disponibles

Espèces	Nombre de provenances	Espèces	Nombre de provenances
Abies balsamea	1	*Picea sitchensis*	61
Betula alleghaniensis	1	*Pinus banksiana*	58
Larix decidua	1	*Pinus contorta*	133
Larix laricina	16	*Pinus nigra*	26
Larix leptolepis	1	*Pinus ponderosa*	6
Picea abies	65	*Pinus resinosa*	5
Picea engelmannii	21	*Pinus rigida*	1
Picea glauca	31	*Pinus strobus*	13
Picea pungens	10	*Pinus sylvestris*	59
Picea rubens	6		

sitchensis, Picea engelmannii, Picea abies, Pinus sylvestris, Pinus contorta et *Pinus nigra*), et les essences retenues uniquement dans un but de conservation, pour l'intérêt que représente leur "pool" génique.

ARBORETA
(C. Chouinard)

Projet Sg 68-SE Réseau de secteurs expérimentaux (arboreta) pour l'amélioration des arbres forestiers

Depuis le mois d'août 1970, quatre nouveaux secteurs ont été établis. Ce sont les secteurs de Lotbinière, Coulonge, Chibougamau et East-Angus. Deux autres seront créés durant l'été de 1973, ceux de Mont-Laurier et de Labrieville. La distribution des secteurs apparaît sur la carte ci-jointe et leurs caractéristiques écologiques, géographiques et climatiques (11, 12, 13 et 14) sont données aux tableaux 10 et 11 respectivement.

La liste des espèces indigènes et exotiques plantées dans les arboreta par la Section de génétique forestière du Service de la recherche est donnée au tableau 8. Celles installées par d'autres organismes sont résumées au tableau 9.

Parmi les plus importants tests réalisés dans les arboreta, nous retrouvons les suivants:

- Test de 22 provenances de Pologne et 22 provenances d'Europe d'épinette de Norvège (*Picea abies*), 1969.

- Test de 41 descendances d'épinette blanche (*Picea glauca*) provenant de la vallée de l'Outaouais, 1969.

TABLEAU 8 Espèces plantées dans les arboreta

Espèces \ Arboreta	Bonaventure	Chibougamau	Coulonge	Duchesnay	East Angus	Gaspé	Guigues	Labrieville	Lac Saint-Ignace	Lotbinière	Matane	Matapédia	Mont-Laurier	Parke	Trécesson
Abies alba	X	–	X	X	–	–	–	–	X	–	–	X	–	X	–
Abies balsamea	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–
Acer saccharum	X	–	–	X	–	X	–	–	X	–	X	X	–	X	X
Aesculus hippocastanum	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Alnus glutinosa	X	X	–	X	–	X	–	–	X	X	X	X	–	X	X
Betula alleghaniensis	–	–	–	X	–	X	–	–	X	X	X	X	–	X	X
Betula pendula	X	–	–	X	–	X	–	–	X	–	–	X	–	–	X
Betula pubescens	X	–	–	X	–	–	–	–	–	–	–	X	–	–	X
Chamaecyparis lawsoniana	X	–	X	–	–	–	–	–	–	X	–	X	–	–	–
Fagus grandifolia	X	–	–	X	–	X	–	–	X	X	–	X	–	X	X
Fagus sylvatica	X	–	–	X	–	–	–	–	–	–	–	X	–	–	–
Fraxinus excelsior	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fraxinus pennsylvanica	X	X	X	X	–	X	–	–	X	–	X	X	–	X	X
Juglans cinerea	X	–	X	X	–	–	–	–	–	X	–	X	–	–	–
Larix decidua	X	X	X	X	X	X	–	–	–	–	–	X	–	X	X
Larix leptolepis	X	–	X	X	–	X	–	–	X	–	–	X	–	X	X
Larix sibirica	X	X	–	X	–	X	–	–	X	–	–	–	–	–	X
Picea abies	–	–	–	X	–	X	–	–	X	–	–	X	–	X	X
Picea glauca	X	–	–	X	–	X	X	–	X	–	–	–	–	–	X
Picea glehnii	X	X	–	X	–	X	X	–	X	–	–	–	–	–	X
Picea jezoensis	X	–	–	X	–	–	–	–	X	–	–	–	–	–	–
Picea mariana	–	–	–	X	–	X	–	–	X	–	–	X	–	X	X
Picea sitchensis	X	X	–	X	–	X	X	–	X	X	–	–	–	X	X
Pinus contorta	–	–	–	–	–	–	–	–	–	–	–	X	–	–	X
Pinus nigra	X	X	X	–	–	X	X	–	X	X	–	X	–	X	X
Pinus sylvestris	X	–	–	–	–	X	–	–	–	–	–	X	–	–	–
Pinus uncinata	–	X	–	–	–	X	–	–	–	X	–	–	–	X	X
Populus sp.	X	–	–	X	–	X	X	–	X	X	X	X	–	X	X
Prunus serotina	X	–	–	–	–	–	–	–	–	X	–	X	–	–	–
Pseudotsuga menziesii	X	–	X	X	X	X	X	–	X	–	–	X	–	X	–
Quercus macrocarpa	X	–	X	X	–	–	–	–	–	–	–	X	–	–	–
Thuja plicata	X	–	X	X	–	–	–	–	X	–	–	X	–	X	–
Tilia cordata	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–

TABLEAU 9 Plantations effectuées dans les arboreta par d'autres organismes que le Service de la recherche

Organisme	Arboreta	Espèces	Nombre	
			Provenances	Descendances
Centre de recherche forestière des Laurentides	Coulonge	*Betula alleghaniensis*	37	126
Université Laval	Duchesnay	*Picea mariana*	31	-
Centre de recherche forestière des Laurentides	Lotbinière	*Betula alleghaniensis*	44	257
Centre de recherche forestière des Laurentides	Matapédia	*Picea abies*	38	-
		Betula alleghaniensis	38	176
		Pseudotsuga menziesii	9	-
Université Laval	Parke	*Picea mariana*	12	-

- Test de 10 provenances d'épinette de Norvège (*Picea abies*) provenant de France, 1969 et 1972.
- Test de 10 provenances de pin noir (*Pinus nigra*) provenant de l'Italie, de la France, du Danemark et de l'Angleterre, 1971, 1972 et 1973.
- Test de 11 descendances et de 6 provenances de sapin pectiné (*Abies alba*) de l'Italie et de la France, 1973.
- Test de 37 descendances de sapin baumier (*Abies balsamea*) du Québec, 1972.
- Test de 38 descendances d'épinette noire (*Picea mariana*) issues de croisements contrôlés. Origine des parents: Ontario, Québec, Terre-Neuve, 1969 et 1972.
- Test de 20 à 35 clones de peuplier, 1969, 1970 et 1971.
- Test de 150 à 175 clones de peuplier, 1973.
- Test de 28 provenances d'épinette blanche (*Picea glauca*) de Colombie-Britannique, 1972.
- Test de 51 provenances d'épinette de Norvège (*Picea abies*) de Bulgarie, 1971.

TABLEAU 10 Caractéristiques écologiques des arboreta

Arboreta	Lieu	Principales séries	Bioclimat	Vocation	Dépôt de surface
Bonaventure	Comté de Bonaventure, canton de Cox, rangs XII et XIII, lots vacants	Sapinière à érable rouge et érablière à bouleau jaune	Relativement chaud, maritime	Agro-forestière	Till limoneux calcaire
Chibougamau	Comté d'Abitibi-Est, cantons de Richardson et de Roy	Pessière noire	Très froid, continental, sec	Forestière	Till mince granitique et sableux
Coulonge	Comté de Pontiac, canton de Litchfield, rangs X et XI	Érablière à bouleau jaune	Humide et tempéré	Forestière	Till sableux à graveleux et till limono-sableux
Duchesnay	Comté de Portneuf, station forestière de Duchesnay	Érablière à bouleau jaune	Relativement chaud, continental, humide	Forestière	Till sableux limoneux granitique
East-Angus	Comté de Compton, canton de Ditton, rang VII, lots 4 à 8 et la moitié ouest du lot 9	Érablière à bouleau jaune	Relativement chaud, continental	Agro-forestière	Till limoneux calcaire et ardoisier
Gaspé	Comté de Gaspé-Nord, canton de Baie-de-Gaspé-Sud, forêt domaniale de Gaspé	Sapinière à épinette noire	Très froid, continental, humide	Forestière	Till gréseux et schisteux avec blocs erratiques
Guigues	Comté de Témiscamingue, canton de Guigues, rangs III et IV	Érablière à bouleau jaune	Relativement chaud et sec	Agro-forestière	Argile lacustre à limon sablonneux fluviatil

TABLEAU 10 (suite)

Arboreta	Lieu	Principales séries	Bioclimat	Vocation	Dépôt de surface
Labrieville	Comté de Saguenay, canton de Virot	Pessière noire	Très froid, continental, humide	Forestière	Till sableux granitique
Lac Saint-Ignace	Comté de Gaspé-Nord, canton de Tourelle, rang XI, lots rétrocédés	Sapinière à bouleau à papier	Froid, continental, humide	Forestière	Till limoneux avec blocs erratiques
Lotbinière	Comté de Lotbinière, seigneurie de Lotbinière	Érablière à bouleau jaune	Continental, humide	Forestière	Till limono-sableux à sablo-limoneux
Matane (Populetum)	Comté de Matane, canton de Cuoq, rang III, lots 15 et 16 et partie des lots 22 à 29 et rang II partie des lots 22 à 28	Sapinière à bouleau jaune	Très frais, continental	Forestière	Till limoneux et terrasse alluviale
Matapédia	Comté de Matapédia, seigneurie du lac Matapédia	Érablière à bouleau jaune	Frais, continental	Agro-forestière	Till limoneux calcaire
Mont-Laurier	Comté de Gatineau, canton de Sicotte, rang V, lots 8 à 10	Érablière à bouleau jaune	Frais, continental	Forestière	Sable fluvio-glaciaire et till sableux granitique
Parke	Comté de Kamouraska, canton de Parke, rangs B et C, réserve cantonale de Parke	Sapinière à bouleau à papier	Froid, continental	Forestière	Till limoneux schisteux
Trécesson	Comté d'Abitibi-Est, canton de Trécesson, rangs I et II	Pessière noire	Très froid, continental, relativement sec	Forestière	Argile et sable lacustres

TABLEAU 11 Caractéristiques géographiques et climatiques des arboreta

Arboreta	Altitude		Latitude	Longitude	Température				Précipitation totale annuelle		Longueur de la saison sans gel (jours)
					moyenne de juin, juillet et août		minimale absolue				
	pi	m			°F	°C	°F	°C	po	cm	
Bonaventure	500-800	*152-241*	48° 10'N	65° 20'O	60.7	*15.9*	-33	*-36.1*	45	*114*	100-120
Chibougamau	1350	*411*	50° 03'N	74° 10'O	58.1	*14.4*	-57	*-48.3*	32	*81*	80
Coulonge	650-1000	*198-305*	45° 51'N	76° 34'O	65.7	*18.3*	-44	*-42.2*	35	*89*	120-140
Duchesnay	500-1100	*152-335*	46° 52'N	71° 37'O	59.7	*15.4*	-43	*-41.7*	46	*117*	120-140
East-Angus	1500-1725	*457-526*	45° 20'N	71° 15'O	64.2	*17.8*	-44	*-42.2*	42	*107*	120-130
Gaspé	600-1100	*201-335*	48° 50'N	64° 40'O	61.2	*16.2*	-44	*-42.2*	36	*91*	80-100
Guigues	600-700	*183-213*	47° 37'N	79° 30'O	62.9	*17.2*	-45	*-42.8*	37	*94*	120-140
Labrieville	1500-1750	*457-533*	49° 12'N	69° 33'O	55.9	*13.2*	-47	*-43.8*	38	*97*	80-90
Lac Saint-Ignace	1500-2150	*457-655*	49° 00'N	66° 20'O	58.9	*14.9*	-44	*-42.2*	39	*99*	100-120
Lotbinière	250-300	*76-91*	46° 30'N	71° 55'O	62.0	*16.7*	-38	*-38.8*	41	*104*	120
Matane (Populetum)	300-1000	*91-305*	48° 40'N	67° 15'O	57.5	*14.2*	-45	*-42.8*	35	*89*	80-100
Matapédia	600-800	*183-244*	48° 30'N	67° 25'O	60.1	*15.6*	-45	*-42.8*	35	*89*	100-120
Mont-Laurier	800-1150	*244-351*	46° 36'N	75° 48'O	62.8	*17.0*	-48	*-44.4*	36	*91*	100-120
Parke	1200	*366*	47° 30'N	69° 30'O	61.2	*16.2*	-43	*-41.7*	39	*99*	80-100
Trécesson	1000-1200	*305-366*	48° 40'N	78° 30'O	59.0	*15.0*	-56	*-48.9*	33	*84*	80-100

- Test de 5 provenances de *Larix leptolepis* et de 5 provenances de *Larix decidua*, 1972 et 1973.

- Test de 15 provenances de sapin de Douglas (*Pseudotsuga menziesii*), 1971, 1972 et 1973.

- Test de 24 descendances de *Populus deltoides*, *Populus balsamifera* et *P. x Jackii*, 1972.

Nous poursuivons l'extention des superficies des arboreta existants et comptons en créer de nouveaux de façon à compléter le réseau projeté de 19 stations.

Au printemps de 1974, le Centre de recherche forestière des Laurentides effectuera les plantations d'épinette noire relatives à l'expérience "Range-wide black spruce study" sur les superficies qu'il a retenues aux arboreta de Lac Saint-Ignace, Chibougamau et Mont-Laurier.

Quant au Service de la recherche, il compte poursuivre les introductions de même que la réalisation d'autres tests de provenances et de descendances, dont, en 1974, celui de 20 descendances de mélèze laricin (*Larix laricina*), expérience n^{o} 376 de la Station forestière expérimentale de Petawawa et celui de 59 provenances de sapin de Douglas (*Pseudotsuga menziesii*) prévu pour 1975.

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THE CONTRIBUTION OF GENETIC VARIATION TO PRODUCTIVITY SYSTEMS IN SPRUCE FOREST ECOSYSTEMS

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The objectives of this work are:

1. To elucidate the contribution of species, forms, provenances and hybrids in productivity systems;

2. To collect and interpret information on genetic variability, crossability, and heritability in regard to genecology and phylogeny of the genus *Picea*;

3. To evaluate the effect of seed zones (site regions) in productivity systems, and to confirm the validity of the limits of movement of spruce stock between regions.

GENECOLOGY

A study has been largely completed on the genecology of *Picea rubens*. A manuscript is being prepared on the genetics and taxonomy of *P. rubens* and *P. mariana*. The variation in *P. rubens* as it comes in contact with *P. mariana* and the extent of hybridization of these species are dealt with. Comparisons have been made with the composition of mature stands and that of the regeneration for all sites. Plot systems cover all moisture regime sites to the limit of *P. rubens* occurrence and a good coverage of *P. mariana*. Data have been collected on ground vegetation, cover type, light, pedological and chemical characteristics of the sites and vegetation.

Progeny of selected range-wide populations have been established in a small number of provenance experiments on different sites, and reciprocal crossing (not always successful) has been carried out. Hybrid progeny from selfing and backcrossing hybrid types have been planted out.

PICETA

Studies are under way to evaluate growth and efficiency, nutrition etc. of a large number of spruce species, forms and provenances across a wide climatic range. Experimental spruce plantations called "Piceta" have been established on a complete range of all major climatic zones (Ouellet and Sherk 1967) in Ontario. One Picetum has been established in British Columbia in cooperation with the Research Division, British Columbia Forest Service.

While it is expected that a good deal of the white and black spruce seed for seedling production in Ontario will ultimately come from seed production areas and orchards, it is probable that for many years, and perhaps indefinitely, much seed will continue to come from normal seed-zone collections. Seed zones in Ontario were delineated from an edaphic and climatic synthesis by G.A. Hills (1954 etc.) and the Tree Production Unit of the Forest Management Branch. In order to provide information towards objective No. 3, a range of *P. glauca* and *P. mariana* provenances representative of these zones and reciprocally planted is included in the Piceta.

Most of the experimental seedlings, representing 28 species, 50 provenances, 14 forms and hybrids have been outplanted over the past few years. The more northern Piceta, of course, contain many fewer species. Some very slowly developing lots, as well as replacements, are still being planted.

HYBRIDIZATION

A series of successful crosses representing several clones were made in 1971. These included *P. omorika* x *omorika*, *P. omorika* x self, *P. mariana* x *mariana*, *P. rubens* x *rubens*, *P. rubens* x self, *P. omorika* x *mariana*, *P. mariana* x *omorika*, *P. rubens* x *mariana*, *P. mariana* x *rubens*, *P. omorika* x *sitchensis*, *P. omorika* x *glauca*, *P. omorika* x *engelmannii*. Of particular interest is the last-mentioned cross, which has not been previously reported. Success was judged only by the production of seedlings. Previous studies indicated that the number of full seed was not a sufficiently reliable criterion to indicate successful hybridization.

After accelerated growth, the progeny from these crosses were planted in replicated experiments in 1972. The experiments were designed to facilitate comparison with earlier crosses and will be outplanted later. A number of other intra- and interspecific crosses involving 12 *Picea* species were attempted in 1972.

The work of the Unit is otherwise largely occupied with ecological productivity studies of natural spruce forests and includes studies of growth and nutrition, nutrient cycling, spruce forest soils and vegetation. A substantial amount of chemical analysis is done. In 1972 there were 14,622 individual determinations on six macro elements done on spruce components and forest soils.

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SEED ORCHARDS AND SEED PRODUCTION AREAS IN ONTARIO

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SEED ORCHARDS

An 80-acre seed orchard site was acquired in 1971 in Tosorontio Township about 7 miles from Angus. The site is flat, moist farmland. Six blocks of black spruce grafts were planted at the southwest corner of the new site in the spring of 1972, each block containing 144 trees at 12' x 12' spacing. Many ramets were producing female strobili in 1972. A large planting program is planned for the spring of 1973.

In O'Connor Township, Thunder Bay District, an additional seed orchard site was selected to hold white and black spruce from Site Region 3W, which could not be added to the Mattawin Seed Orchard near Camp 503. First plantings in this new site are planned for the spring of 1973.

The grafting program at Angus for the seasons of 1971-72 and 1972-73 is summarized as follows:

Species	Grafts	Clones	Survival in greenhouse %
		1971 - 1972	
White spruce	1,602	17	68
Black spruce	1,839	23	70
Norway spruce	40	4	80
		1972 - 1973	
White spruce	2,030	21	75
Black spruce	820	13	78
Norway spruce	1,050	35	96
Scots pine	152	4	96
White pine	120	2	99

PROGENY TESTING

Close cooperation was maintained with the Tree Breeding Unit (TBU), Forest Research Branch, in the progeny-testing work. After the TBU staff control-pollinated the female strobili in the "F" tract black spruce and white spruce seed orchard, local staff assisted in picking the resulting cones in the fall. Later, black spruce cones from 92 crosses were measured, extracted and cleaned by Angus staff, and sent to the TBU for testing.

SEED PRODUCTION AREAS

Red Pine

In the fall of 1972, 20.30 hectolitres of cones were picked from 262 trees in the red pine seed production area at the Lynn Tract, Oro Township. This year, seasonal pickers were employed as in 1970 but were paid 2¢ per cone without any hourly rate. The Ministry-owned Uppups were used, although pickers preferred to use ladders for picking. Cones picked from each tree were kept separate and later counted for records and payment. The number of cones from individual trees ranged from 4 to 1,454. Following is a comparison of collection costs between 1970 and 1972:

	1972	1970
Picking Date	Sept. 5 - Sept. 10	Sept. 15 - Oct. 8
Number of trees picked	262	510
Number of cones picked	56,361	118,854
Volume (hectolitres)	20.30	36.00
Total cost ($)	1,358.42	2,422.96
Cost per hectolitre:		
Salary	11.38	14.63
Wages	55.52	52.66
Overall ($)	66.90	67.29

Height growth and diameter increment of 185 trees in this area were measured after cone-picking. It was found that the average height growth was 5 feet and that average dbh increment was 1.8 inches during the 3 years from 1970 to 1972.

White Spruce

Two white spruce seed production areas have been established in natural stands, one of 15 acres near Segise Lake, Dryden District, the other of 25 acres in Reeves Township, Chapleau District.

Jack Pine

Two additional jack pine seed collection areas have been established, one near the Firesteel River, Thunder Bay District, the other in Dunmore Township, Kirkland Lake District.

Other Species

To help fill the demand for wildlife planting stock, southern Ontario nurseries have lined out certain shrubs, such as autumn olive, to provide more easily accessible areas from which to collect the required seed. Black locust selections are also being used as seed sources on the basis of their nectar-producing ability for the beekeeping industry.

Seed Collection

In the 1971 crop year, 18.60 hectolitres of cones were collected from three seed-production areas. In the 1972 crop year, 57.60 hectolitres of cones were collected from 14 seed-production areas and seed orchards.

CURRENT PROGRAM FOR THE GENETIC IMPROVEMENT OF THE SPRUCE SPECIES IN ONTARIO, 1971-72

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The objective of the spruce program remains the same: to produce genetically superior trees for Ontario. Now that clones within our seed orchards are producing more abundant male and female flowers, detailed crossing patterns are being used in attempts to get improved strains of our native material for the regeneration program. In addition, we have started a nursery selection program in which the selected seedlings will be rooted and evaluated. In the latter approach, we expect to get significant genetic improvement in a relatively short time. In the past, emphasis was placed on producing hybrid material. Many hybrids were obtained and are being tested to determine their worth. The primary characteristic we are concerned with in all of these programs is rapid growth to shorten the rotation age, especially rapid growth in the early years so that trees can overcome competition.

SELECTION AND IMPROVEMENT OF BLACK AND WHITE SPRUCE

This aspect of the program is a cooperative effort with the Tree Improvement Group and the field staff of the Forest Management Branch of our Ministry. They are responsible for the selection of the plus trees across the province and for the establishment of these trees in seed orchards. It is the responsibility of our Tree Breeding Group in Research to test and evaluate all of the selected material.

A modified biparental mating design is used to produce full sib progeny from the plus trees in the orchards. Table 1 demonstrates the pattern of crossing. Each clone is used three times as a male and three times as a female. We feel that the advantages of this design are many. As both parents are known, we can get a good estimate of specific combining ability. Since each clone is used six times, we can obtain an estimate of general combining ability. Also, since every family has both parents identified, we can select the best individuals from the best families and use this material as a basis for a second-generation orchard.

To date, our breeding work has been concentrated in the black and white spruce clonal orchards for seed zone 3E. The clones for these two orchards were first outplanted in 1966. Each year they produce more flowers than the previous year, but there is still a shortage of male flowers to supply all of the required pollen, especially in the white spruce orchard.

TABLE 1. PATTERN OF CROSSING IN THE MODIFIED BIPARENTAL MATING DESIGN USED FOR SPRUCE ORCHARDS IN ONTARIO

	A	B	C	D	E	F	G	H	I	J	K	L
A		x				*				o		
B			x				*				o	
C				x				*				o
D	o				x				*			
E		o				x				*		
F			o				x				*	
G				o				x				*
H	*				o				x			
I		*				o				x		
J			*				o				x	
K				*				o				x
L	x				*				o			

Crosses were made with these clones in earlier years, but 1972 was the first time that the biparental mating design was used.

It will be several years before the crosses for all of the orchards are completed and several more years for the progeny to be evaluated and reselected. But, as sufficient seed from a number of crosses in any one orchard is produced, seedlings will be grown and outplanted in replicated field tests with controls to evaluate the potential of that orchard. As more crosses are completed, a second set of trials will be established with the same controls as in the original experiment. This will be continued until all of the required crosses of that orchard are completed. The controls will provide the continuity for comparison of the various progeny in the different outplantings.

The seed orchard improvement program is a long-term approach, and it will be years before large numbers of genetically improved seed are harvested. As an interim measure, in cooperation with the Forest Management Branch, we will be involved in testing and evaluating seed-production areas throughout the province. This will provide seed with some degree of genetic improvement until the seed from the orchards becomes available.

VEGETATIVE PROPAGATION

Another aspect of our work that appears very promising is the reproduction of select material by rooting of cuttings. A new program was discussed in 1971 and initiated in 1972 as a result of the successful rooting of cuttings in early experiments. Selection was started in six of our large nurseries in Ontario. The three northern nurseries are selecting black and white spruce, whereas the southern nurseries are selecting only white spruce. The features looked for are height, diameter at root collar and stem and branch form. To date some of the selected trees are as much as 150% larger than the controls. These trees are placed in a holding area until they are large enough for cuttings to be taken. The cuttings are placed in mist beds and rooted. The rooted cuttings are to be outplanted in clonal tests on a variety of sites. These test plantings will give us much information on genetic repeatability and enable us to evaluate the field performance of each clone. The best clones can be propagated on a relatively large scale and incorporated into a provincial program of regeneration trials. We hope to get significant improvements in this field in a short time.

Cuttings that rooted in preliminary experiments were planted in the nursery for observation. During the first two growing seasons after rooting, some trees exhibited signs of topophysis. However, once the trees became established, they grew upright. These rooted cuttings now have good form and growth and appear to be sturdier than seedlings of comparable age. Some clonal differences such as time of bud break, branch angle, and growth uniformity can readily be seen in the tests. This demonstration lends more emphasis to a selection program and reproduction through vegetative means.

Several rooting trials were established in 1972. Eight trees of a hybrid *Picea schrenkiana* x *glauca* were set out to root. One half was established at Maple in an enclosed mist chamber and the other at Orono under an open mist system. Twenty-five cuttings per clone were used at each location. The rooting percent averaged 80 at Maple with a range of 68 to 88%, and 91 at Orono with a range of 68 to 100%. In 1969 the same population at four years of age was used in a rooting experiment and the overall rooting percent was 76. Now at seven years of age there is an overall average of 86%. Thus, to date, there is no indication of aging with regard to rooting. We will continue to take cuttings at 2-3 year intervals in this and other species populations to observe the expected decline in rooting success with age. A similar test at the two locations was established with cuttings taken from grafts of black and white spruce where the age of the parent was a maximum of 110 years. One hundred and twenty-five cuttings per clone were set at each location. The rooting percent averaged 19 at Orono and 20 at Maple for white spruce, and 8 and 4 respectively for black spruce. Another experiment, with grafted material of Norway spruce, had an overall rooting average of 35%, many of the clones rooting less than 10% but some rooting as high as 65%. Any rooting success with grafted material of mature and overmature trees indicates a possible rejuvenation of material through grafting.

INTERSPECIFIC HYBRIDIZATION

The breeding program at Maple has produced many hybrids that appear promising in early nursery results and field tests. Two of the crosses meriting further interest are *Picea glauca* x *sitchensis* and *P. mariana* x *omorika*. If these crosses continue to do as well in the next few years, we will produce more of the hybrid seed for larger outplantings.

The crosses made in 1971-72 that produced full seed are the following: reciprocal crosses of *P. abies* and *P. koyamai*, *P. glauca* and *P. omorika*, and *P. mariana* and *P. omorika*, and individual crosses of *P. abies* with *asperata*, *glauca* and *meyeri*; *P. asperata* with *meyeri* and *koyamai*, *P. glauca* with *abies* and *pungens*; *P. glehnii* with *mariana* and *pungens*; *P. koyamai* with *omorika*; *P. mariana* with *asperata* and *jezoensis*; *P. meyeri* with *asperata* and *koyamai*; *P. pungens* with *asperata*, *meyeri* and *pungens*; *P. schrenkiana* with *abies*, *omorika* and *pungens*.

VARIATION STUDY

Measurements were taken in 1971 and 1972 on the black spruce ecotype material mentioned in the last report. To date the only significant differences are occurring between localities, with Thunder Bay the best, Cochrane the poorest, and Geraldton in between. There is a very high correlation between latitude and height growth. The differences in these three localities were also highly significant in the original experiment, which was established in the early sixties. The nursery results of both of these experiments indicate no significant difference in performance between upland stands and lowland stands. The first experiment was outplanted at Swastika in the spring of 1967; the second will be replicated on upland sites at Dog River, near Thunder Bay, and at Limestone Lake, near Nipigon, in the spring of 1973.

ACQUISITIONS

Our spruce collection was enlarged by acquisitions of seeds of *Picea breweriana*, *P. sitchensis*, *P. smithiana* and *P. abies*. The seedlings of *P. breweriana* are extremely slow-growing but have survived our winters. There is much variation in the frost resistance of the *P. sitchensis*, and many seedlings have survived two winters with little damage. The *P. smithiana* showed very little resistance to frost, and most of the population has been lost. From the Petawawa Forest Experiment Station we also received seed from 21 select populations of white spruce from Ontario and Quebec.

Grafts and cutting material were collected in Massachusetts from 15 clones of *P. abies* x *asperata*, 12 of *P. abies* x *koyamai*, 16 of *P. abies* x *montigena*, 26 of *P. asperata* x *abies*, 5 of *P. asperata* x *asperata*, 1 of *P. asperata* x *koyamai*, 8 of *P. montigena* x *abies*, 20 of *P. montigena* x *asperata*, 5 of *P. montigena* x *koyamai*, 2 of *P. montigena* x *montigena*, and 1 of *P. montigena* x *retroflexa*. *P. abies* cutting material was also received from several of the other northeastern states.

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SUMMARY REPORT ON POPLAR AND PINE BREEDING IN 1971 AND 1972

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POPLARS

Our aim is to produce strains of native and hybrid poplars having superior growth, good form, desired wood quality and resistance to diseases. Special attention is given to high-yielding pulpwood varieties. The main approaches are through selection, propagation of the selected trees, establishment and management of breeding arboreta, hybridization, polyploidy induction, nursery testing and propagation, and field testing.

Up to now a remarkable number of outstanding trees have been selected and bred. Nursery and field testing of these trees is under way, the tests providing information on the potential for growth, other silvicultural characteristics and wood quality. The results of testing and the potential of hybrid poplars for short rotation plantations have been discussed by Zufa (1971a, 1972a) and Zufa and Balatinecz (1971). Recent figures on the growth of hybrid poplars are presented in Table 1.

The poplar breeding program has a special significance in southeastern Ontario where regional deficiencies of wood have developed. Chemical and groundwood pulp made from fast-growing poplar compare favorably with pulp made from regular poplar and mixed hardwoods. As a result, pulpwood production trials of fast-growing, good-quality hybrid poplar strains in short rotations are under way on a range of soils in this area. The pulpmills support and the Ontario Ministry of Natural Resources' field organization cooperate on these projects.

The hybridization work in 1971 and 1972 concentrated on crosses that produced outstanding progenies in the past. These were of *P. alba* x *grandidentata*, *P. grandidentata* x *alba* and *P. alba* x *davidiana* type. The goal is to produce seedling stock for testing on a variety of sites.

The testing for frost hardiness in northern Ontario nurseries continued (Zufa 1971b, 1971c). In the first series *P.* x *euramericana* clones were tested; of these, cultivars *gelrica*, *Lons*, *Robusta* (Germany) and *Tardif de Champagne* proved to be the most resistant, and field testing has begun. In the second series, *P. deltoides* and *P.* x *jackii* progenies and hybrid cottonwood and hybrid aspen clones are being observed in northern Ontario nurseries.

TABLE 1. EXAMPLES OF GOOD GROWTH OF HYBRID POPLARS IN EXPERIMENTAL PLANTATIONS IN SOUTHERN ONTARIO

Hybrid	Location	Spacing (ft)	Age (yr)	Height (ft)	DBH (in)	Growth in 1972 Ht (ft)	Growth in 1972 dbh (in)
P. angulata x *berolinensis* cv. NE 32 (DTac 1)	Osnabruck (Kemptville)	9	1	3.8		3.8	
P. x *euramericana* cv. I-262 (DN22)	Kemptenfeldt Bay (Lake Simcoe)	16	2	8.2		5.4	
P. canescens	Leitrim (Ottawa)	13	2	9.2		4.0	
P. x *euramericana* cv. "Jacometti 78B" (DN21)	Anten Mills (Barrie)	10	3	10.8	1.4	4.1	0.8
P. x *euramericana* cv. Regenerata (DN16)	Flos Twp. (Barrie)	10	4	19.8	3.0	5.2	1.1
P. grandidentata x *alba*	Goderich (Lake Huron)	8	7	33.0	3.8	4.6	0.6
P. alba x *davidiana*	Wainfleet (Lake Erie)	8	10	56.7	6.4	5.7	0.9
P. x *euramericana* cv. I-214	Grand Bend (Lake Huron)	8	11	51.0	6.9	4.0	0.8
P. alba x *grandidentata*	Whitchurch (Lake Simcoe)	12	16	63.0	8.4	4.6	0.7

The plantations of exotic poplar species (Zufa 1971b, 1971c) were further expanded. They consist of one-parent progenies of selected trees of *P. alba, P. canescens, P. tremula, P. nigra* and *P. davidiana.* In 1971 and 1972 seeds of these species were obtained from Czechoslovakia, Finland, France, Germany, Hungary, Italy, South Korea and Yugoslavia. The nursery stool collection and the breeding arboretum were also increased by additions of *P. deltoides, P. jackii, P. balsamifera, P. tremuloides* and *P. grandidentata* selections from Newfoundland, Quebec, Illinois, Michigan, Minnesota, Wisconsin and Ontario.

WHITE PINES

The improvement of eastern white pine by selection and breeding and the development of hybrid white pine varieties of rapid growth, desired silvicultural characteristics and resistance to blister rust are the objectives of this program.

In 1971 and 1972 the work concentrated on provenance studies, hybridization, progeny testing and vegetative propagation.

The earlier established provenance trials are being assessed. The 12-year results of an eastern white pine geographic-variation study showed the same pattern for correlation of tree heights with latitude, mean January temperatures and length of frost-free period of place of origin as at the end of the seventh year (Fowler and Heimburger 1968). However, in both test plantations at the end of the twelfth year the Pennsylvania, Nova Scotia and New York sources showed significantly better height and diameter growth than the local Ontario source (Table 2). Thus provenance variation in eastern white pine appeared to be sufficient to warrant selection.

The hybridization work concentrated on breeding Himalayan white pine x eastern white pine. Many of these hybrids exhibit heterotic growth paired with a considerable degree of blister rust resistance.

The control-pollinated and open-pollinated progenies are tested at two levels: in the nursery and in the field. The former involves artificial inoculation for blister rust testing (Zufa 1971b, 1971c). In the past two years nursery tests of progenies of *P. griffithii* x *strobus* crosses and backcrosses, *P. monticola* crosses of resistant trees and *P. strobus* crosses of resistant trees were established and observed. In the field, the performance of the seedlings and their resistance to blister rust and weevil in natural conditions are observed. Three test plantations of *P. strobus* and *P. griffithii* x *strobus* progenies were established for this purpose. Also, more seedlings of these two varieties, as well as seedlings of several *P. griffithii* populations, were prepared for field planting.

The propagation of white pines by cuttings is successful (Zufa 1971b, 1971c and 1972b). In 1972, a clonal test of rooted cuttings was established in the field. This will provide genetic as well as silvicultural

TABLE 2. TWELVE-YEAR HEIGHT AND DIAMETER OF *P. STROBUS* IN TURKEY POINT AND GANARASKA FOREST PROVENANCE PLANTATIONS

Provenance	Latitude ° North	Height - (ft)		Diameter (dbh) - (in)	
		Turkey Point	Ganaraska	Turkey Point	Ganaraska
Georgia	34.8	17.59	12.12	3.28	2.33
Tennessee	36.0	16.71	12.08	3.29	2.32
Ohio	40.8	16.83	11.35	3.16	2.11
Pennsylvania	41.1	17.15	13.16	3.05	2.44
Iowa	43.3	12.99	9.69	2.32	1.60
New York	44.4	16.36	12.79	2.96	2.34
Nova Scotia	44.4	17.39	13.90	3.05	2.52
Maine	44.9	15.25	12.01	2.66	2.16
Wisconsin	45.8	14.64	12.19	2.53	2.19
Quebec	46.4	13.78	11.33	2.31	2.04
Minnesota	47.4	15.18	11.66	2.67	2.12
Ontario	47.5	16.10	11.45	2.71	1.90

information. At the same time cutting propagation stools of the promising clones, which also show consistent rooting ability, were established and their propagation, for larger-scale testing, was initiated.

HARD PINES

The objectives of this program are to improve red pine by selection and breeding and to develop disease-resistant hard pines of superior growth.

In red pine, crosses were made with red pine pollen, irradiated at 250R and 500R, to introduce more variation in its progenies. In previous years, attempts were made to produce interspecific hybrids of *P. resinosa* by using highly irradiated (200,000R) recognition pollen of red pine as intermediate. Few putative hybrids of *P. resinosa* x *nigra* and *P. resinosa* x *densiflora* resulted (Zufa 1971b, 1971c). Microtechnical studies are in progress to identify these hybrids.

To test hybrid hard pines, more seedlings of *P. densiflora* x *sylvestris* x *nigra* were produced in several combinations and prepared for outplanting. Two comparative field plantations of these hybrids were established. Also, more seedlings of *P. rigida* x *taeda* were prepared for testing on a variety of sites. This hybrid demonstrated outstanding growth in a small test plantation at Turkey Point, Ont. (Lake Erie). A partial survey of test plantations of hybrid hard pines showed surprisingly good performance of other hybrids as well (Table 3).

TABLE 3. EXAMPLES OF GROWTH OF HYBRID HARD PINES IN SMALL TEST PLANTATIONS IN SOUTHERN ONTARIO

Hybrid	Location	Age (yr)	No. of trees	Average Ht. (ft)	Average DBH (in)
P. (*densiflora* x *austriaca*) x *sylvestris*	Maple	9	27	18.3	3.4
P. sylvestris x (*densiflora* x *austriaca*	Maple	9	24	17.5	3.3
P. rigida x *taeda*	Turkey Point	8	138	18.1	3.7
P. rigida x *elliottii*	Turkey Point	8	37	17.5	3.3
P. rigida x *taeda*	Turkey Point	6	63	14.2	2.5

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RESEARCH ON TREE GENETICS AND BREEDING AT PETAWAWA FOREST EXPERIMENT STATION, 1971-73

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INTRODUCTION

The purpose of this report is to give a broad outline of genetics, tree improvement and related research activities at Petawawa for the two-year period 1971-73. The other reports on individual species and problems give the details of the work.

PROGRAM DEVELOPMENT

The two year period was one of continued austerity. In common with many other research stations in Canada and the United States, it has been necessary to reexamine the Station's priorities in the context of limited budgets. Every year it becomes more and more necessary to justify research programs in economic terms, and to attempt to quantify "intangible" benefits.

One problem has been that the period of austerity, with its limitation on manpower and money, has coincided with a period of labor-intensive work, i.e. the remeasurement of most of the 10, 15 and 20-year-old trials.

The Petawawa program in tree genetics and breeding is closely linked with operational needs, priority being given to species most widely used in man-made forests east of the Rockies. The program includes basic research aimed at finding shortcuts for raising experimental material, carrying out short-term genetic trials, and screening trees at an early age for superior growth potential. This physiology research is closely linked with the genetics research, particularly in the case of white spruce.

During the 1971-73 period, a team of one geneticist and one physiologist (Dr. A.H. Teich and Dr. D.F.W. Pollard) went on an expedition to the Yukon to collect seed and examine the variability of the white spruce. Parts of this area were free from ice during the last glaciation and it is possible that these will prove to be the locations of centre of diversity.

There has been an increase in liaison with geneticists and silviculturists of the Ontario Ministry of Natural Resources and the forging of links with people engaged in work on shade trees, notably the Ontario Shade Tree Council.

Petawawa Forest Experiment Station is in the process of developing a program concerned with the interpretation of research and forest activities to varied audiences, particularly nontechnical audiences. This has led to consideration of ways and means of interpreting the genetics and tree breeding research to the public as well as to foresters who are still unable to see the value of genetics and tree improvement research in operational forestry. We are conscious that although a very good case can be made, and indeed has been made, for the support of genetics and tree improvement research, this case has not always been made to the right audiences. The interpretive program will give us a good opportunity to put this case to a very wide spectrum of people.

RESEARCH PROGRESS AND RESULTS

Jack Pine (*Pinus banksiana* Lamb.)

Further work on the injury of jack pine by cold and pests was carried out, and a number of northeastern provenances were found to be resistant to scleroderris canker, supporting earlier findings. A survey of lodgepole pine (*Pinus contorta* vir. *latifolia* Engelm.) and jack pine x lodgepole pine hybrids demonstrated the lack of resistance of both lodgepole pine and the hybrids to sweet fern blister rust.

Plus and minus jack pine were selected for growth, form and susceptibility to insects and diseases, and provenance hybrids were made.

White Spruce (*Picea glauca* [Moench] Voss)

Progenies from individual trees from Beachburg were tested by accelerated growth techniques to identify trees with inherent superior growth potential; promising progenies were field-planted.

Seed collections for the all-range white spruce trial were initiated with emphasis on Ontario. A seed collection was made in the Yukon in a possible centre of diversity.

White spruce genotypes with both precocious flowering and good growth were located.

Further examination of the provenance trials supported the earlier findings that the Cobourg, Ont., provenance is superior at many test locations to the other tested provenances. As the trials grow older, the gains of this and other superior provenances in relation to the local provenances increase substantially.

Black Spruce (*Picea mariana* [Mill.] B.S.P.)

As part of the all-range black spruce trial, nursery sowings and trials were established by cooperators in Newfoundland, the Maritimes, the Lake States and Alberta.

A complete diallel experiment was established in the Petawawa nursery, and black spruce provenance hybrids were planted in a field experiment. A cooperative progeny test program is being developed with the Ontario Ministry of Natural Resources.

Red Pine (*Pinus resinosa* Ait.)

During the two-year period the main activity has been measurement of the provenance trials and progeny tests and the establishement of a provenance hybrid experiment.

Introduced Species

The emphasis was on larch during 1971-73. Here also the work concentrated on measurement of trials. Plus trees were selected and scions distributed to cooperators, and a preliminary paper was published on survival and growth of exotic larch species and hybrids. (Teich and Holst 1973). A stand test of local tamarack progenies was sown.

Physiology

The growth acceleration system devised by the physiologists is now being used successfully for many purposes, in cabinets, chambers and greenhouses.

Fast- and slow-growing provenances of jack pine have been found to have different photosynthetic rates in the fall. However, attention is turning from the use of rates of photosynthesis as a screening tool to the possibility of using the endogenous and environmental factors of bud development.

The Seed Unit

Demands on the Unit for seed collection, extraction and testing have doubled in the past few years, and this year (1973), the Unit has been provided with additional professional help.

The seed bank now carries seed of 61 species and 375 provenances of known origin and quality for research purposes. The Unit participates in referee testing for the International Seed Testing Association.

A review of seed storage methods has been produced and is in press.

STAFF MOVEMENTS

Dr. Teich returned in 1972 from his year's stay in Israel, where he studied the genetics of citrus species, and resumed his research on white spruce. The author was seconded to the Canadian Forestry Service Headquarters in Ottawa for two periods of three months to work on the preparations for the Stockholm Conference and to assist in writing and editing a book on conservation.

Dr. Venkatesh, a Canadian International Development Agency (C.I.D.A.) fellow from India, who is an experienced geneticist, visited the Station during the period May-August 1973, to obtain experience in hybridization techniques. An F.A.O. fellow, R.S.W. Nkaonja of Malawi, also spent the summer of 1973 at Petawawa assisting with the genetics program.

This year (1973) additional professional assistance will be provided for the Seed Unit to enable Mr. Wang to devote more of his time to investigation of seed testing and storage methods.

RESEARCH FACILITIES

During the year an extension was made to the cone-drying and storage shed, and plans have been made to construct a vault for storage of genetics and tree-breeding records. The old nursery buildings have been replaced by structures better suited to nursery work and large-implement storage.

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THE INTRODUCTION AND SELECTION OF EXOTIC TREE SPECIES, PETAWAWA, 1972-73

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INTRODUCTION

The objective of this project is to determine the role of selected genotypes of exotic species in Canadian forestry. In eastern Canada some exotic tree species have outproduced native species or have shown resistance to native insects and diseases. Others have produced high yielding species hybrids. Thus there is a definite need for introduction of the most promising exotics.

During the period 1937-50, Dr. C.C. Heimburger and Professor J.L. Farrar established several test plantations of spruce (*Picea* spp.), pine (*Pinus* spp.), fir (*Abies* spp.), larch (*Larix* spp.), poplars (*Populus* spp.) and other hardwood species (*Betula* spp., *Fraxinus* spp. and *Tilia* spp.).

During the period 1950-73, the Petawawa Forest Experiment Station (P.F.E.S.) and cooperating organizations in the United States and Canada established the following experiments with exotic species or species groups: Norway spruce (*Picea abies* [L.] Karst.), 95 experiments on 263 acres; other exotic spruces, 48 experiments on 44 acres; Scots pine (*Pinus sylvestris* L.), 61 experiments on 100 acres; other exotic pines, 43 experiments on 48 acres; exotic larch species, 46 experiments on 72 acres; and birch, 17 experiments on 10 acres.

NORWAY SPRUCE

The production of hardy, fast-growing and weevil (*Pissodes strobi* Peck) resistant types continues to be the main objective of breeding work in Norway spruce.

Work Done during 1972-73

Hardy and weevil-free types were selected in a 30-year-old second generation plantation (Exp. No. 29) derived from the winter-hardy Norway spruces selected by Dr. C.C. Heimburger at Hudson's Place, P.F.E.S. Scions of these were sent to the Ontario Ministry of Natural Resources, Angus, Ont., and to the Institute of Forest Genetics, Rhinelander, Wis., for use in the establishment of seed orchards (Exp. No. 387-A and -B).

We furthermore selected hardy weevil-free types out of 20-year-old Norway spruce observation plots of fast-growing but frost-tender European provenances established for this purpose (Exp. No. 76 and 80-A and -B). These were grafted for further testing and observation of Norway spruce of known origin at P.F.E.S.

In the fall of 1971 two open-pollinated progeny tests of the winter-hardy Norway spruce on Hudson's Place were measured when they were 21 years old (Exp. No. 120-A and -B). On the good spruce site there was high survival, good growth and very little weevil damage. On the poorer shallow part of the poorer spruce site there were low survival, poor growth and high weevil damage. On the better part of the poorer site there were high survival, fairly good growth and fairly high weevil damage. Some of the parent trees were propagated as cuttings by Dr. Heimburger and Professor Farrar in 1940-42 and were planted in replicated plots in our arboretum. These were measured and scored for weevil damage in the fall of 1972. Both the amount of weevil damage and the ability to recover from weevil damage are of importance and are easily observed in the clonal material. The damage pattern is also visible in progenies from open pollination.

In the fall of 1972 several provenance tests about 30 years old were measured and thinned (Exp. Nos. 19, 20, 29 and 30). These included the IUFRO provenance experiment of 1939 (Exp. No. 28), for which we have 10 years of annual observation of weevil damage. Summaries and interpretations of these data are in progress.

On June 10, 1972, a very severe late spring frost offered the opportunity to score spring frost damage in various tests (Exp. Nos. 6-C and -D, 10, 80-A, 119-open, 265-A, -B and -C, 277-A and -C, 310-A and 352-A). More than 14,000 plants were scored, and we hope to use the data for later selections of late-flushing types.

Measurements were made in a provenance test located at Longlac, Ont. (Exp. No. 200-E), and in three nursery single-tree progeny tests and provenance experiments at P.F.E.S. (Exp. Nos. 308-B, 349-A and 357-A).

Nursery Test of 24 Polish Provenances

In 1964 Dr. M.M. Giertych of the Institute of Dendrology and Kornik Arboretum, Polish Academy of Sciences, collected seed from 25 native stands of Polish Norway spruce. The sample was 10 trees per stand. In Poland this material was used to study cone morphology, phenology, response to grass competition, and response to varying concentrations of nitrogen, phosphorus, potassium, magnesium and calcium.

Twenty-four of these provenances were sown in 1965 in the P.F.E.S. nursery and transplanted in 1967 in five replications with 100 trees per plot (Table 1). In the fall of 1968 the height of 20 random trees and the 10 highest trees per plot were measured. There were significant differences between provenances in both types of height ($P<.01$). In 1968 a count was made of the number of trees with double leaders. In the spring of 1969 winter frost damage was scored, but it was obvious that some of the slower-growing provenances were covered by snow and not exposed to the desiccating winter sun. A general rating of the frost damage was done on the plants that remained in the nursery in the spring of 1970. The association between heights, multiple leaders and winter frost damage was investigated (Table 2).

Using 20 random trees per plot, Wisla had the best growth, closely followed by a group of fast-growing provenances with very similar heights (Blizyn, Garbatka, Rycerka, Istebna and Stronie), while Konstancjewo, Brody and Ilawa still had acceptable growth rates. The provenances with intermediate growth were Angustow, Nowe Ramuki, Suwalki, Goldap, Kowary, Miedzyrzec, Przerwanki, Wetlina and Bialowieza. The slow-growing provenances were Myszyniec, Zwierzyniec, Borki and Slawki - and the very slow growing provenances were Sadlowo and Dolina. The correlation between provenance heights in Poland and at P.F.E.S. was high ($r = .77$; $P<.001$).

When the 10 tallest trees per plot (about 10% of the plants) were measured, Rycerka and Istebna clearly grew better than Stronie, Wisla and Konstancjewo. Garbatka, Augustow, Miedzyrzec and Brody had acceptable growth rates. Ilawa, Kowary, Bialowieza, Zwierzyniec, Wetlina, Goldap and Przerwanki had intermediate growth. The slow-growing provenances were Suwalki, Myszyniec, Nowe Ramuki and Slawki - and the very slow growing provenances were Dolina, Borki, and Sadlowo.

This material lends itself well to estimates of within-population variation, as each provenance lot was uniformly sampled (10 trees per stand). Norway spruce is renowned for its within-stand variation of taxonomic characters and phenology. To get an estimate of within-population variation in height, in each 100-tree plot we measured a random sample of 20 trees as well as the 10 tallest trees per plot and calculated the coefficient of variation (c.v.). If the provenances were very variable (high c.v.), intermediate or very uniform (low c.v.) this could possibly explain their response to selection.

Within the framework of the nursery experiment at P.F.E.S. we compared mean height and ranking of a random sample and a selection of the highest 10% of the trees. The increase in height by this kind of selection is substantial. Among the fastest-growing provenances it was 42% for Wisla and 35% for Blizyn, Garbatka, Rycerka, Istebna and Stronie. However, it is only nursery selection. Whether or not the selection would be effective would depend on the within-population variation in height: if it is high, our selection would be effective, but we may end up with a variable population; if it is low, our selection would not be as effective, but we should end up with a less variable population. A few examples to clarify the situation follow.

TABLE 1. ORIGIN, 4-YEAR HEIGHT AND COEFFICIENT OF VARIATION FOR RANDOM AND SELECTED PLANTS, MULTIPLE LEADERS AND FROST DAMAGE IN 24 POLISH NORWAY SPRUCE PROVENANCES

	Twenty random plants per plot			Ten tallest plants per plot			Multiple leaders 1969		Winter frost damage 1968-69[1]		Mean winter frost score 1969-70[2]
Origin	Height cm	Rank	c.v.	Height cm	Rank	c.v.	%	Rank	%	Rank	0-none 1-some 2-severe
Wisla	37.0 a	1	0.088	47.2 a-c	5	0.109	23 b-d	15	13.3 ab	2	2
Blizyn	35.6 ab	2	0.362	47.7 a-c	4	0.305	23 b-d	14	7.3 a-f	8	1
Garbatka	35.6 ab	3	0.145	46.6 a-d	7	0.110	24 b-d	9	5.2 b-g	10	1-2
Rycerka	35.3 a-c	4	0.227	50.8 a	1	0.153	24 b-d	8	13.0 a-c	3	1-2
Istebna	35.2 a-c	5	0.233	50.3 a	2	0.181	25 b-d	6	15.7 a	1	2
Stronie	35.1 a-d	6	0.091	47.8 ab	3	0.079	23 b-d	16	9.8 a-d	5	1
Konstancjewo	34.6 a-e	7	0.098	47.0 a-c	6	0.130	29 bc	2	10.0 a-d	4	1
Brody	34.2 a-f	8	0.164	45.3 a-f	10	0.088	36 a	1	7.7 a-e	7	1-2
Ilawa	33.3 a-g	9	0.280	43.9 a-f	11	0.260	21 cd	20	8.3 a-e	6	2
Angustow	32.3 a-g	10	0.084	45.9 a-c	8	0.140	22 b-d	17	4.0 b-g	11	2
Nowe Ramuki	31.6 b-h	11	0.194	40.3 c-f	20	0.189	26 bc	3	2.5 f-j	15	1
Suwalki	30.1 b-h	12	0.242	40.6 c-f	18	0.182	23 b-d	11	1.0 g-j	19	1
Goldap	30.1 b-h	13	0.151	41.7 c-f	16	0.153	21 cd	19	7.3 a-j	9	2
Kowary	30.1 b-h	14	0.122	43.9 a-f	12	0.081	25 b-d	7	3.0 e-i	14	1
Miedzyrzec	30.0 b-h	15	0.213	45.3 a-e	9	0.164	23 b-d	10	4.0 c-g	12	2
Przerwanki	30.0 b-h	16	0.152	41.0 c-f	17	0.171	25 b-d	5	1.7 g-j	18	0-1
Wetlina	29.4 b-h	17	0.138	41.8 b-f	15	0.121	20 cd	22	3.4 d-h	13	0
Bialowieza	29.0 c-h	18	0.194	43.5 b-f	13	0.182	22 b-d	18	2.0 f-j	16	1
Myszyniec	28.4 d-h	19	0.114	40.3 c-f	19	0.071	23 b-d	12	2.0 f-j	17	1-2
Zwierzyniec	28.2 e-h	20	0.182	42.5 b-f	14	0.154	23 b-d	13	1.0 g-j	20	1
Borki	27.8 f-h	21	0.267	38.0 ef	23	0.204	19 cd	23	0.5 h-j	22	0-1
Slawki	27.6 f-h	22	0.099	40.1 d-f	21	0.130	26 b-d	4	0.5 h-j	21	0-1
Sadlowo	26.4 gh	23	0.212	37.9 f	24	0.151	21 cd	21	0.0 j	24	0-1
Dolina	24.7 h	24	0.138	38.6 ef	22	0.216	19 d	24	0.3 ij	23	1

Means followed by a common letter are not significantly different at P<05 (Duncan, Biometrics 11:1-42. 1955).

[1]Values listed in original percentages. Analysis was done on transformed data.

[2]Based on scoring of whole plots.

TABLE 2. CORRELATION OF CHARACTERS FOR 24 POLISH NORWAY SPRUCE PROVENANCES

		X_2	X_3	X_4	X_5
X_1	Height of 20 random plants	+.87***	+.41*	+.85***	+.49*
X_2	Height of 10 tallest plants		+.33	+.86***	+.54**
X_3	Multiple leaders 1969			+.28	+.11
X_4	Winter frost damage 1968-69				+.58**
X_5	Winter frost score 1969-70. The ranges 0-1 and 1-2 calculated as 0.5 and 1.5				-

Significantly different: *P<.05; **P<.01; ***P<.001.

After selection of the highest 10% of the trees, Rycerka and Istebna attained first and second rank (they gained four ranks each) through their height c.v. (respectively 0.227 and 0.233). Stronie attained third rank (it gained three ranks) by having a good height to start with but a low c.v. (0.091). Blizyn (fourth rank) fell two ranks by being the most variable of all the provenances (c.v. = 0.362). Wisla was the tallest of the provenances in the comparison of 20 random trees but fell to fifth rank because of its low c.v. (0.088); i.e., it did not respond to selection. This within-population variation explained the effect of selection very well. It is furthermore worth noting that populations that are variable before selection retain their variability after selection. The same holds true for uniform populations. The correlation between c.v. for 20 random plants and the 10 tallest plants is high (r = .81 P<.001). Thus the variable populations will likely respond to further selection, while the uniform populations are of interest only if they are fast-growing from the start.

There was no geographic pattern to the variation in c.v., nor was the c.v. related to provenance height or levels of winter frost damage. Thus the c.v. must be determined experimentally for a specific material in a specific environment.

Winter frost damage for 1968-69 was assessed by counting the number of plants having winter-burned needles in May 1969. Because of the many zero values, a constant (0.1) was added to each plot mean and the data were then transformed by arcsin percentage to make them more nearly normal in distribution. There were significant differences in winter damage between provenances (P<.01). This assessment is only of limited value, as not all the plants were above the snow line. This ranking of winter frost damage is therefore highly correlated with provenance height (r = .85; P<.001). One year later a second attempt was made to assess winter damage in the plants that remained after field planting. Here sampling was probably less satisfactory, but the overall assessment is more appropriate to the problem. The correlation with provenance height is lower (r = .49; P<.05).

In general, multiple leaders develop when plants are injured by late spring frost or early fall frost. In our experiments the damage was caused mainly by spring frost, but the exact phenological stage at which the damage occurs has not been established. Brody (36%) was significantly different from the other provenances. Also high were Konstancjewo (29%), Nowe Ramuki (26%) and Slawki (26%). Lowest were Borki and Dolina (both 19%). The damage pattern is significant ($P<.01$) and weakly correlated with the height of 20 random plants ($r = .41$; $P<.05$).

A Nursery Test of Central European and Canadian Norway Spruce Provenances

The purpose of this experiment was to assess the growth rate and hardiness of the fast-growing, but perhaps frost susceptible, provenances from the Carpathian Mountains and the mountain range between Czechoslovakia and Germany (Böhmerwald, Thüringer Wald and Erzgebirge) with the slower-growing but frost-hardy provenances from Latvia, Lithuania and White Russia and to compare these with Norway spruce selected in Canada.

In 1963 Dr. V. Benea of the Forest Research Institute in Roumania provided seven provenances from the Carpathian Mountains. From the southwest slopes of the Carpathians we got seed from Toplita, Turda and Cimpini. We also obtained seed from the northeast slopes of the Carpathians (Marginea, Dorna Cindreni and Comanesti). Seed from Rycerka, Poland (obtained in the seed trade) would also qualify as coming from the Carpathians. There are three provenances from high yielding stands in Germany representing Böhmerwald (Tännesberg), Thüringer Wald (Rothenkirchen) and Erzgebirge (Carlsfeld). There are six provenances from Latvia and Lithuania (where previously we have obtained hardy and fairly fast-growing provenances) and three provenances from White Russia. In addition we have tested four Canadian provenances. The origin of all provenances is shown in Table 3.

This provenance material was sown in the same year - and treated, measured, scored and calculated in the same manner as the 24 Polish provenances already discussed.

There were significant differences between provenances in the height of 20 random plants and the 10 tallest plants (both $P<.01$), in winter frost damage ($P<.05$), the differences in this case being correlated with provenance height ($r = .59$ to $r = .64$ $P<.001$), and in the number of multiple leaders ($P<.01$), these differences being weakly correlated with the mean winter-frost score for 1969-70 ($r = .42$ $P<.05$). The association between characters is shown in Table 5.

There were no major changes in ranking based on 4-year height when 20 random trees were used or when the 10 tallest trees were used (Table 4). The tallest provenances came from Roumania. Best were Toplita, Turda and Cimpini (mean 41.5 cm), and Dorna Cindreni and Marginea (mean 39.0 cm) while Bicaz (36.7 cm) and Comanesti (33.5 cm) were less vigorous. Thus the three provenances from the southwest slopes of the Carpathian Mountains were faster-growing than the four provenances from the northeast slopes. All

TABLE 3. ORIGIN OF CENTRAL EUROPEAN AND CANADIAN NORWAY SPRUCE PROVENANCES

Seedlot No.	Origin	Lat. N.	Long. E.	Elev. (m)
S.5396	Toplita For. Dist., Prov. of Tirgu Mures, Roumania (Forest II, Voivodeasa [104b])	46°55'	25°25'	880
S.5394	Turda For. Dist., Prov. of Cluj, Roumania (Forest V, Virtopeni [34a])	46°35'	23°47'	1,110
S.5395	Cimpeni For. Dist., Prov. of Cluj, Roumania (Forest XV, Valea Mare [24])	46°20'	23°00'	1,260
S.4027	Manure Plot, Proulx Plantations, Que. (Unselected trees - general collection)	46°40'	72°40'W	130
S.5391	Dorna Cindreni For. Dist., Prov. of Suceava, Roumania (Forest II, Rosia [50a])	47°21'	25°22'	975
S.3153	Forstamt Tännesberg, Böhmerwald, Germany	50°00'	12°30'	600-800
S.5390	Marginea For. Dist., Prov. of Suceava, Roumania	47°45'	25°45'	670
S.5408	Rothenkirchen For. Dist., Frankenwald, Germany	50°20'	11°20'	470-640
S.3154	Rycerka For. Dist., Biskid Mts., Poland	49°32'	19°00'	600-800
S.4076	Proulx Plantations, Que.[1] (General collection - not from Manure Plot)	46°40'	72°40'W	130
S.4064	Thomas Field, P.F.E.S., Chalk River, Ont. (Mixture of nonweeviled plus trees from Hudson's Place, IUFRO provenance exp. and Dr. Heimburger's Proulx selections)	46°00'	77°26'W	180
S.5392	Bicaz For. Dist., Prov. of Bacau, Roumania (Forest II, Floarea Invanesti [73a])	46°50'	25°55'	1,150
S.5407	Carlsfeld For. Dist., Erzgebirge, East Germany	50°25'	12°35'	920
S.5406	Minski Leshos, Minsk Oblast, White Russian S.S.R.	(53°50')[2]	(27°35')[2]	(660)[2]
S.5393	Comanesti For. Dist., Prov. of Bacau, Roumania (Forest IV, Bortea [21])	46°17'	26°37'	780
S.4028	Manure Plot, Proulx Plantations, Que.[3] (Mixture of 22 selected plus trees)	46°40'	72°40'	130
S.5404	Gorodokski Leshos, Vitebsk Oblast, White Russian S.S.R	(55°30')	(30°00')	(200)
S.5398	Daugavpils, Latvian S.S.R	(55°50')	(26°30')	(250)
S.2365	Hudson's Place, Petawawa For. Exp. Stn., Chalk River, Ont. (Mixture of 4 plus trees, S.T. Nos. 100, 109, 116, 122)			

TABLE 3. ORIGIN OF CENTRAL EUROPEAN AND CANADIAN NORWAY SPRUCE PROVENANCES (Cont'd)

Seedlot No.	Origin	Lat. N.	Long. E.	Elev. (m)
S.5401	Tukums, Latvian S.S.R.	(57°00')	(23°05')	(70)
S.5397	Auce, Latvian S.S.R.	(56°25')	(22°50')	(150)
S.5399	Jelgava, Latvian S.S.R.	(56°40')	(23°40')	(100)
S.5405	Glubokski Leshos, Vitebsk Oblast, White Russian S.S.R.	(55°15')	(30°10')	(200)
S.5403	Wilno, Lithuanian S.S.R.	(54°35')	(24°15')	(300)
S.5400	Skede, Latvian S.S.R.	(57°00')	(27°00')	(180)

[1]General collection from Proulx plantations; may also contain German Norway spruce.
[2]Values in parentheses estimated at P.F.E.S.
[3]Came originally from Untersäker, Jämtland, Sweden (63°20'N; 13°15'E).

TABLE 4. ORIGIN, 4-YEAR HEIGHT AND COEFFICIENT OF VARIATION FOR RANDOM AND SELECTED PLANTS, MULTIPLE LEADERS AND FROST DAMAGE IN CENTRAL EUROPEAN AND CANADIAN NORWAY SPRUCE PROVENANCES

Origin	Twenty random plants per plot			Ten tallest plants per plot			Multiple leaders 1969		Winter frost damage 1968-69[1]		Mean winter frost score 1969-70[2]
	Height cm	Rank	c.v.	Height cm	Rank	c.v.	%	Rank	%	Rank	0-none 1-some 2-severe
Toplita, Roumania	41.9 a	1	0.140	58.2 a	1	0.144	25 a-d	5	16.9 a	2	2
Turda, Roumania	41.3 a	2	0.193	57.0 ab	3	0.068	26 a-d	4	15.0 ab	4	2
Cimpini, Roumania	41.2 ab	3	0.069	57.9 a	2	0.056	24 a-d	8	14.9 a	1	2
Proulx, Que.	41.2 a-c	4	0.204	55.6 bc	4	0.123	20 b-d	20	5.0 c-f	12	1
Dorna Cindreni, Roumania	39.3 a-c	5	0.170	53.2 b-d	5	0.097	23 a-d	11	9.4 a-d	6	1
Tännesberg, Germany	38.8 a-c	6	0.213	51.5 cd	10	0.185	31 ab	2	16.1 a	3	2
Marginea, Roumania	38.7 a-c	7	0.182	52.8 b-d	7	0.232	20 b-d	21	8.8 b-e	7	1
Rothenkirchen, Germany	38.6 a-c	8	0.146	51.8 b-d	8	0.128	26 ac	3	10.3 a-c	5	2
Rycerka, Poland	38.0 a-c	9	0.168	53.1 b-d	6	0.097	20 cd	23	7.6 b-e	8	1
Proulx, Que.	37.6 a-e	10	0.111	51.5 cd	9	0.136	21 b-d	16	4.0 c-f	14	2
Thomas Field, Ont.	36.8 b-f	11	0.189	50.2 c-e	11	0.166	22 b-d	15	5.6 c-f	11	2
Bicaz, Roumania	36.7 b-g	12	0.156	49.9 de	12	0.079	21 b-d	17	6.8 c-f	9	1
Carlsfeld, Germany	35.4 b-g	13	0.126	49.5 de	13	0.153	24 a-d	6	5.8 c-f	10	1-2
Minski, Russia	34.5 b-g	14	0.061	46.3 d-g	15	0.156	21 b-d	18	0.5 hi	20	0-1
Comanesti, Roumania	33.5 c-g	15	0.100	46.3 e-g	16	0.110	18 cd	24	4.3 c-f	13	1-2
Proulx, Que.	33.5 d-h	16	0.121	49.0 d-f	14	0.122	21 a-d	14	3.3 e-h	15	1
Gordokski, Russia	32.1 e-h	17	0.242	43.9 gh	19	0.084	23 a-d	9	0.3 i	21	0-1
Daugavpils, Latvia	31.5 f-i	18	0.199	45.6 e-g	17	0.104	20 b-d	19	1.1 g-i	18	0
Hudson's Place, Ont.	31.4 f-i	19	0.153	43.4 gh	20	0.241	20 b-d	22	0.1 i	25	1
Tukums, Latvia	31.3 g-i	20	0.262	42.8 gh	22	0.238	15 d	25	0.3 i	23	0-1
Auce, Latvia	30.7 g-i	21	0.130	44.7 f-h	18	0.090	24 a-d	7	2.1 f-i	16	1
Jelgava, Latvia	30.5 g-i	22	0.056	43.3 gh	21	0.035	23 a-d	10	1.4 g-i	17	1
Glubokski, Russia	29.5 hi	23	0.120	40.3 hi	24	0.156	23 a-d	13	0.3 i	22	0-1
Wilno, Lithuania	29.1 i	24	0.150	42.2 hi	23	0.171	23 a-d	12	0.5 hi	19	1

TABLE 4. ORIGIN, 4-YEAR HEIGHT AND COEFFICIENT OF VARIATION FOR RANDOM AND SELECTED PLANTS, MULTIPLE LEADERS AND FROST DAMAGE IN CENTRAL EUROPEAN AND CANADIAN NORWAY SPRUCE PROVENANCES (Cont'd)

Origin	Twenty random plants per plot			Ten tallest plants per plot			Multiple leaders 1969		Winter frost damage 1968-69[1]		Mean winter frost score 1969-70[2]
	Height cm	Rank	c.v.	Height cm	Rank	c.v.	%	Rank	%	Rank	0-none 1-some 2-severe
Skede, Latvia	26.5 j	25	0.154	38.2 i	25	0.098	32 a	1	0.1 i	24	1

Means followed by a common letter are not significantly different at P<.05 (Duncan, Biometrics: 1-42, 1955).

[1]Listed as original percentages. Analysis was on transformed values.

[2]Based on scoring of whole plots.

TABLE 5. CORRELATION OF CHARACTERS FOR 25 NORWAY SPRUCE PROVENANCES

		X_2	X_3	X_4	X_5
X_1	Height of 20 random plants	+.98***	+.04	+.59**	+.62***
X_2	Height of 10 tallest plants		+.04	+.64***	+.63***
X_3	Multiple leaders 1969			+.23	+.42*
X_4	Winter frost damage 1968-69				+.54**
X_5	Winter frost score 1969-70. The ranged 0-1 and 1-2 are calculated as 0.5 and 1.5				--

Significantly different: *P<.05; **P<.01; ***P<.001.

the Roumanian provenances were damaged by winter frost - Toplita, Turda and Cimpini most (mean 15.6%) and Dorna Cindreni, Marginea, Bicaz and Comanesti least (mean 7.3%).

Of the three German Norway spruce provenances tested, Tännesberg and Rothenkirchen ranked sixth and eighth (mean 38.7 cm), while Carlsfeld was slower-growing (13th and 35.4 cm). All provenances had a tendency to form many double leaders, and Carlsfeld was slightly more resistant to winter frost damage.

All the provenances from Latvia, Lithuania and White Russia were slow-growing and below the mean of the provenances tested. Best of this group was Minsk, from White Russia, which attained 14th rank (34.5 cm). The other White Russian provenances (Gorodokski and Glubokski) attained 17th and 23rd rank (32.1 cm and 29.5 cm respectively). The provenances from Latvia and Lithuania (Daugavpils, Tukums, Auce, Jelgava and Wilno) had a mean height of 30.6 cm and attained 18th, 20th, 21st, 22nd and 24th rank. Skede had significantly less height growth than the other provenances (25th rank and 26.5 cm) and had most plants with double leaders while Tukums had very few plants with double leaders. All provenances in this group were winter-hardy and resistant to winter burn.

Of the four Canadian provenances the general collection from around Wilson's Manure Plot in the Proulx Plantation, Grand'Mère, Que., ranked fourth (41.2 cm). The plus trees from Wilson's Manure Plot had 16th rank (33.5 cm). These trees originally came from Jämtland, in northern Sweden, and were pollinated mainly with trees within the stand. Both lots are winter-hardy. The third lot collected in the Proulx Plantations includes mainly German Norway spruce and is intermediate in growth (37.6 cm, 10th rank) but had a higher winter frost score. The lot from Hudson's Place, on the Petawawa Forest Experiment Station, Ontario, had a surprisingly low ranking (19th). However, we have observed that 2-2 nursery stock of the four slender and fine-branched trees selected for weevil resistance (S.T.100, S.T.109, S.T.116 and S.T.122) were smaller than the other trees tested. When field-planted they tend to pick up. The lot that came from weevil-free trees on Thomas Field, on the Petawawa Forest Experiment Station, contains a mixture of provenances from the IUFRO provenance experiment, trees originating from Hudson's Place and from German Norway spruce selected for frost hardiness in the Proulx Plantations. It has 11th rank and is fairly frost-susceptible, perhaps mainly owing to backcrossing to German or Roumanian provenances.

The coefficient of variation for 20 random plants and the 10 tallest plants in a 100-tree plot was calculated. The correlation between the coefficient of variation for 20 random plants and 10 tallest plants was low (r = .34) and not significant. The coefficient of variation did not shed any light on the effect of nursery selection as it did for the 24 Polish provenances already discussed. The reason may be that there are no major changes in ranking in the experiment and that the provenances were not as uniformly sampled as the Polish provenances. So the coefficient of variation is put on record for later comparisons.

In any kind of early productivity assessment it is hard to strike the proper balance between hardiness and growth rate; it is not known whether all trees within a provenance are frost tender or whether there are some trees that combine fast growth with hardiness. Only field tests and further observation can tell this. Of the fast-growing provenances at P.F.E.S., Toplita, Turda, Cimpini, Tännesberg and Rothenkirchen may be too frost-tender to produce well when field-planted, while Dorna Cindreni and Marginea may have enough hardy trees to produce well. Outstanding in this group is Proulx, Que. (S.4027), which combines fast growth and hardiness. Provenances from White Russia, Latvia and Lithuania have generally been slow-growing and frost-hardy and should not be planted in the Great Lakes-St. Lawrence Forest Region. They may, however, have some merit when planted in the Boreal Forest Region.

SCOTS PINE

The breeding work in Scots pine continues to have the following objectives: testing of stands and provenances in terms of timber production; selection and breeding of Christmas trees; heritability studies of quality traits and weevil resistance; production of a precocious dwarf rootstock that will induce early flowering.

The 1971-72 winter was rather severe and provided a good opportunity to score our Scots pine material for winter damage. In August 1972 winter damage, weevil attack and attack by the eastern gall rust (*Cronartium quercuum* [Berk.] Miyabe ex Shirai) were scored in all Scots pine clones found in the Pine Graft Arboretum, in four clonal seed orchards (Exp. Nos. 86-open and 190), in randomized clonal tests (Exp. Nos. 280-B-1 and 280-B-2 and in controlled crosses (Exp. Nos. 272-A, -B and -C). The clones show high broad-sense heritability in winter damage and weevil attack. Some clones have early and severe attack of eastern gall rust, while others have later and lighter attacks. Most clones are free of galls.

LARCH

The objectives in larch breeding are to find the best provenances of a number of larch species suitable for eastern Canada, to select well-adapted plus trees for breeding and to produce heterotic species hybrids.

In larch we are testing various exotic larch species such as European (*Larix decidua* Mill.), Japanese (*L. leptolepis* [Sieb. & Zucc.] Gord.), Siberian (*L. sukaczewii* Djil.), Korean (*L. gmelini* var. *olgensis* [Henry] Ostenf. & Larsen) and Kurile larch (*L. gmelini* var. *japonica* [Reg.] Pilger), local tamarack (*L. laricina* [Du Roi] K. Koch), western larch (*L. occidentalis* Nutt.), and a small number of hybrids. Our purpose is to assess both species and provenances under local conditions of soils and climate and to select plus trees for further breeding and testing.

Work Done during 1972-73

Larch trees were selected for fast growth and good form in Experiments Nos. 35, 90, 100, 202-A and -J, 209-A and -E. Scions of these were sent to the Institute of Forest Genetics, Rhinelander, Wis., the Maritimes Forest Research Centre, Fredericton, N.B. and the Ministère des Terres et Forêts, Quebec, Que. (Exp. Nos. 386-A, -B and -C).

Seedlings of a single-tree progeny test of local tamarack (Exp. No. 376-A) and species hybrids in larch (Exp. No. 381-A) were scored for both winter frost damage and spring frost damage from the June 10, 1972, late frost. The local tamarack was absolutely winter hardy and not damaged by late spring frost. Siberian larch had slight winter frost damage and 25% with no spring frost damage. European larch plus trees of Polish and Sudeten origin selected at P.F.E.S. had slight winter frost damage but no spring frost damage. Japanese larch suffers both heavy damage from winter frost (90%) and spring frost (99%). The species hybrids tended to be intermediate in winter frost damage.

To improve local tamarack we have selected 57 "plus" phenotypes distributed over seven stands (Exp. No. 376-A). The seed was sown in the spring of 1971.

Performance of Tamarack and Exotic Larch Species

Young plantations of tamarack often have poor stem form with wavy sinuous trunks. We have found one plus tree with an absolutely straight stem and fine branches in a seed lot (S. 461) collected 30 years ago from trees growing on upland sites near Corry Lake, P.F.E.S. (Table 6). On a fairly uniform sandy loam in Arboretum #2, P.F.E.S., this tamarack compares favorably in height growth and perhaps also in diameter growth with a lot of European larches of unknown origin (which are straight) and with Dunkeld larch (Japanese x European), which tends to have a pronounced basal sweep. All these lots are faster-growing than the European larch from Visingsö, Sweden, which has good stem form. Siberian larch from Raivola, Finland,

TABLE 6. HEIGHT, DIAMETER AND MEAN ANNUAL HEIGHT INCREMENT OF LARCH SPECIES IN ARBORETUM #2, PETAWAWA FOREST EXPERIMENT STATION, MEASURED FALL 1966

			Number of trees		Mean		
Seed lot	Species	Origin	Planted	Surviving	Height m	Diam. cm	Annual height increment cm
S.461-46	*L. laricina*	P.F.E.S.	49	43	10.03	14.3	48
S.326-43	*L. decidua*	Unknown	35	10	11.92	18.5	50
S.444-45	*L. eurolepis* F_2	P.F.E.S.	49	22	10.67	16.6	49
S.462-46	*L. eurolepis* F_2	P.F.E.S.	49	46	10.61	13.4	51
S.441-45	*L. decidua*	Visingsö, Sweden (IUFRO #55)	82	75	8.63	13.0	39
S.434-45	*L. sukaczewii*	Raivola via Punkaharju, Finland (IUFRO #37)	47	44	5.52	7.0	25
S.385-44	*L. suk.* x *dec.* F_2	Dropmore, Man.	28	26	6.04	8.7	26
S.222-41	*L. gmelini* var. *olgensis*	Hozan, Korea	47	4	6.33	11.3	24

the Siberian larch from Raivola, Finland, the Siberian x European larch from Dropmore, Man., and the Korean larch had very poor height growth, and the last-named also had very low survival and poor form.

In another set of observation plots field-planted in 1957 and 1962, height and diameter of adjacent rows were measured to give comparable results (Table 7). The local tamarack from P.F.E.S. grew better (11% in height and 12% in diameter) than tamarack from Bancroft, Ont., and Angus, Ont., and had double the height growth rate of tamarack from Lesser Slave Lake, Alta. The tamarack lots also had higher survival (mean 73%) than the other species tested. About 2% of the trees from P.F.E.S. and Bancroft, Ont., had straight stems and acceptable stem form while none could be found in the Angus, Ont., lot. None of the selected trees were as well formed as the tree selected in S. 461, Arboretum #2, already mentioned. In a part of the area that formed a broad basin with shallow soil, tamarack showed superior resistance to snow damage from an early wet snow storm (October 18, 1967). The tamarack had some bent trees (which were never broken), while the adjacent European larch from Kroscienko, Poland, had many broken stems and a high percentage of trees that were blown down owing to their poor root development in the shallow moist soil. However, where the soil depth was adequate, the European larch stood firm. Tamarack is not liked by the larch growers of eastern North America on account of the poor stem form it shows when young and its supposedly slow diameter growth. In our observation plots it seems to hold its own in terms of diameter growth, while the sinuous stem form of the young tree can be improved through selection and is not worse than the kinks and lean of some provenances of European larch.

The two fast-growing European larch provenances (Muszyna and Kroscienko, Poland) were similar to local tamarack in height and diameter. Muszyna exhibited better stem form, with a slight tendency for basal sweep, and Kroscienko was characterized by many stems that were of the corkscrew type or wavy and possessed pronounced basal sweep. The two slow-growing provenances from Rosalia and Paternion, Austria, had fairly good stem form, but their mean annual increments were 34% and 38% less than the local tamarack.

The F_2 of the Dunkeld and hybrid larch (Japanese x European) originates from a small stand of 20 well-spaced trees on P.F.E.S., now almost 45 years old. The material consists of two controlled crosses and four open-pollinated single-tree progenies of the straightest trees with fine branches of the hybrids in this plantation. The height is 17% less than in the local tamarack, while the diameter growth is the same. The stem is straight and much better than in the earlier seed collections (see S. 444 and S. 462 in Table 6), which came from a few early-flowering types with pronounced basal sweep. The Dunkeld hybrid is 10% shorter than the two Polish lots, but 20% taller than the two Austrian lots.

The origin of the Siberian larch is Raivola, in the Karelian Peninsula in Finland, which came to us via the Mustila Arboretum, Finland. The mean annual increment of the pure Siberian larch was only 24% of that of local tamarack, while its hybrids with European larch were 34% and 35% of local tamarack.

TABLE 7. HEIGHT, DIAMETER AND MEAN ANNUAL HEIGHT INCREMENT OF LARCH SPECIES IN THE FUELWOOD AREA, PETAWAWA FOREST EXPERIMENT STATION, MEASURED FALL 1966 AND 1971

Seed lot	Species	Origin	Fall 1966 Survival %	Height m	Diam. cm	Mean annual height increment cm
S.2077-54	*L. laricina*	S.T. 449, P.F.E.S.	87	7.75	8.3	60
S.2084-54	*L. laricina*	Gen. Coll., P.F.E.S.	62	8.01	8.2	62
S.2118-54	*L. laricina*	Angus, Ont.	66	7.17	6.8	55
S.2119-54	*L. laricina*	Bancroft, Ont.	76	7.19	7.3	55
S.2145-54	*L. dec. sud.*	Muszyna, Poland	45	7.58	8.8	58
S.1894-54	*L. dec. pol.*	Kroscienko, Poland	43	7.22	7.2	55
S.2071-54 to S.2076-54	*L. eurolepis* F_2	Dunkeld via P.F.E.S.	34	6.53	8.3	50
S.1886-53	*L. decidua*	Rosalia, Austria	38	5.56	7.0	40
S.1887-53	*L. decidua*	Paternion, Austria	30	5.30	6.5	38
S.1711-52	*L. sukaczewii*	Mustila, Finland	(52)[1]	3.60	4.3	24
S.1711-52	*L. suk.* x *dec.*	Mustila, Finland		5.13	7.6	34
S.1711-52	*L. suk.* x *dec.*	Mustila, Finland		5.32	6.8	35

Odd Lots			Number Planted	Number Surviving	Height fall 1971 m	Annual height increment cm
S.2369-57	*L. laricina*	Lesser Slave Lake, Alta.	1	1	4.20	28
S.2563-58	*L. occidentalis*	B.C.	116	8	1.84	13
S.2574-58	*L. occidentalis*	B.C.	52	3	2.10	16

[1]Also includes survival of the hybrids.

During the past two decades several attempts were made to grow western larch at P.F.E.S., but it faded away in the nursery. From the 265 grams of seed sown in 1958, 2,000 seedlings were transplanted in 1959, 161 field-planted in 1961, but only 11 trees survived in 1971. The mean annual increment was only 25% of that of local tamarack. In the Arboretum at the Central Experimental Farm, Department of Agriculture, Ottawa, there is a fast-growing and perfectly healthy tree of western larch on a rich calcareous loam. It may be that western larch fails at P.F.E.S. because it is not adapted to growing on the typically acid soils of granitic origin. The same seems to be true for Siberian larch, which is both faster-growing and more healthy in the Central Experimental Farm Arboretum in Ottawa than at Petawawa.

PUBLICATION

Teich, A.H., and M.J. Holst. 1973. Survival and growth of some exotic larch species and hybrids in the Ottawa Valley. For. Chron. 49:224-225.

THE GENETIC BASIS FOR IMPROVEMENT OF RED PINE, PETAWAWA, 1972-73

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INTRODUCTION

The broad objectives for the genetic improvement of red pine (*Pinus resinosa* Ait.) are to provide information on the best seed available for the establishment of man-made forests, and to develop guidelines for improvement through selection and breeding.

When the tree-breeding projects were reactivated in 1950, no work had been done in Canada on the provenance problem of red pine. Nothing was known about what could be gained by using the right provenances or what could be lost by using the wrong provenances - and no provenances zones were used. Red pine continues to be an important reforestation species for abandoned farm lands in eastern Canada because of its good stem form and relative freedom from pests. Its uniformity is deceiving and has led to indiscriminate seed transfer. This may have serious consequences, particularly in the colder parts of the red pine range. The red pine provenance problem still requires intensive study.

During the period 1950-73 the Petawawa Forest Experiment Station (Petawawa F.E.S.) and cooperators established 43 red pine experiments on 57 acres in eastern Canada, and eight experiments were established by cooperators on 16 acres in the United States; seed for 11 experiments was sent overseas. The Ontario Ministry of Natural Resources has planted four red pine provenance experiments of their own (Exp. No. 196-A to -C), testing 16 provenances. All these experiments were measured every 5 to 10 years.

WORK DONE DURING 1972-73

Further work was done on the provenance description and climatic data for all red pine provenances distributed by the tree-breeding group at Petawawa F.E.S. as well as on the climatic data for each test location.

An assessment was made of all red pine grafts associated with various experiments. Some of our older grafts can now be used for controlled crosses. It takes the grafts about 15 years to start bearing flowers.

In the fall of 1972 we measured 19-year heights and diameters in Exp. No. 96-E, -F, -G and -H, and our cooperators provided measurements of Exp. No. 96-A, -B, -C, -D, -I and -J; we also measured 15-year heights and diameters in Exp. No. 216-B and -G, while our cooperators measured Exp. No. 216-C, -D, -E, -F, -H, -I and -J.

We also measured a 22-year-old progeny test of Petawawa red pine (Exp. No. 38); a 22-year-old provenance test (Exp. No. 39); a 21-year-old provenance test (Exp. No. 74-B and -C); 21-year-old provenance observation plots located at the Harrington Ecology Centre of the Canadian International Paper Company at Harrington, Que. (Exp. No. 177); 21-year-old observation plots located in the Durling Fields, N.S. (measured by the Maritimes Forest Research Centre, Exp. No. 180); a 20-year-old provenance test (Exp. No. 81); a 13-year-old test of hybrids between Petawawa normal red pines and the Bancroft, Ont., tassel pine (Exp. No. 211-A, -B, -C and -D); and test of open- and control-pollinated progenies of Petawawa red pine (Exp. No. 291).

A section on red pine was written for a cooperative paper: "Plus-tree selection: review and outlook."

PROVENANCE TESTS

In the Petawawa F.E.S. nursery we have raised plants for two cooperative red pine provenance experiments (Exp. No. 96, sown in 1954, and Exp. No. 216, sown in 1958). During the 1950's seed for these experiments was provided by the Maritimes Forest Research Centre, Nova Scotia Department of Lands and Forests, Quebec Department of Lands and Forests, Ontario Ministry of Natural Resources, Northern Forest Research Centre, University of Wisconsin and State of New York Conservation Department. Field tests were established by Bowaters Mersey Paper Company Ltd., Canadian International Paper Company, Dryden Paper Company Ltd., Nova Scotia Department of Lands and Forest, Province of Prince Edward Island, Maritimes Forest Research Centre, Laurentian Forest Research Centre, Laval University, Ontario Ministry of Natural Resources, Petawawa Forest Experiment Station, University of Toronto, Northern Forest Research Centre and the University of Wisconsin. The 10-year-height measurements on which this report is based were provided by Bowaters Mersey Company Ltd., Maritimes Forest Research Centre, Laurentian Forest Research Centre, Laval University, Canadian International Paper Company, Ontario Ministry of Natural Resources, University of Toronto, Petawawa Forest Experiment Station, Northern Forest Research Centre and the University of Wisconsin. Thus the progress made in red pine provenance research is due to the cooperation of many individuals and organizations, and their assistance is gratefully acknowledged.

The following is a summary, by location, of test areas highlighting results attained with the 10-year-heights in Exp. No. 96 (Tables 1 and 2) and in Exp. No. 216 (Tables 3 and 4). At each test site an attempt has been made to get the best estimate of the provenance performance by using either all healthy plants per plot or the 10 tallest plants per plot. In a few locations

TABLE 1. TEN-YEAR-HEIGHT IN CENTIMETERS OF RED PINE PROVENANCES IN EXP. NO. 96

Seed lot number	Origin	Location									
		A[1]	B[1]	C[2]	D[3]	E[4]	F[3]	G[3]	H[4]	I[2]	J[3]
S.1712-54	Raco, Mich.	65	131	201	253	146	212	193	181	137	140
S.1713-54	Trout Lake, Wis.	-	146	-	-	167	-	-	162	149	-
S.1714-54	Petawawa F.E.S., Ont.	68	137	207	239	156	218	208	160	146	127
S.1715-54	Thessalon, Ont.	61	143	205	260	154	227	189	159	137	133
S.1716-54	Sault Ste. Marie, Ont.	56	128	204	234	159	205	204	172	139	130
S.1717-54	Regina Bay, Ont.	65	134	180	242	148	227	186	171	124	142
S.1718-54	Sturgeon Falls, Ont.	62	131	206	269	154	214	190	178	141	136
S.2044-54	Upper Jay, N.Y.	-	131	-	-	148	-	198	155	128	-
S.2045-54	Stanley, N.S.	57	125	183	244	142	214	176	154	126	116
S.2046-54	Grand Lake, N.B.	60	125	187	220	136	208	184	155	127	120
S.2047-54	Cass Lake, Minn.	-	128	193	226	154	219	214	-	-	-
S.2112-54	Sorel, Qué.	-	128	214	-	161	-	202	-	-	-
S.2113-54	Mattawin River, Qué.	-	149	-	-	-	-	212	-	-	-
S.2114-54	Kenogami, Qué.	-	125	200	-	145	-	-	155	140	130
S.2115-54	Eagle River, Ont.	-	-	-	-	-	-	193	156	131	-
S.2130-54	St. Charles de Mandeville, Qué.	-	119	189	-	150	-	191	-	-	-
S.2131-54	St. Alphonse, Qué.	-	131	-	-	151	-	204	-	-	-
S.2132-54	Rawdon, Qué.	-	-	-	-	-	-	201	-	-	-
S.2569-54	Zone 2, Ont.	-	-	-	-	155	-	-	-	-	-
No number -54	Sandilands, Man.	-	-	-	-	-	-	-	-	-	120
Mean		62	132	197	243	151	216	197	163	134	129

[1]Mean of all healthy plants per plot.
[2]Mean of all healthy plants per plot, from which some plot values were excluded to get best estimate.
[3]Mean of 10 tallest trees per plot.
[4]Mean of 10 tallest trees per plot, from which some plot values were excluded to get best estimate.

TABLE 2. LOCATION OF RED PINE PROVENANCE EXPERIMENTS IN EXP. NO. 96 AND COOPERATORS WHO ESTABLISHED AND MEASURED THE EXPERIMENTS

Location		Planted by:	Measured by:
A	Durling Fields, Annapolis Co., N.S.	Bowaters Mercey Paper Company Ltd., Liverpool, N.S.	Bowaters Mersey Paper Company Ltd. (R.S. Johnson and L. Holt)
B	Chignecto Game Sanctuary, Cumberland Co., N.S.	Nova Scotia Department of Lands and Forests and Maritimes Forest Research Centre	Maritimes Forest Research Centre (H.G. MacGillivray)
C	Valcartier Forest Experiment Station, Quebec Co., Que.	Valcartier Forest Experiment Station, Laurentian Forest Research Centre	Laurentian Forest Research Centre (N. Cleyndert)
D	Chatham Twp., Argenteuil Co., Que.	Canadian International Paper Company, Grenville, Que.	Canadian International Paper Company (P.L. Aird and M.M. Putnam)
E	Turkey Point, Charlotteville Twp., Norfolk Co., Ont.	Forest Research Branch, Ontario Ministry of Natural Resources	Ontario Ministry of Natural Resources (D.P. Fowler)
F	University Forest, Dorset, Ridout Twp., Haliburton Co., Ont.	University Forest, University of Toronto	University of Toronto (G.M. Wilson)
G	Petawawa Forest Experiment Station, Wylie Twp., Renfrew Co., Ont.	Petawawa Forest Experiment Station, Canadian Forestry Service	Petawawa Forest Experiment Station (P. Viidik and M.J. Holst)
H	Ingram Twp., Timiskaming Distr., Ont.	Forest Management Branch, Ontario Ministry of Natural Resources	Ontario Ministry of Natural Resources (Arrangements by C.H. Lane)
I	Van Horne Twp., Thunder Bay Distr., Ont.	Forest Management Branch, Ontario Ministry of Natural Resources	Ontario Ministry of Natural Resources (Arrangements by C.H. Lane)
J	Sandilands Forest Reserve, Piney Ranger Distr., Man.	Northern Forest Research Centre, Canadian Forestry Service	Northern Forest Research Centre (J.H. Cayford and K. Roller)

TABLE 3. TEN-YEAR HEIGHTS IN CENTIMETERS OF RED PINE PROVENANCES IN EXP. NO. 216

Seed lot number	Origin	Location								
		B[1]	C[1]	D[1]	E[1]	F[1]	G[2]	H[1]	I[1]	J[1]
S.1713-58	Trout Lake, Wis.	175	163	170	99	132	-	-	91	82
S.2045-58	Stanley, N.S.	168	122	150	89	121	-	77	76	73
S.2046-58	Grand Lake, N.B.	164	134	143	101	132	-	90	76	82
S.2132-58	Rawdon, Que.	162	137	151	89	147	151	74	98	85
S.2356-58	Sturgeon Falls, Ont.	175	118	150	100	159	150	83	85	82
S.2530-58	Thistledew Lake, Minn.	159	128	156	83	130	151	-	-	-
S.2531-58	Clubhouse Lake, Minn.	169	142	158	90	-	-	-	-	-
S.2532-58	Itasca Park, Minn.	171	140	157	90	137	153	-	-	-
S.2533-58	Cass Lake, Minn.	165	149	144	93	-	-	-	-	-
S.2559-58	Dryden, Ont.	153	134	150	83	132	121	-	85	76
S.2560-58	Fort Frances, Ont.	168	141	108	93	128	135	-	85	79
S.2561-58	Douglas, Ont.	179	134	166	99	144	134	98	98	85
S.2567-58	Lake States, U.S.A.	171	127	155	93	-	-	-	-	-
S.2577-58	Dairymen's Ctry. Club, Wis.	180	-	125	-	-	-	-	88	79
S.2578-58	Schoolcraft Co., Mich.	171	146	161	103	143	171	-	85	85
S.2579-58	Grand Traverse Co., Mich.	167	135	148	99	137	154	-	98	79
S.2580-58	Presque Isle Co., Mich.	186	139	173	105	164	136	101	76	70
S.2581-58	Superior Nat. For., Minn.	179	141	161	95	141	148	-	79	73
S.2582-58	Chippewa Nat. For., Minn.	175	146	174	104	152	127	-	82	70
S.3136-58	Boulder Junction, Wis.	177	144	154	99	-	155	83	-	-
S.3137-58	Oneida Co., Wis.	177	132	156	98	-	172	-	-	-
S.3138-58	Six Mile Lake, Minn.	173	158	168	102	-	123	93	-	-
S.3139-58	Lake Thirteen, Minn.	175	152	188	99	-	157	87	-	-
S.3140-58	Grand Bend, Ont.	168	150	138	103	165	-	80	-	-
Mean		171	140	154	95	141	146	87	86	79

[1]Mean of all healthy plants per plot.
[2]Mean of all healthy plants per plot, from which some plots were excluded to get best estimate.

TABLE 4. LOCATION OF RED PINE PROVENANCE EXPERIMENTS IN EXP. NO. 216 AND COOPERATORS WHO ESTABLISHED AND MEASURED THE EXPERIMENTS

Location		Planted by:	Measured by:
B	Petawawa Forest Experiment Station, Buchanan Twp., Renfrew Co., Ont.	Petawawa Forest Experiment Station, Canadian Forestry Service	Petawawa Forest Experiment Station (P.Viidik and M.J. Holst)
C	Dryden, McIlraith Twp., Ont.	Dryden Paper Company Ltd., Dryden, Ont.	Ontario Ministry of Natural Resources (J. Sellers and C.H. Lane)
D	St. Jean Chrysostome, Levis Co., Qué.	Laval University, Quebec, Qué.	Laval University (Professor L. Parrot)
E	Garden-of-Eden Barrens, Pictou Co., N.S.	Province of Nova Scotia and Maritimes Forest Research Centre	Maritimes Forest Research Centre (H.G. MacGillivray)
F	Iris, Queens Co., P.E.I.	Province of Prince Edward Island and Maritimes Forest Research Centre	Maritimes Forest Research Centre (H.G. MacGillivray)
G	Turkey Point, Charlotteville Twp., Norfolk Co., Ont.	Forest Research Branch, Ontario Ministry of Natural Resources	Petawawa Forest Experiment Station (J. Veen and M.J. Holst)
H	St. Raymond, Portneuf Co., Qué.	Laval University, Quebec, Qué.	Laval University (Professor L. Parrot)
I	Armenia Twp., Juneau Co., Wis.	University of Wisconsin, Madison, Wis.	University of Wisconsin (D.T. Lester)
J	Waukesha Co., Wis.	University of Wisconsin, Madison, Wis.	University of Wisconsin (D.T. Lester)

some poor plots were excluded. For each test site, only the best and the poorest provenances are discussed.

Eastern Manitoba

At Sandilands, Manitoba, in the extreme western part of the red pine range, nine provenances raised in the Petawawa F.E.S. nursery were tested against control from Sandilands raised in the local nursery. The control plants were smaller than the other provenances at the time of planting. (Exp. No. 96-J). In this experiment there were significant differences in height and survival ($P<.05$). The greatest height growth occurred in trees from Regina Bay, Ont. (18% greater than the control), but these had only average survival. Next best growth was in trees from Raco, Mich. (17% higher than the control), and these had high survival. Poorest height growth was in trees from Grand Lake, N.B., and Stanley, N.S. (2% less than the control). Stanley, N.S., also had very low survival. The local control from Sandilands had very high survival and had for the last 5 years grown as well as Raco, Mich. Survival was correlated with annual precipitation ($r = .66$) and frost-free days ($r = .58$) (both $P<.05$).

Thus red pine from Raco, Mich., might be tested further in eastern Manitoba.

Northwestern Ontario

In northwestern Ontario, near Dryden, we have two red pine provenance experiments. In the first test (Exp. No. 96-I), 12 provenances are being tested. There were significant differences in height ($P<.01$), but not in survival (which was high). Red pine from Trout Lake, Wis., and Petawawa F.E.S., Ont., had respectively 14 and 11% better height growth than the local control from Eagle River, Ont. Poorest height growth occurred in trees from Upper Jay, N.Y., Grand Lake, N.B., and Stanley, N.S., which grew 3% less than the local control.

The other test in northwestern Ontario (Exp. No. 216-D), which comprises 24 provenances, had significant differences in height growth ($P<.001$) and winter frost damage ($P<.01$) but not in survival (which was high). Trout Lake, Wis., was best, having 22% better height growth than the local control from Dryden, Ont. Of the five tallest provenances (which were on the average 15% taller than the local control), one comes from Wisconsin (Trout Lake), three from Minnesota (Six Mile Lake, Lake Thriteen and Cass Lake) and one from Ontario (Grand Bend). Of these, the Wisconsin and Minnesota provenances were winter frost hardy, while the one from Grand Bend, Ont., had the highest winter frost damage of all the provenances tested. Lowest height growth occurred in trees from Thistledew Lake, Minn., Lake States, Stanley, N.S., and Sturgeon Falls, Ont.: they had 7% less height growth than the local control. Winter frost damage was negatively correlated with latitude ($r = -.83$; $P<.01$), longitude ($r = -.82$; $P<.01$) and height ($r = -.42$ n.s.). Winter frost damage was most severe in the Grand Bend, Ont., provenance, which was significantly different from all the other provenances. A group of 10 provenances from nothern Michigan and western Ontario had very little frost damage.

For use in western Ontario, provenances from northern Wisconsin (Trout Lake) and selected northern Minnesota provenances would warrant further trial in comparison with local provenances from western Ontario.

Northeastern Ontario

The only experiment in northeastern Ontario (Exp. No. 96-H) is located near Swastika. There were significant differences in height growth ($P<.05$) but not in survival, which was generally high. Twelve provenances are being tested, none of which is a local control. Raco, Mich., was the tallest, having 11% better height growth than the experimental mean. The four tallest provenances (Raco, Mich., Sturgeon Falls, Ont., Sault Ste. Marie, Ont., and Regina Bay, Ont.) were on the average 8% taller than the mean. The four provenances with least height growth (Eagle River, Ont., Kenogami, Que., Grand Lake, N.B., and Stanley, N.S.) were 5% shorter than the mean.

Further testing in northern Ontario should include red pine from Trout Lake, Wis., selected Minnesota provenances and local northern Ontario provenances.

East-central Ontario

The experiments in east-central Ontario are located at the Petawawa Forest Experiment Station and at Dorset. At Petawawa F.E.S. two field tests have been established with this material. Exp. No. 96-G includes 16 provenances, and in these there were significant differences in height ($P<.01$) but not in survival. Red pine from Cass Lake, Minn., and Mattawin River, Que., were 3% taller than the local control from Petawawa F.E.S., Ont. Trees from St. Alphonse, Que., Sault Ste. Marie, Ont., Sorel, Que., and Rawdon, Que., were on the average 3% shorter than the Petawawa F.E.S., Ont., control. The five poorest provenances (Sturgeon Falls, Ont., Thessalon, Ont., Regina Bay, Ont., Grand Lake, N.B., and Stanley, N.S.) were on the average 11% shorter than the local control. Red pine from Stanley, N.S., were 15% shorter than the control. Winter frost damage during the 1958-59 winter was scored. Most damage occurred in trees from Upper Jay, N.Y. (43%), St. Charles de Mandeville, Que., and Sorel, Que. (mean 36%) and Grand Lake, N.B., and Stanley, N.S. (mean 35%). Trees from Petawawa F.E.S., Ont., had 23% damage, and those from St. Alphonse, Que., Sault Ste. Marie, Ont., and Mattawin River, Que., had somewhat less damage (mean 15%). Red pine from Regina Bay, Ont., Cass Lake, Minn., and Eagle River, Ont., had very little winter frost damage (mean 4%). It is remarkable that trees from Cass Lake, Minn., in this experiment combine very fast growth with extreme hardiness. However, in Exp. No. 216-B, Cass Lake, Minn., is 8% shorter than the local control, which is perhaps a warning that the growth rate may not be so impressive. Trees from Mattawin River, Que., St. Alphonse, Que., and Sault Ste. Marie, Ont., all grow at about the same rate as those from Petawawa F.E.S., Ont., but appear to be more winter frost hardy.

Exp. No. 216-B, testing 24 provenances, was planted with three replications only, and the height-growth differences were barely significant

(P<.10). Best height growth occurred in trees from Presque Isle Co., Mich., which were 4% taller than the local control from Douglas, Ont. There were 14 provenances that were similar in height growth to the local control (±4% of Douglas, Ont.). Red pine from Dryden, Ont., had the poorest height growth, which was 15% less than Douglas, Ont. The five poorest provenances were on the average 10% shorter than the local control.

Near the ranger school at Dorset, Ont., nine provenances were tested (Exp. No. 96-F). Differences in height growth were significant (P<.10). The best growth occurred in trees from Regina Bay, Ont., and Thessalon, Ont.; it was 5% higher than the mean. Red pine from Cass Lake, Minn., and Petawawa F.E.S., Ont., also performed well (height growth 1% better than the mean). The poorest growth was in trees from Grand Lake, N.B., and Sault Ste. Marie, Ont. (both 5% less height growth than the mean).

In east-central Ontario the local provenances, such as Petawawa F.E.S., Ont., and Douglas, Ont., have always had good height growth. Provenances that may have faster growth than the local ones are those from Presque Isle Co., Mich., Trout Lake, Wis., Dairymen's Country Club, Wis., and Oneida Co., Wis.

Southern Ontario

Turkey Point, at Lake Erie, is the location of two experiments. Exp. No. 216-G includes 16 provenances in two replications in which the height growth differences were barely significant (P<.10). Tallest were the trees from Oneida Co., Wis., and Schoolcraft Co., Mich. (both 18% taller than the mean). Next best were a group of provenances (Lake Thirteen, Minn., Boulder Junction, Wis., Grand Traverse Co., Mich., and Itasca Park, Minn.) with similar heights (6% taller than the mean). The poorest height growth was in trees from Chippewa National Forest, Minn., Six Mile Lake, Minn., and Dryden, Ont. (15% less than the mean).

The other experiment (Exp. No. 96-E) tests 16 provenances and has five replications. Height growth of provenances was significantly different (P<.01). Trees from Trout Lake, Wis., grew fastest and had 11% better height growth than the mean. The five tallest provenances (Trout Lake, Wis., Sorel, Que., Sault Ste. Marie, Ont., Petawawa F.E.S., Ont., and Ontario Ministry of Natural Resources, Zone 2) were 5% higher than the mean. The six poorest provenances (Upper Jay, N.Y., Regina Bay, Ont., Kenogami, Que., Stanley, N.S., Raco, Mich., and Grand Lake, N.B.) had on the average 5% less height growth than the experimental mean.

Thus for southern Ontario selected Michigan and Wisconsin provenances as well as those from southern Ontario itself have done well.

Lake States

In the Lake States 14 provenances are being tested in two experiments. One is located in Juneau County, central Wisconsin (Exp. No. 216-I), and the other in Waukesha County, southern Wisconsin (Exp. No. 216-J). In central Wisconsin, trees from Rawdon, Que., Douglas, Ont., and Grand Traverse Co., Mich., grew best, while Presque Isle Co., Mich., Stanley, N.S., and Grand Lake, N.B., had poorest growth. In southern Wisconsin, red pine from Rawdon, Que., Douglas, Ont., and Schoolcraft Co., Mich., grew best, while Stanley, N.S., Superior National Forest, Minn., Chippewa National Forest, Minn., and Presque Isle Co., Mich., were poorest.

Southwestern Quebec

Two experiments were planted by the Canadian International Paper Company: one at the Harrington Ecology Centre, Harrington, Que., (Exp. No. 177, testing 10 provenances), which does not belong in the red pine provenance series under discussion; the other (Exp. No. 96-D, testing nine provenances) in the same general area near Grenville, Que. In the latter trial there were significant differences in height growth ($P<.05$). The three tallest provenances (Sturgeon Falls, Ont., Thessalon, Ont., and Raco, Mich.) were 7% higher than the experimental mean. The three shortest provenances (Sault Ste. Marie, Ont., Cass Lake, Minn., and Grand Lake, N.B.) were 7% shorter than the mean.

As this experiment did not include any Quebec provenances, it is not possible to make specific recommendations for southwestern Quebec.

Eastern Quebec

The three red pine experiments in this area are all located in the vicinity of Quebec City. Exp. No. 96-C was planted at the Valcartier Forest Experiment Station, near Loretteville. Laval University established two experiments: Exp. No. 216-D was planted near St. Jean Chrysostome, and Exp. No. 216-H near St. Raymond.

In the experiment planted at the Valcartier Forest Experiment Station (Exp. 96-C) 12 provenances were tested. There were significant differences in height growth ($P<.01$). There were three Quebec provenances in this experiment: Sorel, Que., was the best, having 9% better height growth than the mean, Kenogami had 2% better height growth than the mean, and St. Charles de Mandeville, Que., had 4% less height growth than the mean. In addition to Sorel, Que. the four fastest-growing provenances were: Petawawa F.E.S., Ont., and Sturgeon Falls, Ont. (both 5% taller than the mean), and Thessalon, Ont., and Sault Ste. Marie, Ont. (both 4% taller than the mean). Poorest growth occurred in trees from Regina Bay, Ont. (9% less than the mean), Stanley, N.S. (7% less than the mean) and Grand Lake, N.B. (5% less than the mean).

In the experiment planted near St. Jean Chrysostome, in Levis Co. (Exp. No. 216-D) 24 provenances were tested. Only the provenance means are available. The five best (Lake Thirteen, Minn., Chippewa National Forest, Minn., Presque Isle Co., Mich., Trout Lake, Wis., and Six Mile Lake, Minn.) were on the average 13% taller than the experimental mean. The five poorest provenances (Cass Lake, Minn., Grand Lake, N.B., Grand Bend, Ont., Dairymen's Country Club, Wis., and Fort Frances, Ont.) had on the average 14% less height growth than the mean. The only Quebec provenance (Rawdon) in this experiment had 2% less height growth than the mean.

In the experiment planted near St. Raymond (Exp. No. 216-H) 10 provenances were tested. We only have the provenance means. The three fastest-growing provenances (Presque Isle Co., Mich., Douglas, Ont., and Six Mile Lake, Minn.) had an average of 12% better height growth than the experimental mean. The three poorest provenances (Grand Bend, Ont., Stanley, N.S., and Rawdon, Que.) had on the average 11% less height growth than the mean. The only Quebec provenance (Rawdon) had 27% less height growth than the fastest-growing provenance, Presque Isle Co., Mich.

For eastern Quebec the one experiment in the Exp. No. 96 series at Valcartier Forest Experiment Station shows that local trees from Sorel, Que., are promising and had 10% better height growth than the other Quebec provenances (Kenogami, and St. Charles de Mandeville). Also, red pine from Ontario (Petawawa F.E.S., Sturgeon Falls, Thessalon and Sault Ste. Marie) may warrant further trial. The two experiments in the Exp. No. 216 series indicate that red pine from Lake Thirteen and Six Mile Lake (both in Minnesota), Trout Lake, Wis., Presque Isle Co., Mich., and Douglas, Ont., should be included in future tests in eastern Quebec.

The Maritimes

In the Maritimes there are red pine tests in Nova Scotia and on Prince Edward Island. There are four replicated experiments and one experiment with unreplicated observation plots. The Mersey Paper Company, Liverpool, N.S., planted two experiments (Exp. Nos. 96-A and 180) in the Durling Fields, Annapolis County, N.S. The Canadian Forestry Service, Maritimes Forest Research Centre, made arrangements for three experimental plantings: in Chignecto Game Sanctuary, Cumberland County, N.S. (Exp. No. 96-B), in the Garden-of-Eden Barrens, Pictou County, N.S. (EXP. No. 216-E) and at Iris, Queens County, P.E.I. (Exp. No. 216-F).

In the Durling Fields (Exp. No. 96-A) eight provenances are being tested. There were significant differences in their height growth ($P<.01$). The three best provenances (Petawawa F.E.S., Ont., Raco, Mich., and Regina Bay, Ont.) had 7% better height growth than the experimental mean, while the height growth of the poorest provenances (Grand Lake, N.B., Stanley, N.S. and Sault Ste. Marie, Ont.) was 7% less than the mean. The red pine from Grand Lake, N.B., and Petawawa F.E.S., Ont., were respectively 5% and 19% taller than the local provenance from Stanley, N.S. The overall growth rate was poor owing to heavy clay soil.

In the Chignecto Game Sanctuary (Exp. No. 96-B) 16 provenances are being tested, and there are significant differences in height growth ($P<.05$). The four best provenances (Mattawin River, Que., Trout Lake, Wis., Thessalon, Ont., and Petawawa F.E.S., Ont.) had 9% better height growth than the experimental mean. The four poorest provenances (Stanley, N.S., Grand Lake, N.B., Kenogami, Que., and St. Charles de Mandeville, Que.) had 6% less height growth than the mean. Mattawin River, Que., was 19% taller than the two Maritime control provenances (Grand Lake, N.B., and Stanley, N.S.). The overall growth rate has been good and the soil is a coarse-textured well-drained sand. For a short period (1958-60) the experiment was browsed by deer. In the fall of 1960 the leaders were protected by polyethlene film.

In the Garden-of-Eden Barrens (Exp. No. 216-E) 23 provenances are being tested, and there are significant differences in height growth (P<.01). The five best provenances (Presque Isle Co., Mich., Chippewa National Forest, Minn., Schoolcraft Co., Mich., Grand Bend, Ont., and Six Mile Lake, Minn.) had 9% better height growth than the experimental mean. The five poorest provenances (Itasca Park, Minn., Rawdon, Que., Dryden, Ont., Thistledew Lake, Minn., and Stanley, N.S.) had 10% less height growth than the mean. The fastest-growing provenance (Presque Isle Co., Mich.) was 18% taller than the two local controls from Stanley, N.S., and Grand Lake, N.S. The overall growth rate was poor, but not as poor as in the Durling Fields (Exp. No. 96-A); so the site conditions in the Garden-of-Eden Barrens are not well suited to red pine. In 1966-67 the European pine shoot moth (*Rhyacionia buoliana* [Schiff.]) attacked the red pines lightly and the difference between provenances were significant (P<.10). The total number of attacked shoots per 25-tree plot in 1967 ranged from 0.4 to 7.3. Although there was considerable provenance-to-provenance variation, the 12 fast-growing provenances had nearly double the damage (3.4 shoots attacked per plot) than the 11 slow-growing provenances (1.8 shoots attacked per plot).

At Iris, P.E.I., 16 provenances are being tested. They are significantly different in height (P<.005). The four best provenances (Grand Bend, Ont., Presque Isle Co., Mich., Sturgeon Falls, Ont., and Chippewa National Forest, Minn.) were 14% taller than the experimental mean. The four poorest provenances (Grand Lake, N.B., Thistledew Lake, Minn., Fort Frances, Ont., and Stanley, N.S.) were 9% shorter than the mean. Compared with the local provenance from Stanley, N.S., Grand Lake, N.B. was 9% taller and Grand Bend, Ont. was 36% taller. The overall growth rate was the best of the five experiments in the Maritimes. In 1966-67 the European pine shoot moth was noted in this plantation.

The two Maritime control provenances (Stanley, N.S., and Grand Lake, N.B.) were respectively 8% and 3% shorter than the experimental mean for the four experiments, while the faster-growing provenances were 13% taller than the mean. Future experiments in the Maritimes should include the Mattawin River, Que., Petawawa F.E.S., Ont., Sturgeon Falls, Ont., Thessalon, Ont., Grand Bend, Ont., Presque Isle Co., Mich., Trout Lake, Wis., and Chippewa National Forest, Minn., together with the most promising provenances identified in Michigan and tested against a larger number of local Maritime provenances.

Conclusion

In the Exp. No. 96 series it is very difficult to pick out any stars that performed well in all locations where the experiment was planted. It is a lot easier to pick out the consistently poor performers, i.e. red pine from Stanley, N.S., Grand Lake, N.B., and Kenogami, Que.

In the Exp. No. 216 series there are no overall good performers either, and there are some curious interactions between provenances and test locations. For instance, Presque Isle County, Mich., has first to third rank in the five experiments planted on acid granitic soils in east-central Ontario, Quebec and the Maritimes. In contrast Presque Isle Co., Mich., has the lowest rank in the three experiments planted on soils in southern Ontario and Wisconsin. Another example is the red pine from Douglas, Ont., which is in the best third of the provenances in Wisconsin, east-central Ontario, Quebec and the Maritimes, but in the lowest third in southern and western Ontario. The consistently poor performers were easier to spot, viz., Stanley, N.S., with a mean ranking from the bottom in the tests in which it occurs of 2.6, Thistledew Lake, Minn., and Dryden, Ont., which both ranked 3.2 from the bottom, Fort Frances, Ont. (rank 3.3), Grand Lake, N.B. (rank 3.4) and Rawdon, Que. (rank 4.0).

The 10-year heights reported here must be considered as preliminary data, as in the experimental planting various kinds of establishment difficulties were encountered. The 20-year assessment should give more reliable data on provenance performance.

HERITABILITY ESTIMATES IN PETAWAWA RED PINE

Since 1961, several attempts have been made at the Petawawa Forest Experiment Station to estimate the degree of subdivision of red pine in the Ottawa Valley by sampling a number of stands and raising their progeny on a single-tree basis. A large study initiated in 1961 covering the area from Bristol, Que., to Mattawa, Ont. (120 miles) and 32 stands failed when chipmunks destroyed the seedbeds and mixed the seed (Exp. No. 257-A). A more limited study was also sown in 1961, sampling stands within a radius of 5 miles of the Station headquarters. This study has now provided data on this problem as well as the first estimate of heritability (Exp. No. 238-D).

Ten trees from each of eight stands were sampled, and progeny was raised from them in a replicated experiment with 10 replications. When the 10-year height was measured, it was found that the differences between stands accounted for only 1% of the total variance and were not significant (Table 5). Thus, the degree of subdivision of the Petawawa stands is very small, and they all can be considered as the same breeding population.

The single-tree progenies within stands contributed 21% of the total variance, and the differences were significant ($P<.01$). The best single-tree progeny was 11% higher than the overall mean. Correlations were computed between parent-tree height, the annual increment of the parent tree, a parent-tree growth efficiency index and progeny height for each stand, and with only 10 progenies tested per stand it was difficult to get significant correlations (Table 7). In stands growing on fairly uniform and fertile red pine sites there was a positive correlation between parent-tree height and progeny height ($r = .12$, n.s.; $r = .31$, n.s.; $r = .62$, $P<.10$). From stands growing on rocky, shallow soils, there were both positive and negative correlations between parent-tree height and progeny height, but none of these was significant. A

TABLE 5. PETAWAWA RED PINE STAND TEST: COMPONENTS OF VARIANCE WHEN WITHIN-PLOT ANALYSIS IS INCLUDED

Source	D.F.	M.S.	F	M.S. estimates
Stands	7	1,227.7500	1.45 n.s.	$\delta^2_w/h + \delta^2_p + 10\delta^2_{T_2} + 100\delta^2_S$
Trees	72	849.6146	3.78***	$\delta^2_w/h + \delta^2_p + 10\delta^2_T$
Trees x Reps = Error	720	224.4771		$\delta^2_w/h + \delta^2_p$
Within plots*	720	586.0829		δ^2_w/h**
Total	1,519			

*From separate analysis of variance.
**h = harmonic mean = 10.0.
n.s. - not significant; *** significant level P<.01.

TABLE 6. PETAWAWA RED PINE STAND TEST: CALCULATION OF VARIANCE COMPONENTS FROM TABLE 5 AND ESTIMATE OF NARROW-SENSE HERITABILITY (h^2_{ns})

$$\delta^2_w/h = 586.08/10 = 58.61$$

$$\delta^2_p = 224.48 - 58.61 = 165.87$$

$$\delta^2_T = (849.61 - 224.48)/10 = 62.51$$

$$\delta^2_S = (1227.75 - 849.61)/100 = 3.78$$

$$h^2_{ns} = \frac{4\delta^2_T}{\delta^2_T + \delta^2_p + \delta^2_w} = \frac{4 \times 62.51}{62.51 + 165.87 + 586.08}$$

$$= \underline{\underline{0.31}}$$

TABLE 7. RESULTS OF THE PARENT-PROGENY REGRESSIONS OF 10-YEAR PROGENY HEIGHT ON: (1) TOTAL PARENTAL TREE HEIGHT, (2) MEAN ANNUAL HEIGHT INCREMENT OF PARENT TREE, AND (3) EFFICIENCY INDEX[1]

Stand No.	Correlation coeff. (r) Regression coeff. (b)	Total parental height	Mean annual height increment	Efficiency index	Age determined by	Site of parental stand
1-1	r	+.31	+.57*	+.46	Ring	Sandy and
	b	+.16	+.01	-.16	count	uniform
1-2	r	+.13	-	+.25	Esti-	Sandy and
	b	+.07	-	+.02	mate	uniform
2-1	r	+.03	+.09	+.02	Ring	Dumped till over
	b	-.01	-.001	-.001	count	shallow rock
2-2	r	+.40	-	+.10	Esti-	Dumped till over
	b	-.08	-	-.01	mate	shallow rock
3-1	r	+.61*	+.62*	+.16	Ring	Sandy and
	b	+.28	+.004	+.01	count	uniform
3-2	r	+.12	-	+.38	Esti-	Sandy and
	b	+.14	-	+.15	mate	uniform
4	r	+.23	-	+.04	Esti-	Dumped till over
	b	+.24	-	+.004	mate	shallow rock
5	r	+.32	-	+.26	Esti-	Dumped till over
	b	-.25	-	-.01	mate	shallow rock

[1](Diameter at b.h)^2 x height/crown diameter ^{2}x crown length.
*Significant at 10% level.

growth efficiency index calculated for the parent trees as breast height diameter squared times height - divided by crown diameter squared times crown length - gave nonsignificant positive and negative correlations with progeny height with no apparent pattern. The heritability (h^2) for 10-year height was .31 (Table 6), and is within the range of height heritabilities found for red pine in Wisconsin but may be slightly biased upward because of derivation from a single test site.

Most of the natural red pine stands on the Petawawa Forest Experiment Station originated from fires and were seeded from a few scattered seed trees. They appear to be very uniform in growth rate and form. Because of their extreme uniformity and the low priority of red pine breeding program, intensive plus-tree selection in these stands has not been undertaken. It is worth noting that on uniform sandy soils, but not on soils of shallow dumped till, the tallest parent trees also gave the tallest progenies. Thus the plus trees are to be found among the tallest trees in a stand and the search for plus trees should be confined to stands growing on uniform sandy soils. Both the positive correlation between parent-tree height and progeny height and the fairly high heritability ($h^2 = .31$) for 10-year-progeny height indicate that a combined plus-tree selection and progeny test should pay off in terms of increase in growth.

PROVENANCE HYBRIDS

Dr. D.P. Fowler's red pine population study containing selfings, within-stand and between-stand crosses (all crossed with Maine) were measured in the fall of 1970 when they were 9 years old from seed (Exp. No. 207-C). In another set of Dr. Fowler's provenance hybrids (Exp. No. 207-D) two northern Ontario provenances (Swastika and Lake Abitibi) were crossed with pollen from Minnesota, Wisconsin, Petawawa, New York, Maine and Pennsylvania and compared with open-pollinated single-tree progenies taken from the same trees at Swastika and Lake Abitibi. These were also measured in the fall of 1970, when they were 7 years old from seed. The results will be published in a paper jointly prepared with Dr. Fowler in these Proceedings (Part 2).

A nursery test (Exp. No. 305-B) with 3-year-old seedlings of red pine provenance hybrids was measured. The hybrids were made on seven trees located on Petawawa F.E.S. They were crossed with pollen mixtures from Petawawa F.E.S., Ont., Angus, Ont., and Trout Lake, Wis. The provenance hybrids were respectively 5% and 6% taller than the Petawawa control. As this test did not include controls of the Angus, Ont., and the Trout Lake, Wis., provenances, we could only compare the provenance hybrids with the Petawawa control.

In a 14-year-old field test the Petawawa x Rochester, N.Y., provenance hybrid was 11% taller than the Petawawa control and Petawawa x Massey, Ont., was 8% shorter than the Petawawa control. Also in this test the pollen parents were not included.

All of these tests were grown in one location only (Petawawa F.E.S.), which could be considered an intermediate habitat to which the Maine provenance was not adapted. When fast-growing hardy provenances from more continental climates were used, the provenance hybrids were taller than the Petawawa control. If this trend holds true, provenance hybridization would not only broaden the genetic base in red pine but could also increase yield.

RED AND BLACK SPRUCE GENETICS, PETAWAWA, 1971-72

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The genetics program at Petawawa dealing with red spruce (*Picea rubens* Sarg.) and black spruce (*Picea mariana* [Mill.] B.S.P.) progressed generally as planned during the review period, June 1971 - December 1972. The studies under way are of three types:

1. those having broad objectives (e.g., exploring various breeding alternatives, including such diverse methods as interspecific hybridization in the genus *Picea*), provenance studies in red spruce, and various progeny tests from controlled crosses and open pollination in black spruce, which were undertaken to develop theory but do not contribute to an applied breeding program (some of these experiments date back as much as 20 years);

2. those exploring geographic variation of eastern black spruce in studies initiated in 1963, based mainly upon the Lake Erie-James Bay transect; and

3. the range-wide black spruce study of 1967 that was jointly initiated by cooperators across Canada and in the northern United States and that offers opportunities for studies of geographic variation, the testing of open-pollinated progeny to obtain genetic parameters, and a variety of investigations in physiology, biochemistry and other disciplines.

In the first group of studies, a review of the older experiments was made and will be published. A paper on interprovenance hybridization (Morgenstern 1974) in black spruce will be presented at this meeting. Progeny tests initiated in 1970, included the greenhouse performance of the 7 x 7 diallel cross; the results of this performance have been analyzed, and a paper is in preparation. The material has been transferred to the nursery and will eventually be established in field experiments.

Early results from the eastern black spruce study have been given since 1966 in these Proceedings and in other publications (Morgenstern 1969). Recently an analysis was made of regional variation in the level of inbreeding and of the heritability of height growth. The inbreeding analysis showed that in black spruce populations of southern Ontario there was a lower percentage of filled seed, poorer germination, and a higher percentage of chlorophyll-deficient seedlings than in northern populations. That inbreeding was involved was confirmed by Wright's inbreeding coefficient, F, which was calculated from morphological, phenological and growth characters in greenhouse and nursery experiments (Morgenstern 1972). The heritability of height growth obtained at age 4 years on an individual-tree basis in a Petawawa nursery experiment on two sites was 0.18. This value is within the range determined for several other species when similar methods of analysis were applied. It is clear that the low heritability of height growth complicates selection and demands a very methodical approach, particularly when plus trees are selected in natural stands.

In the range-wide black spruce study, a nursery experiment was sown in 1970 at Petawawa with 100 provenances in six replications. Two replications suffered heavy mouse damage during the long winter of 1971-72 and were excluded from subsequent analyses. The characters measured during the first three growing seasons included height at ages 2 and 3, date of growth initiation at the beginning of the third growing season, and date of growth cessation at the end of the second and third growing season. The analysis of results from this experiment was begun. In spring of 1972 - i.e. at the beginning of the third growing season - one or two rows of seedlings in each replication of 74 provenances (that had not been marked for measurement) were lifted and transplanted to prepare stock for field planting in 1974. Five experiments are planned for Ontario that will be established in cooperation with the provincial Ministry of Natural Resources. Black spruce seed from the range-wide study and earlier collections was also sent to H. Barner in Denmark for distribution to European cooperators through the IUFRO Coordination Centre for the Procurement of Seed for Provenance Research.

An extension of the range-wide study is a series of progeny tests from open-pollinated trees in those regions of Ontario where black spruce is most important. Seed for the progeny test in Region 3E (Hills 1959) was sown in June 1971; it consisted of 100 progenies from eight stands. Considerable damage by cutworms (Order *Lepidoptera*, Family *Noctuidae*) occurred before it could be controlled and this necessitated a second sowing in 1972. This sowing was made in the greenhouse in April and included 37 additional, open-pollinated progenies from trees in the seedling seed orchard of Spruce Falls Power and Paper Co. Ltd. at Moonbeam, Ont. An 18-hour photoperiod and appropriate nutrition and temperature control in the greenhouse produced seedlings that were equal in size to those sown in the nursery the previous year. Both sets could then be transplanted to separate replications in the nursery in August 1972 to produce material for field planting. Seed for the Region 3W test will be sown in the spring of 1973. These progeny tests are an integral part of the federal-provincial research and breeding program discussed in 1972 by the Canada-Ontario Joint Forest Research Committee.

Cooperators in the range-wide study have remained in frequent contact to assist one another and exchange their experiences. Because the number of provenances is too large for inclusion in the experiments of a single cooperator, it was of interest to determine to what extent the provenances chosen by any cooperator overlapped with those of his neighbor. A survey in 1972 indicated that there is sufficient overlap, for example, among the experiments initiated in Newfoundland, the Maritime Provinces, and Quebec;

among those in Quebec, Ontario, and Wisconsin; and so on. Hence, there will be many opportunities for comparisons of the results and for joint analyses of the provenance-environment interaction.

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GROWTH ACCELERATION AND PHYSIOLOGICAL SCREENING OF SEEDLINGS FOR A TREE-IMPROVEMENT PROGRAM

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INTRODUCTION

There are two main objectives to the physiological studies being undertaken at Petawawa Forest Experiment Station (P.F.E.S.) in support of the tree improvement program. One is to devise a system of growing seedlings rapidly for use in genetic or physiological experiments. This system would complement the conventional nursery system by providing the researcher with experimental material in 2 to 3 months, rather than 2 to 3 years. The second objective is to develop a technique for an initial screening of superior genotypes at an early age by identifying the relevant physiological characters controlling genotypic variation in growth.

Both components of the study are aimed at improving the efficiency of the tree-improvement program by reducing the time element required by conventional tree-improvement methods. In addition to this practical application, the program contains potential for increasing our basic knowledge of tree growth. The investigations have been confined to two species: white spruce, *Picea glauca* (Moench) Voss and jack pine, *Pinus banksiana* Lamb.

GENERAL APPROACH TO PROBLEMS

The first objective has been met. A growth acceleration system for production of seedlings has been devised (Pollard 1971) and successfully demonstrated in growth cabinet, growth room and greenhouse. In this paper we describe some preliminary results obtained with the system in plastic greenhouse and nursery bed, and illustrate its use in genetic and silvicultural programs. It is being used on a regular basis for production of seedlings for physiological experiments, and we believe it has considerable potential in forest research.

Emphasis has now turned towards the second objective. We have had some success in screening jack pine provenances by measuring their photosynthetic efficiency in the fall. Although fast- and slow-growing provenances could be identified by this means, we found that throughout most of the growing season their photosynthetic rates were similar. White spruce provenances could not be screened by this method. These findings suggested that photosynthetic efficiency is not the most important parameter of growth for these two species. Attention is now directed towards the production of needle primordia as a parameter of growth. There is a strong correlation between needle initiation and subsequent growth. The bud, with its primordial shoot, determines the potential for extension growth of the following year; furthermore, the number of needle primordia strongly influences the subsequent photosynthetic capacity of the plant.

The phenology of jack pine has proved more difficult to manipulate than that of white spruce, and the development of its bud has been more difficult to assess because it is complicated by the presence of sterile cataphylls in which there is no axillary development of short shoots.

RESULTS

Investigations Related to Screening

Photosynthesis

In an earlier investigation of 10 jack pine provenances selected from a 7-year-old all-range provenance trial, differences in photosynthetic efficiency were found after September but not before. After September the fastest-growing provenances had the highest photosynthetic rates per gram of needle (Logan 1971). Similar results were obtained in two successive years by using seedlings from two different provenance trials. Subsequent studies confirmed the possibility of screening 1- and 2-year-old jack pine provenances by gas analysis. However, the smaller seedlings, raised in nursery seedbeds, posed a problem, for the technique and current investigations are aimed at increasing the efficiency of the system by the use of growth-accelerated seedlings. To date it has not been possible to demonstrate differences in the photosynthetic rate of jack pine provenances in controlled environments under a wide range of temperature-photoperiod conditions during periods of either accelerated growth or bud induction. One unusual finding was that short days stimulate the rate of photosynthesis (Logan 1973a), and further studies are in progress to investigate this phenomenon.

Induction of Quiescence

The maximum daylength and the minimum number of short days in which seedlings will form buds, and the influence of seedling age on the sensitivity of seedlings to bud-inducing conditions, have been briefly studied.

Under a twice-weekly reduction in photoperiod of 15 min, white spruce formed bud scales when the photoperiod had fallen from 16 hours to 11 hours. Only one provenance (Chalk River, seedlot no. 66-127) was studied, but seedlings differed in the maximum daylength for bud-induction by at least ½ hour. Magnesen (1969) has demonstrated provenance variation by a similar method for Norway spruce, *Picea abies* (L.) Karst.

Twelve-week-old white spruce seedlings were subjected to periods of 8-hour (short) days ranging from 1 to 20 days and then returned to 16-hour (long) days. No effect was noticed from treatments lasting 1 to 3 days; slight temporary reductions in height growth began with 4 days' treatment, the pause being noticeable about 3 weeks after the treatment. The reductions became more pronounced until, with 13 days, some seedlings set bud. This bud usually burst a few weeks later without chilling. With 20 days of short-day treatment, all seedlings set terminal buds that could be broken only by chilling.

Younger seedlings of white spruce were less sensitive to a 14-day short-day treatment than older seedlings: when treated at age 4 weeks, all seedlings resumed normal growth on their return to long days. At 8 weeks, fewer than half resumed growth at the shoot apex, while the remainder developed a new leader from a lateral bud. At 12 weeks, most seedlings resumed growth from lateral buds, and a few became dormant. By 16 weeks, only half were able to flush from lateral buds, while the others became quite dormant. These results reflect the increasing difficulty of keeping spruce seedlings in an active (indeterminate) state of growth, especially in nurseries.

Needle Initiation

Experiments into the control of needle initiation have included the endogenous factors associated with seedling size and bud position, and certain environmental factors associated with natural growing seasons.

The size and age of spruce seedlings had a profound effect on both needle initiation and subsequent growth. After 10 weeks of short days, seedlings which were 6 weeks old and, on the average, 5 cm tall at start of treatment developed about 125 needles and grew 5 cm; 10-week-old seedlings, 8 cm tall, produced 200 needles and grew 7 cm. At 16 weeks, the seedlings were 16 cm tall, produced about 275 needles and grew 10.5 cm. The gains in both needle initiation and height increment diminished with increasing size and age, and the results suggested that seedlings taller than about 25 cm would not show an increase in the rate of initiation and in subsequent height growth.

The position of buds on 11-year-old white spruce strongly influenced the rate of bud development. Initiation of needle primordia in terminal buds of the leader and of the four most recent primary whorls of branches continued from mid-July (or earlier) until mid-September. Throughout this period, rates of initiation reflected bud position so that by mid-September the leader had accumulated 630 initials, and the branches had accumulated 435, 400, 340 and 270 initials in the first, second, third and fourth whorls respectively. Only in the leader was further development indicated, with 710 needles recorded in early October.

The seasonal patterns of initiation in 11-year-old white spruce were examined in relation to the selection value of various provenances. Rates of needle initiation in lateral-branch terminal buds averaged about seven primordia per day between mid-May and mid-September in the 10 provenances studied. Significant variation among the provenances was not apparent until late September; a correlation then emerged between accumulated primordia and height growth. The correlation became increasingly strong in October. Slower-growing provenances did not significantly increase their primordia after September.

Applications of Growth Acceleration

A progeny trial of 17 selected parent trees from the notable Beachburg (Ont.) provenance of white spruce was conducted in the first application of the existing system for growth acceleration (Pollard and Teich 1972). Progenies attained a mean height of 22 cm in 25 weeks from sowing, the two best progenies exceeding this mean by 22%. The seedlings were hardened, overwintered outside, and transplanted directly into a field trial the following spring.

During winter 1972-73, about 25,000 seedlings were reared in an acceleration system employing BC/CFS Styroblocks. White spruce seedlings were urgently needed for replanting part of a silvicultural research area at P.F.E.S. Because of the extent of the plantation, which included two seed orchards, seedlings of known genetic origins were specified. A total of 37 different seed sources was represented in seedlings raised in two series. After hardening in short days, seedlings will be chilled and planted directly in the cutover area in the early summer of 1973. Production of another 75,000 seedlings will follow if this scheme is successful.

A small experiment examined the effects of the delayed release of white spruce seedlings from cold storage into a nursery in spring. Setbacks occurred when cold storage was continued after mid-June, and were evident in the year of release and in the following 2 years.

Seedlings used in many of our experiments are raised in the growth-acceleration system in BC/CFS Styroblocks and then transplanted into plastic pots for further experimentation. A study of the effect of age at the time of transplanting on subsequent height growth showed that white spruce seedlings could be transplanted any time between 3 and 13 weeks after germination without affecting height growth in the same season. However, if seedlings were kept in the Styroblocks beyond age 13 weeks, their height growth declined slightly (Logan 1973b).

The growth-acceleration system developed at P.F.E.S. has been designed for use in growth cabinet, growth rooms and conventional greenhouses. In 1972 the system was tested in areas having much less environmental control. These included a plastic greenhouse, with either a plastic roof or plastic walls, or with both roof and walls, and a fully exposed nursery bed. At the end of the summer, white spruce and jack pine in the fully enclosed plastic greenhouse were taller and heavier than those grown in all other treatments. However, the results may have been influenced by a late spring frost, which no doubt had the least effect on seedlings in the plastic greenhouse. In comparison with conventional nursery-grown seedlings of the same age, white spruce were the same height but 3 to 4 times heavier in dry weight, and jack pine were 1.5 to 2 times taller and 8 to 12 times heavier.

CONCLUSION AND FUTURE PROGRAM

While the growth-acceleration system is being continually modified to suit particular applications, little developmental research is envisaged for this study in the future.

The next 12 months will see intensive investigation of the endogenous and environmental factors of bud development. Principles of phenological control currently studied in white spruce will be applied to the IUFRO collection of Sitka spruce (*Picea sitchensis* [Bong.] Carr.) in an effort to predict performance of these provenances.

We have a special collection of Yukon provenances, gathered in collaboration with A.H. Teich in 1972. Genetic variability will be compared both quantitatively and qualitatively with that of provenances from eastern Canada; biochemical assays may be used in these tests.

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THE GENETIC IMPROVEMENT OF WHITE SPRUCE, PETAWAWA, 1972-73

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INTRODUCTION

Current tactics for the improvement of white spruce (*Picea glauca* [Moench] Voss) are exploration of the genetic resource, testing provenance collections, and application of results from both proven and promising materials. The past 2 years have seen important developments in all three.

EXPLORATION OF THE GENETIC RESOURCE

Existing trials involve many provenances from Ontario, Quebec, and other parts of North America (Teich 1972c). While these large areas have been only thinly sampled, certain patterns of variation are emerging; in particular, fast growth seems to characterize provenances from southeastern Ontario and the St. Lawrence Valley in Quebec.

Representation of western and northern parts of Canada has been too meager to permit evaluation of that vast segment of the white spruce resource. An area of particular interest has been the Yukon Territory, for it was in the unglaciated region near the Alaska border that western elements of white spruce probably survived the last ice age. As a centre of survival for the species in the northwest, the Yukon may hold a large genetic potential, especially as the variety of terrain in the Territory has provided a suitable environment for expression and preservation of this resource.

A seed-collecting excursion was made in 1972 along a 1,300-mile round route from Whitehorse, through Haines Junction, Beaver Creek, Dawson City, Mayo and Carmacks. Eight provenances were each represented by five single-tree collections at two sites. In addition, two elevational transects were run to the tree limit, and collections were made in and around a site of suspected introgression with Sitka spruce *Picea sitchensis* (Bong.) Carr.

The genetic diversity of the Yukon collection will be compared with diversity displayed in eastern Canada. During the excursion, several bark types were noted, and the crowns were usually much narrower than those seen in the east. Of special interest was the great range of habitats tolerated by this species.

TESTS OF SEED COLLECTIONS

The 15- and 20-year measurements, respectively, in the Great Lakes - St. Lawrence Forest Region provenance experiments, nos. 194 and 93, are due to be taken in 1973, and the results will be fully described in the next report. However, the continuing excellence of the Cobourg (Peterborough, Ont.) provenance, and an improving rank of the Swastika (Ont.) provenance were evident in 1972 from a special study of flowering in these experiments at the Petawawa Forest Experiment Station.

A few provenances flowered at several locations in 1972, and cones from the previous year (11 years from seed) were also seen (Teich and Pollard 1973) (Table 1). The flowering provenances were from Winchester (Ont.) (2,442) and Grandes-Piles (near Grand'Mère, Que.) (2,447). These provenances were also among the tallest in the experiments; within provenances, flowering trees were taller than nonflowering (P = 0.001). Other tall provenances did not show marked precocity.

A trial of northern provenances at Chalk River (Expt. 218F1, -2, -3) was measured after 10 years from seed (Teich 1973). The most northerly provenances flushed early and were damaged by late frost. Frost damage to the leader resulted in a bushy habit. The three tallest provenances, from Kapuskasing, Moosonee and Chalk River (experimental control) did not differ significantly in height. Moosonee also had the second highest survival; the Pagwachuan Lake (Ont.) provenance had higher survival but was also the shortest.

A progeny test of 17 Beachburg plus trees, carried out under conditions for accelerated growth (frequent feeding with nutrient solutions, long days), resulted in an average height of 22 cm at 25 weeks from seed. The two tallest progenies attained 26.7 cm, being 22% taller than average (Pollard and Teich 1972). There was only a small correlation (0.16) between seed weight and seedling height. Seedlings were overwintered outside, and were winter-hardy. They have been planted in a field trial after only 1 year from sowing instead of the usual 4 years.

A progeny test of 12 Chalk River plus trees in a field trial was measured for height and diameter after 22 growing seasons (Teich and Khalil 1973). Progenies that had been tallest after 11 growing seasons were still the tallest after 22 growing seasons, and they also had the largest diameters. Selection after 11 growing seasons would have resulted in the select population having 80% more volume than the original experimental population at 22 years of age.

APPLICATION OF RESULTS

Selections from the precocious and other rapid-growing provenances in Expt. 194 D-1 at Petawawa Forest Experiment Station were crossed to Petawawa plus trees in 1972. The female flowers had not been bagged prior

TABLE 1. FREQUENCY OF TREES WITH CONES IN 1972 AND MEAN HEIGHTS* IN FOUR PROVENANCE TRIALS

Location	Owen Sound, Ont.		North Pond, Nfld.		Chalk River, Ont.		Chalk River, Ont.	
Experiment No.	194 E		194 V		194 D-1		194 M	
	With cones %, 1972	Mean height cm - 1969	With cones %, 1972	Mean height cm - 1969	With cones %, 1972	Mean height cm - 1969	With cones %, 1972	Mean height cm - 1969
Provenance								
2,442	67	64	not included		not included		33	78
2,447	17	47	4	108	20	133	10	87
Tallest provenance	67	64	4	108	6	135	10	87
Experimental mean	12	51	1	92	4	116	1	72

*Last complete height measurements in 1969.

to pollination, but there was little white spruce pollen available from the wind (cones collected from trees not artifically pollinated yielded little seed). Two seedling seed orchards were designed, one incorporating this seed and seed from Beachburg progeny-tested plus trees (Pollard and Teich 1972) (southern orchard, 9 acres), and the second having precocious Swastika selections and Swastika plus trees (northern orchard, 2 acres) collected by D. Skeates (Ontario Ministry of Natural Resources).

These two seed orchards were established from seedlings reared in the growth-acceleration system used in earlier work (Pollard and Teich 1972). Seedlings were reared in BC/CFS Styroblock containers for about 15 weeks, hardened in 8-hour photoperiods, and chilled for 5 weeks before planting.

A grafted seed orchard of clones from Cobourg, Beachburg and Douglas, initiated in 1969, was expanded with 10 ramets from 50 clones of precocious and nonprecocious rapid-growing provenances and progeny-tested ortets.

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FOREST TREE SEED UNIT, PETAWAWA, 1971-72

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Since the last progress report the Seed Unit has continued with its dual functions of service and research on seed problems. With the increasing number and complexity of requests for information, seed, seed-processing and testing services, and for research in seed-quality control and testing standards, the workload of the Unit has more than doubled since its establishement in 1967.

INFORMATION SERVICE AND SEED DISTRIBUTION

The establishment of an information file and a worldwide network of contacts has facilitated seed procurement and distribution as well as making available other information on tree seed at short notice. During 1971-72, 70 requests for information and for seed were received from 14 countries and Canada, in response to which 300 seedlots of 47 species were provided. In particular, further distribution of *Pinus sylvestris* L. seed of three U.S.S.R. provenances (Woronesh, Orlovsk and Kiev) was made to the Forestry Branch of the Saskatchewan Department of Natural Resources at Prince Albert and to the Northern Forest Research Centre at Edmonton. Some seed of these provenances remains and is available for interested researchers or forest managers.

Although most enquiries from abroad have concerned seeds of western tree species, some correspondents were interested in seed of eastern Canadian tree species such as *Pinus strobus* L., *Pinus resinosa* Ait., *Picea glauca* (Moench) Voss, *Picea mariana* B.S.P., *Acer saccharum* Marsh. and *Thuja occidentalis* L.

The 1961 FAO seed directory is being revised; the new directory will be greatly simplified by listing only species and countries from which seed of a given species is available. The Seed Unit has submitted a list of seed of 33 species for listing in the new directory.

SEED COLLECTION AND PROCUREMENT

In 1972 the seed crops were generally poor for most tree species throughout the country, and most of that year's seed collections were small.

Locally, *Pinus strobus* produced a fair seed crop while *Picea glauca* trees showed fair fruiting early in the summer, but by late July cones of many trees had fallen to the ground owing to the spruce budworm infestation. Approximately 50 bushels of cones of bulk and single trees of *Pinus strobus* were collected from a cutting area near P.F.E.S. In addition to the local collections, a total of 22 bushels of *Picea sitchensis* (Bong.) Carr., *Pinus contorta* Dougl., *Thuja plicata* Donn and *Tsuga heterophylla* (Raf.) Sarg. cones was procured from British Columbia.

The IUFRO working party on poplar provenances, chaired by Dr. Robert Koster of the Forest Research Station at Wageningen, Holland, is planning to collect *Populus trichocarpa* Torr. & Gray seed of 67 provenances from British Columbia, Washington and Oregon. The Pacific Forest Research Centre of the Canadian Forestry Service has offered to cover the collections in British Columbia.

To meet requests received from within Canada, seedlots of *Picea abies* (L) Karst., *Picea jezoensis* (Sieb. & Zucc.) Carr., *Picea sitchensis*, *Tsuga mertensiana* (Bong.) Carr., *Pinus sylvestris* and *Abies veitchii* Lindl. were purchased or obtained in exchange from Denmark, Sweden, Estonia, Iceland and Japan. To fill requests from abroad, many seedlots of various species were kindly collected or supplied by the British Columbia Forest Service, the Quebec Department of Lands and Forests, and Research Centres of the Canadian Forestry Service.

The up-to-date inventory of seed stocked in the seed bank consists of 61 tree species including 375 provenances and 1,040 seedlots. A new list of seed available from the seed bank will be published in 1973.

SEED EXTRACTION

During 1972 the seed extraction plant processed a total of 600 lots of seed of various coniferous and hardwood species. Service extraction included 30 bushels of cones of western Canadian tree species for the Icelandic Forest Service and 197 lots of single-tree collections of *Picea glauca* cones for a cooperative project with the Ontario Ministry of Natural Resources, the Grest Lakes Forest Research Centre and the Petawawa Forest Experiment Station. The cone shed was enlarged to provide space for storing and air-drying an additional 60 to 80 bushels of cones.

Although soaking of cones and additional kiln-drying had the effect of increasing the seed yield of *Pinus resinosa* and *Picea mariana*, this effect was not so pronounced in *Pinus banksiana* Lamb (3 to 13% of the total seed yield from second kiln-drying). Loboratory germination tests revealed that seeds of some *Pinus banksiana* lots extracted from the second and third kiln-drying not only germinated more slowly but had a reduction of germinability of 15 to 59% and an increase in abnormal germination of 5 to 45% as compared with the seeds from the first kiln-drying (Wang 1973).

SEED DE-WINGING

Most coniferous seeds are not difficult to de-wing. However, the de-winging of *Abies* seed is always a problem owing to the thin seed coat and its high resin content. Although separating empty seeds from filled seeds in *Abies* is difficult, seed quality can be improved when seeds are de-winged.

A preliminary test of a de-winging technique with one lot of *Abies balsamea* (L.) Mill. seed of Newfoundland origin was successful. After cleaning, the winged seed was stored in a cold room (1 to 2°C) overnight and then rubbed gently by hand in a cotton bag immediately after its removal from cold storage. A comparison of the quality of de-winged and winged *Abies balsamea* seed is given in Table 1.

TABLE 1. COMPARISON OF SEED QUALITY OF DE-WINGED AND WINGED *ABIES BALSAMEA* SEED OF NEWFOUNDLAND ORIGIN BY X-RADIOGRAPHY

Treatment	Sample no.	% of filled seeds	Germinability (%)[1]
De-winged	1	85.0	74.0
	2	85.0	83.0
	3	85.0	84.0
	4	84.0	81.0
	Average	84.8	80.5
Winged	1	72.0	67.0
	2	65.0	64.0
	3	74.0	70.0
	4	67.0	61.0
	Average	69.5	65.5

[1]Seed was prechilled in moist Kimpak paper cellulose for 4 weeks at 1 to 3°C and germinated at 20 to 30°C alternating temperature with 8-hour photoperiod. Germinability was calculated at end of 4 weeks with radicle emergence to fully developed seedling as criterion.

SEED STORAGE

Preliminary results from some long-term storage studies and tests of old stored seeds have shown that most coniferous and small hardwood seeds can be stored safely in airtight containers at 1 to 2°C for 10 to 25 years when the moisture content is reduced to less than 8% of fresh weight. Two *Pinus banksiana* seedlots tested in 1972 showed 70% and 84% germination respectively after storage in airtight glass jars for 21 and 19 years at 1 to 2°C (Wang 1974). There was no loss of germination in *Picea glauca* and *Pinus strobus* seed after 6 to 7 years or of *Picea rubens* after 16 years' storage at 1 to 2°C. Seed of *Populus grandidentata*, *P. tremuloides* and *P. deltoides* var. *occidentalis* Rydb. ratained their original germinability after storing at -18°C for 4 to 6 years (Wang 1973). A review of tree seed storage has been completed and will be published by the Department in 1974.

SEED-TESTING AND RESEARCH

Although only 10 service tests were performed in 1972, routine testing of stored seed is still far behind schedule owing to a shortage of assistance. Keen interest has been expressed by foresters of several provinces in establishing standards for testing Canadian native tree seed.

The Unit participated in a referee testing of *Fagus sylvatica* L. seed sponsored by the Forest Seed Committee of the International Seed Testing Association. A consensus was reached from the results of the eight participating laboratories around the world, but there was much variation among individual laboratories. The referee system is used to verify proposed new methods of seed-testing. The currently recognized rules for testing tree seed prescribed by the International Seed Testing Association (1966) and the Association of Official Seed Analysts (1970) are revised from time to time.

Dormancy of *Picea glauca* seed was further studied. Forty-six percent of the 48 seedlots tested showed a definite requirement for stratification (or prechilling) for maximum germination. This was especially true with seed of local provenances. Work on this subject is in progress.

Although stratification treatment is recommended for nursery or field sowing of *Picea glauca* and *P. mariana* seed (U.S. Department of Agriculture 1948), many nurseries do not comply. A nursery test of the stratification effect on field performance of *Picea glauca*, *Picea mariana* and *Pinus strobus* indicated that stratified seed of 80% of all the seedlots tested had two to five times more germination than the unstratified seed. The test results suggest that 4 weeks stratification treatment not only will prepare the seeds of *Picea glauca*, *Picea mariana* and *Pinus strobus* for rapid and more nearly complete germination but will result in greater uniformity in seedling development.

Earlier results of testing large hardwood seed by X-radiography were encouraging, but a large-scale follow-up study with *Juglana nigra* L. nuts was not successful, because of the thick shell of the nuts. A further study of these nuts with the X-ray contrast technique is planned.

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JACK PINE GENETICS, PETAWAWA, 1972-73

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Work on jack pine during the period under review included observations of injury in northern all-range provenance tests; selection and propagation of plus and minus phenotypes for testing, demonstration and breeding; a survey of disease in lodgepole pine and its hybrids with jack pine planted in eastern Canada; and the creation of provenance hybrids in cooperation with the U.S. Forest Service. Fruitful discussions were held with provincial forest services responsible for seed production and improvement.

PROVENANCE STUDIES

Evidence of winter injury to conifers was prevalent in eastern Ontario in the spring of 1972. The opportunity was taken to survey cold and pest injury to jack pine provenances planted in northern Ontario and Quebec (Exp. No. 255-E). Substantial loss of foliage and some bud injury occurred within provenances from mild climates, southern and maritime, when planted in boreal environments. At the Lakehead, western Ontario, browsing by hares and deer was severe on trees from the Lake States to the Maritimes, apparently associated with late maturity and relative succulence in the late growing season and fall. Infestations by pitch nodule maker (*Petrova albicapitana* [Busck]) and infection with Armillaria root rot (*Armillaria mellea* [Vahl ex Fr.] Kummer) appeared to be random within tests but occurred with higher frequency at some locations than at others.

Scleroderris canker (*Gremmeniella abietina* [Lagerb.] Morelet) was recorded at three test locations - near Caramat and Fraserdale in northern Onatrio, and near Clova in northwestern Quebec. Fewer-than-average infections occurred within a number of northeastern provenances from Quebec, New Brunswick and Nova Scotia, a result consistent with earlier observations in nursery tests (Teich and Smerlis, 1969). Higher-than-average susceptibility occurred in many southern provenances ranging from the Ottawa Valley to Kenora. At the Clova site, for example, infection levels among these provenances ranged from 37 to 50% in contrast to levels of 3 to 12% within near-local and eastern provenances. Commonly, important differences in mean height, winter injury and incidence of scleroderris canker occur between adjacent provenances from the same climatic region or forest section. All 12 range-wide tests planted in eastern Canada are to be assessed in 1973 at age 10 years from sowing.

SINGLE-TREE SELECTION

Consistency of form and disease occurrence within, and differences between, jack pine clones planted on two sites at Petawawa Forest Experiment Station (Petawawa F.E.S.) provide evidence of strong expression of genetic differences between individual trees. In the winter 1971-72 some 20 jack pine trees were selected in natural stands and plantations for plus and minus characteristics of form, budworm injury (*Choristoneura pinus pinus* Freeman) and rust infection (*Endocronartium harknessii* [J.P. Moore] Y. Hiratsuka, and *Cronartium comptoniae* Arth.) (Exp. No. 392). Grafted clones of these trees will provide material for demonstration and studies of broad- and narrow-sense heritability. Seed was also collected for comparisons among the open-pollinated progenies.

In the fall of 1972 a program of plus tree selection was initiated in the region of the Upper Ottawa, Petawawa, and Madawaska valleys (Exp. No. 391). Contrasting good and poor phenotypes were selected from eight stands (4 plus, 4 minus per stand), with primary emphasis placed on stem form and branch angle. The plus trees were all in the dominant crown class and above average in height. The grafts are to be planted in a spacing trial to determine the effects of form and spacing on wood production, and thus the gain to be expected by genetic improvement. The clones will also be planted in an arboretum for demonstration and breeding. Families derived from open-pollinated seed will be used to estimate breeding values (general combining ability) of the selected trees by planting them in progeny tests at normal spacing on typical jack pine sites. A seedling seed orchard will be established to study design, techniques, costs and seed production.

Assistance was given to M.A. Chaudhry in selecting and propagating plus trees from the Swastika District of the Ontario Ministry of Natural Resources (Exp. No. 393). Scions were grafted at Petawawa and will be returned to Swastika for planting in a clone test. Seed from open-pollinated cones was extracted by the Petawawa Seed Unit and will be used for progeny tests in the area of origin.

PROVENANCE HYBRIDS

Control pollinations were made in 1971 and 1972 within and among six jack pine provenances distributed from Nova Scotia to the Northwest Territories (Exp. No. 390). This work is part of a cooperative investigation with the Institute of Forest Genetics, Rhinelander, Wis., to determine modes of inheritance of quantitative characters associated with geographic origin. Conelet abortion limited the number of cones to reach maturity, and the yield of filled seed varied widely from a few to more than 30 seed per cone but ranged more commonly between 10 and 20 seed per cone. Some pollinations will be repeated in 1973.

LODGEPOLE PINE IN EASTERN CANADA

A survey in 1971 of 10- to 15-year-old plantations of lodgepole pine (*Pinus contorta* var. *latifolia Engelm.*), jack pine and their hybrids, originating both as seedlings and grafts, confirmed the total lack of resistance of lodgepole pine to sweetfern blister rust when grown on typical jack pine sites at Petawawa F.E.S. Severe infection and low survival due to this disease were evident among lodgepole x jack pine hybrids. In 1972 an assessment of all known plantings of lodgepole pine in Ontario and Quebec confirmed the high susceptibility of this species and its hybrids with jack pine to sweetfern blister rust. Because of the danger of introducing deleterious genes into native jack pine, it is recommended that the introduction of lodgepole pine into eastern Canada cease.

GENERAL

Interest in applied genetics is increasing as evidence accumulates of the opportunities to improve jack pine seed used in forestation. Consultations were held with representatives of forest industry and provincial forest services in Quebec and Ontario concerning the control of jack pine seed collection and distribution and the development of breeding programs.

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TREE IMPROVEMENT IN THE NORTHERN REGION, 1971-73

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JACK PINE BREEDING PROGRAM

Eastern District Family Test and Seedling Seed Orchard

A test of open-pollinated families for eastern Manitoba was planted in the spring of 1972. The test involves plantations on four sites, with 15 replicates, 216 entries and nearly 13,000 plot trees. Selection of superior genotypes based on test results may be exercised among the planted trees themselves, as well as among the parent genotypes; hence the designation "family test" rather than "progeny test".

The statistical design for the test is cubic lattice. This design, in common with other incomplete block designs, affords more effective removal of site variation from error than does random block design. Part of the price for this extra precision is that extra work must be done before planting to ensure correct arrangement of the families in the plantation. In this instance, where planting stock was bare-root, a six-man crew spent about three calendar days on labelling and packing the seedlings after lifting was completed. Furthermore, about one man-month during the winter was devoted to design construction, label-marking and arrangement of labels. The actual planting operation was, however, no more complicated than the planting of a randomized-block experiment. When both genetic variation and site variation become manifest in plantation performance, it will be possible to judge whether the extra effort required for the use of this design is justified by the results.

An establishment report has been prepared for the test and includes a description of all phases of test establishement, source data for all families in the test, site location maps, and plot layout diagram-maps for all replicates.

A seedling seed orchard using largely the same set of families was also planted in 1972. That plantation has about 4,500 plot trees on three-fourths of an acre. A report on the seedling seed orchard will be included in the Technical Session of this meeting.

Stock Production for Further Family Tests

In the current stock-production activity for the western breeding district family test (central Saskatchewan to eastern Alberta), Spencer-

Lemaire fold-up plugs having a capacity of about 30 cubic inches are employed. Seedlings produced in containers such as these can be completely arranged for planting without disturbing the seedlings. Sowing was in progress when this report was prepared. A sowing of the western district families at Big River, Sask., reported to the 1971 meeting of the Committee, was not successful.

Parent Tree Selection Grafting

Collection of breeding materials for this program was completed in December 1971, when parent trees were selected in eastern Saskatchewan. Grafted ramets of parent trees selected in the central and western breeding districts have been planted in a temporary clone bank in Alberta. Source documentation for all parent trees in the program has been completed and distributed to cooperators.

In April 1973, scions were collected from primary ramets of eastern breeding district parents growing a Birds Hill Research Nursery near Winnipeg, Man., and were grafted at the Northern Forest Research Centre. Most of the secondary ramets obtained will be planted in a permanent clone bank being prepared this summer at the research nursery. This clone bank will eventually contain ramets of all surviving parental clones represented in the eastern district family test, plus ramets of the best seedlings in the test for all other families. I hope to establish district clone banks for the central and western breeding districts as well, plus a general clone bank near the Northern Forest Research Centre, but there has been only preliminary exploration in respect of these.

PROVENANCE EXPERIMENTS

About a decade after initiation of the cooperative study, plantations of the All-Range Jack Pine Provenance Experiment have been established in western Canada. A 5-replicate plantation of 3 + 0 stock was planted in southeastern Manitoba, and a 10-replicate plantation of 2 + 0 stock in north central Saskatchewan. Both plantations are in lattice square design with 81 populations and four-tree row plots, and both were planted in the spring of 1972. A procedure analogous to that for the breeding program's family test was followed in labelling and packing the seedlings. An establishment report is in preparation.

The Northern Region is participating in the Cooperative Black Spruce Geographic Variation Study. Seedlings for nursery measurements and field planting are being grown at the Provincial Tree Nursery near Edmonton.

OTHER ACTIVITIES

Forestry agencies of the three prairie provinces have expressed interest in an improvement program for white spruce. Two complementary study proposals for such a program were prepared, but tangible activity will probably be delayed until plantation establishment for the jack pine breeding program has been completed.

North Western Pulp and Power Limited, of Hinton, Alta., requested consultative assistance to enable them to carry out an improvement program, mainly with lodgepole pine, for reforestation on their timber-lease area. A program proposal was accordingly submitted to them in September 1972. The principal initial effort proposed is establishment of test plantations designed to identify genetically superior stands as well as superior families or parental genotypes. Intensity of parent-tree selection is to be decided on the basis of a pilot trial on the relation of phenotypic selection cost per candidate to selection differential achieved. Test plantation establishment is to be spread over several years, so that the number of families planted in any year will not place an unreasonable burden on available resources.

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GENECOLOGY OF 39 PROVENANCES AND 545 SINGLE-TREE PROGENIES OF THE 1970 IUFRO SITKA SPRUCE COLLECTION

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A report was presented at the 13th meeting of the Committee on Forest Tree Breeding, giving the origin, geographical coordinates of the material studied and some results of a cone and seed morphological study (Falkenhagen 1971).

A total of 545 single-tree progenies of Sitka spruce, grouped into 39 provenances, were sown in April 1971 in a randomized complete-block design with four replications and 24 seedlings per replication, or 96 seedlings per progeny. The seeds were sown in styro-blocks at the new British Columbia Forest Service nursery at Surrey, by the method recently developed by the Pacific Forest Research Centre in cooperation with the British Columbia Forest Service.

Germination rate, bud set, length of epicotyl and survival after the first growing season were assessed in 1971. The seedlings were transplanted at 6 x 6-inch spacing in plain soil seedbeds in May 1972, each progeny being kept separate and having the same statistical design as in 1971. The seedling characteristics so far studied indicate a general pattern of clinal variation in bud burst, bud set, color of the needles and epicotyl length at the end of the first year. Bud burst was negatively correlated with longitude ($r = -0.50$). Bud set appeared to be under strict genetic control as attested by the second estimation of this character at the end of the second growing season (with latitude : $r^2 = 0.77$). Latitude and altitude of the place of origin of the provenances explained 65% of the total variation in epicotyl length. Total stem height after the second growing season is being measured. Variation in foliar macro- and micronutrients of 10 provenances is at present under investigation. Seed characteristics are being used to compare multivariate statistical classifications of the provenances. Some indications as to the best available method to be used have been obtained already.

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FOREST GENETICS AND TREE BREEDING AT THE FACULTY OF FORESTRY, UNIVERSITY OF BRITISH COLUMBIA

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ACADEMIC PROGRAM

Undergraduate

The forest genetics course was taken by 18 students during the spring term of 1971-72 and by 17 students during the fall term of 1972-73. The change in the terms was implemented only for 1972-73, to allow the instructor to begin his leave of absence from January 1, 1973.

Graduate

R. Ho defended his Ph.D. thesis, "Studies on Pollen of Selected Species in Pinaceae", in April 1972. At present he is working as NRC Post-doctorate Fellow at the Department of Botany, University of Victoria.

M.D. Meagher is still in the process of finishing his Ph.D. thesis.

H.G.D. Marshall successfully passed the Ph.D. comprehensive examination and submitted the first draft of his thesis, "Examination of Selection Criteria for the Genetic Improvement of Coastal Douglas-fir in British Columbia." He is now on a CIDA program in Ceylon.

E.R.A. Falkenhagen completed the comprehensive examination in October 1972. His report is submitted separately to the Committee on Forest Tree Breeding in Canada.

J.L.A. Berney's M.F. thesis, "Studies on the Probable Origin of Some European Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) Plantations", was accepted in December 1972.

RESEARCH PROGRAM

Research is concentrated mainly on studies related to intraspecific variation in nuclear characteristics and DNA content of Douglas-fir. With the assistance of Dr. El-Lakany, these characteristics were investigated on 51 provenances collected by IUFRO Section 22 in 1966 and 1968.

Selection of *Pinus contorta* var. *latifolia* for Stora Kopparberg, Falun, Sweden, was carried out between latitudes 54°N and 56°N in the interior of British Columbia. A total of 105 individual plus trees was registered and 75 of them are included in the tree breeding program of Stora Kopparberg and B.C. Forest Service.

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TREE IMPROVEMENT IN COASTAL DOUGLAS-FIR BY THE B.C. FOREST SERVICE

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Since the last progress report, the emphasis of the British Columbia Forest Service tree improvement program for coastal Douglas-fir has been placed on consolidating the breeding materials that have been accumulated and reappraising goals and approaches. The clones of the registered plus trees have been established on the Cowichan Lake Forest Experiment Station, and reproductive buds are starting to appear. In 1971, for example, a controlled pollination program involving 8,000 female strobili from 83 clones was possible.

While the first level of B.C. Forest Service seed orchards is in process of establishment to meet short-term seed requirements, a long-term breeding program making use of the accumulated materials is also needed. The B.C. Forest Service's responsibilities continue to change, and since 1968 changes in the intensity of approach and in the choice of breeding methods within the tree improvement program have also evolved. Early results of Dr. Orr-Ewing's research are becoming available to provide more positive guidance in selecting the most efficient approach. Several breeding alternatives have been discussed, ranging from subjective selection in the F_1 generation of crosses made with plus trees to a balanced factorial progeny test. Considerable experience has been gained, but by 1972 it had become clear to the Forester i/c Research that more specialized services in the field of quantitative genetics were needed. Dr. Gene Namkoong of the U.S. Forest Service came, under contract, to fulfill this need by examining the present program of the Division and discussing the options available for the future. These program options are still under consideration, but as the objectives of breed production, estimation of genetic parameters and testing of genotypes can all be met by some form of partial diallel mating design, it is likely that a recurrent selection program using this mating design will be adopted as part of the long-range approach. Although limited cone and pollen production occurred in 1973, a start was made on this program and 120 crosses have been attempted.

The seed orchards of the B.C. Forest Service are being established by the Reforestation Division and are under the direction of M. Meagher, who is now an Active Member and will submit his own report.

On a personal note, leave of absence was granted to complete a Masters' degree at the University of Victoria, and the following publication resulted from the thesis.

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LODGEPOLE PINE GENETICS, BRITISH COLUMBIA, 1971-73

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The lodgepole pine improvement program in British Columbia comprises: (1) studies of genetic variation in wild and cultivated population samples; (2) selection and propagation of plus phenotypes for breeding through simple recurrent selection. Objectives, methods and some preliminary results have been detailed in previous reports to this Committee.

PROVENANCE RESEARCH

Nursery Studies

Data analyses of growth behavior and morphological traits were continued for a range-wide collection of provenances studied in two nurseries.

A similar set of provenances is being grown for field tests. Sown in three randomised blocks at Red Rock nursery (central interior) in 1971, they provided further opportunities for observing geographic variation at the seedling stage. The first occurrence of Sirococcus shoot blight (*Sirococcus strobilinus* Preuss) in a British Columbia nursery and on lodgepole pine in North America was recorded on these provenances in 1971. The greatest disease incidence occurred among provenances from the southern interior wet belt (Columbia Forest Zone) and from the Cascade and Sierra ranges. Genetically based geographic variation in the susceptibility of lodgepole pine to this disease was inferred (Illingworth 1973).

During the winter of 1972-73, the failure of snow to provide young plants with their customary protection against low temperatures resulted in extensive damage to many species in British Columbia nurseries. However, these conditions also afforded an opportunity to observe frost injury among lodgepole pine provenances in nursery and field tests, permitting an early screening of many coastal provenances from potential use in the central interior. Among 2-year seedlings in an all-range test of lodgepole pine at Red Rock nursery, coastal provenances suffered extensively. Variation was clinal, being negatively correlated with latitude (Figure 1), and ranged from 100% (California coast) to nil (Alaska coast, Queen Charlotte Islands). Provenances from the outer coast were less damaged than those from the inner coast (fjords, east Vancouver Island, lower mainland). Injury to provenances from east of the coast ranges consisted only of slight needleburn on a few provenances from south of 50°N, notably on those from the Columbia Forest Zone. Five-year-old trees in test plantations showed a similar pattern of injury, and a Queen Charlotte Island provenance also suffered slightly.

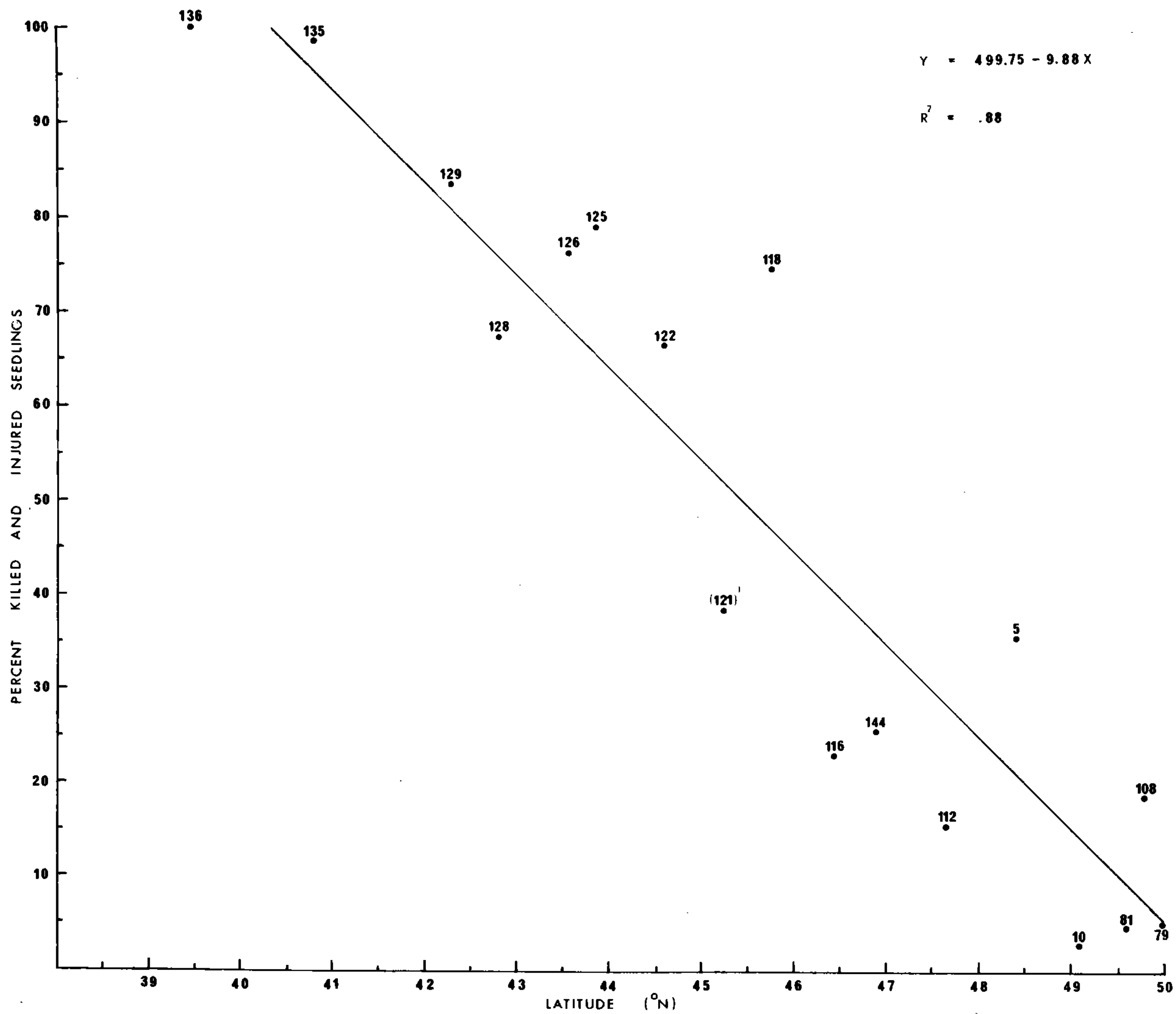

Figure 1. Damage by severe autumn frost to 2-year-old seedlings of outer-coast provenances of lodgepole pine at Red Rock nursery, 1972. Provenance 121 (IUFRO No. 2092), of questionable origin, was excluded from the regression calculation.

Field Tests

Thirty provenances grown at both Red Rock and Lake Cowichan nurseries are being tested in southeast and central British Columbia (Figure 2 and Table 1). After two summers in the field, overall survival was 99.9%, while second-year height increment averaged 16 cm and total height 43 cm. Provenances differed significantly in 1972 height increment (p=0.1) and there were no detectable interactions with test sites or nursery sources. Consequent shifts in provenance rankings preclude early conclusions based upon top height, but consistent height-increment groupings are noteworthy. At both test locations, coastal provenances comprised the least vigorous cluster, within which that from Port Clements (Queen Charlotte Islands) consistently showed greater vigor and hardiness than those from Porcher Island, Tofino and Chemainus (Vancouver Island). Grouped with them was a high-elevation source from Yellowstone Flats (2,300 m, Montana). Interestingly, this large-seeded provenance had put on, together with the Chemainus source, an outstanding display of early vigor at both nurseries. Significant growth differences occurred between provenances from the coast-interior transition zone of the Skeena and Nass rivers, Aiyansh being consistantly poorer than Kitsumkalum and Kitwanga. Interior provenances outgrew all others, although the ranking among them is irregular. At each test site, the most and the least vigorous group of five interior provenances included local as well as distant seed sources. The possibility of greater intraregional variation within the subspecies *latifolia* than had previously been supposed questions present assumptions regarding seed transfer rules and the preferred use of local seed sources for reforestation with this species.

In 1972, 43 provenances were planted in 10 replications in the Chilcotin and Fraser Canyon regions of British Columbia. First-year survival was 83.7 and 93.6%, respectively. Early losses are attributed mainly to the quality of planting (large block difference) and stock condition, rather than to provenance effects.

The main series of field tests will be installed in the spring of 1974. A total of 150 provenances will be planted on 60 test sites sampling broad climatic and latitudinal zones in the interior of the province.

Lodgepole pine has an insignificant role in coast reforestation, but interest is increasing in its potential for use on difficult sites. These include severe frost pockets where pilot trials have demonstrated the relative hardiness, ease of establishment and early vigor of the coastal variant of the species. However, its susceptibility to modification in form as a result of site and stand influences, especially initial spacing, is well known. In the spring of 1973, therefore, 2-year-old seedlings of six provenances (representing a north and south transect from outer to inner coast) were planted on frost-prone sites in a north coast valley (Kitimat) and on Vancouver Island. Twelve circular Nelder plots were installed at each location. Each plot comprises three replications of the six provenances planted at spacings varying between 5 and 13 feet. These trials will be used to investigate spacing and provenance effects upon tree growth and development.

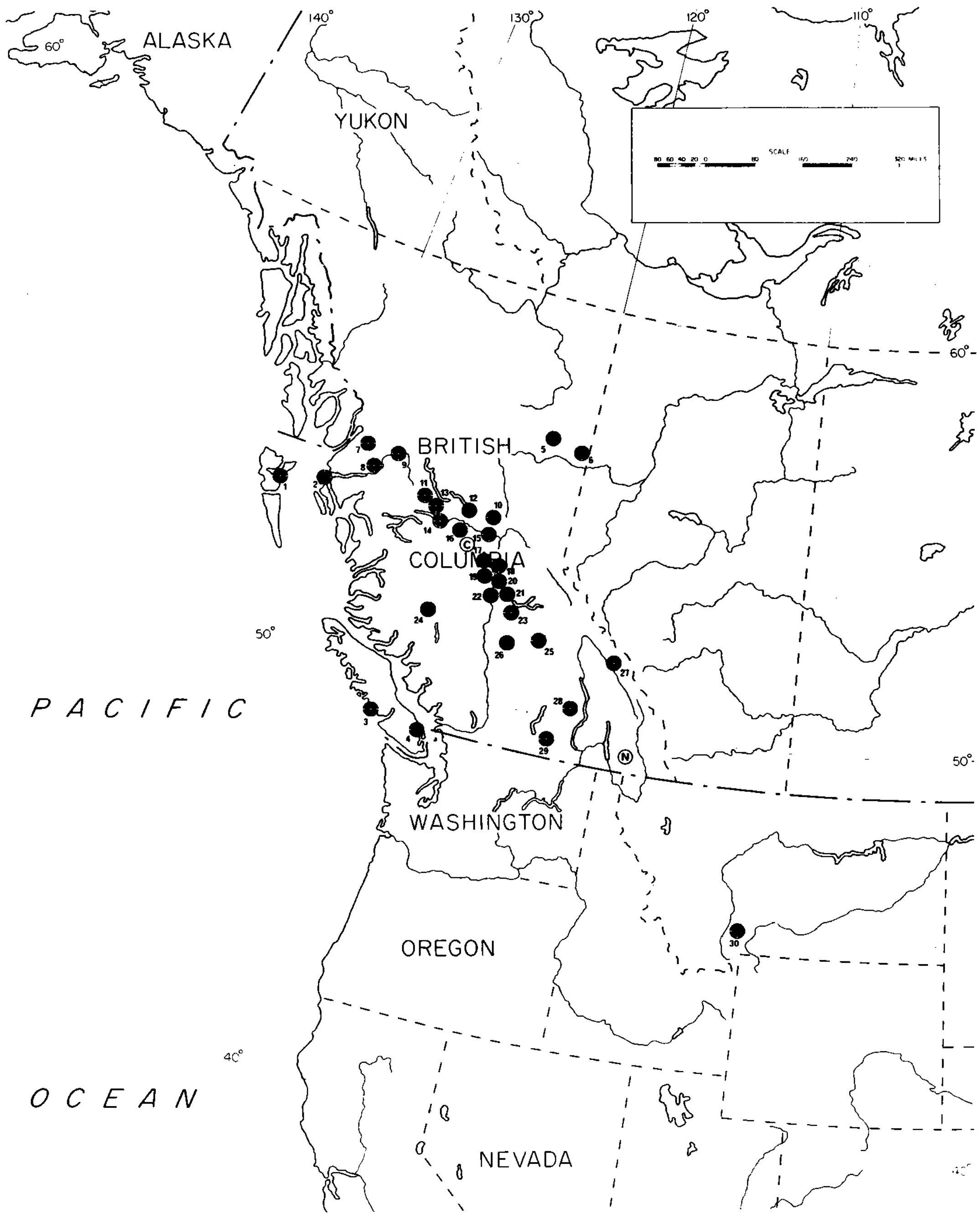

Figure 2. Map showing the locations of 30 lodgepole pine provenances planted in 1971 at two test sites: (N) Negro Creek, (C) Cluculz Lake.

TABLE 1. GEOGRAPHIC ORIGIN OF THIRTY *PINUS CONTORTA* PROVENANCES PLANTED AT NEGRO CREEK AND CLUCULZ LAKE, BRITISH COLUMBIA, 1971

No.	Location	Lat. °N	Long. °W	Elev. M.
1	Port Clements, Mayer L. (Q.C.I.)	53°39'	132°04'	23
2	Porcher I.	54°02'	130°17'	46
3	Tofino	49°05'	125°47'	23
4	Chemainus	48°55'	123°45'	60
5	Wonowon	56°42'	121°43'	915
6	La Grande Ck. N.E. Ft. St. John	56°30'	120°20'	685
7	Nass R. (Aiyansh)	55°12'	129°05'	150
8	Kitsumkalum	54°40'	128°35'	215
9	Kitwanga	55°08'	127°52'	490
10	Salmon R.	54°30'	123°10'	795
11	Rose L. ½ mi. S.W. Broman L.	54°25'	126°10'	840
12	Ft. St. James	54°20'	124°15'	700
13	Burns Lake	54°15'	125°43'	840
14	Tchesinkut L.	54°05'	125°40'	795
15	Reid L.	54°00'	123°10'	685
16	Tachick L. (Vanderhoof)	53°55'	124°20'	770
17	Punchaw L.	53°20'	123°00'	770
18	Strathnaver	53°20'	122°40'	610
19	Puntchesakut L. (Quesnel)	52°58'	122°58'	915
20	Kersley	52°50'	122°34'	610
21	Beaver Ck.	52°40'	122°10'	770
22	Narcosli Ck.	52°34'	122°33'	915
23	Miocene (Horsefly)	52°16'	121°32'	915
24	Horne L. (Tatla L.)	51°46'	124°44'	915
25	Clearwater	51°47'	120°12'	1356
26	100 Mile House	51°36'	121°28'	1000
27	Marl. Ck. (Big Bend)	51°35'	117°12'	900
28	Cherryville (Monashee)	50°13'	118°33'	670
29	Trapping Ck.	49°35'	119°01'	1000
30	Yellowstone Flats, Montana	*45°30'	*110°45'	2030

* Approx. only.

BREEDING

Breeding Arboreta

To permit their genetic evaluation and preservation for tree improvement and other scientific purposes, population samples from throughout the geographic range of lodgepole pine have been established in breeding arboreta at Lake Cowichan and Red Rock. In addition to stand samples, the Red Rock arboretum includes 780 wind-pollinated families representing 53 provenances from Alberta, Yukon Territory and the interior of British Columbia. These families are also being evaluated in a 65-acre field test near Prince George.

Single Tree Selection

Ramets of 150 plus phenotypes from Yukon Territory and central and northern British Columbia have been established in clone banks. Three years after grafting, 78.4% of the 7,629 grafts are viable. Despite unusually scant snow cover and, therefore, increased exposure during the winter of 1972-73, losses in the clone banks averaged only 4%. They are attributed mainly to the physiological deterioration of the rootstocks after planting, rather than to winter dessication or poor graft unions. However, the existence of graft incompatability in lodgepole pine is suggested by a few clones in which, despite initially healthy scions, the same grafter and rootstocks, graft failures reached 70% (clone S.C.A. 24).

Rapid turnover of generations promises to be a very real help in lodgepole pine breeding. To aid predictions, flowering habits are being observed. Of 75 clones grafted in the spring of 1971, a tally in June 1972 showed that one or more ramets in 44 clones bore male strobili, that 20 clones produced one or more female strobili, and that 10 clones produced both.

REFERENCE

Illingworth, K. 1973. Variation in the susceptibility of lodgepole pine provenances to Sirococcus shoot blight. Can. J. Forest Res. (In press.)

IMPROVEMENT OF WHITE AND ENGELMANN SPRUCE COMPLEXES OF BRITISH COLUMBIA PROGRESS REPORT

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Establishment of open-pollinated-progeny trials was the main objective of our program during the past 2 years.

Eleven thousand seedlings representing the 181 trees selected in the Prince George selection unit were planted at Aleza Lake on 17.5 acres in the spring of 1972.

In 1973 three more plantations were established (Red Rock, Quesnel and Barbie Lake). All four plantations are within the plus tree selection area and represent different environmental conditions. A total of 49,000 seedlings representing these 181 selected trees were planted at the last three sites (the total area of the three plantations is about 75 acres).

Survival was excellent at each plantation. Initial height measurements were taken of each seedling. Further height measurements will be taken at 3- to 5-year intervals.

Further progeny trials for the Smithers-Houston selection unit trees are planned for 1974. Thirty-two planting sites have already been staked and prepared for planting. The plantations, each of which will be about 2 acres, are well distributed throughout the selection unit and represent several site types. A control plantation of approximately 15 acres will be established near Red Rock, which is well outside of the original selection unit.

Both the selection units just mentioned are considered to be in the white spruce zone, but the Prince George unit contains hybrid swarms of white and Engelmann spruces. In my opinion many of the selected trees in the Smithers-Houston selection unit might contain some elements of Sitka spruce.

The East Kootenay selection unit is considered to be in the Engelmann spruce zone. Here cones were collected from 110 of the 132 plus trees in 1971. Seedlings of this collection will be outplanted in 1975 in an arrangement similar to those of the Smithers-Houston unit. Family-oriented differences in height growth exist in this selection unit also.

The grafted clones of the plus trees are developing well. It is interesting to note that the East Kootenay grafts, in general, are growing faster than those of the local trees. This might be viewed as supporting evidence to Roche's (1967) contention that "... a silvicultural gain will result ..." from the transfer of high-elevation southern provenances to lower elevations of northern latitudes (p. 136). Some ramets of East Kootenay plus trees grew as much as 50 to 60 cm this year. In general, it appears that the height growth of the East Kootenay clones is about 20% better than that of the Prince George clones.

Some strobili production appeared on the 4- and 5-year-old grafts. Most of the strobili were male; only a few female ones were noted. It is my opinion that, given favorable environmental conditions, many of these grafts could already bear a light cone crop. Many of the grafts are more than 1 m tall.

A preliminary study of white, Engelmann and Sitka spruce chromosomes was carried out in 1972 and an "in service" report was prepared. The highlights of this report can be summarized as follows:

1. All three species have metacentric and submetacentric chromosomes.

2. White and Sitka spruces appeared to have secondary constrictions that were not apparent in Engelmann spruce.

3. Sitka and white spruce karyotypes often contained a single supernumerary chromosome. No supernumeraries were found in Engelmann spruce. Fletcher and Faulkner (1972) (p. 6) have referred to a paper in press by Moir and Fox (1972) in which the authors discuss the occurrence of supernumerary chromosomes in seed of 8 Sitka spruce provenances. To my knowledge, however, no supernumerary chromosomes have been reported as yet in white spruce. They appeared to be quite common in white spruce root tips.

4. Pronounced average size differences were noted between chromosomes of the three species. White spruce chromosomes were the largest. Sitka spruce chromosomes were on the average 5% smaller than those of white spruce chromosomes. Engelmann spruce chromosomes were the shortest, being about 27% shorter than white spruce chromosomes.

The Piceta at Chilliwack and Red Rock are nearly complete. About 25 species of spruces are represented in Chilliwack and 13 species are in the Red Rock Picetum. Both eastern white and black spruces (*Picea glauca* [Moench] Voss and *P. mariana* [Mill.] B.S.P.) are growing well at Red Rock, but red spruce (*Picea rubens* Sarg.) is doing very poorly. Serbian spruce (*Picea omorica*) is a far-removed exotic that seems to be doing well at Red Rock.

REFERENCES

Fletcher, A.M., and R. Faulkner. 1972. A plan for the improvement of Sitka spruce by selection and breeding. G.B. For. Comm. Res. Dev. Pap. 85. 31 pp.

Roche, L. 1967. Geographic variation in *Picea glauca* in British Columbia. A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Faculty of Forestry, University of British Columbia.

SUMMARY OF TREE-IMPROVEMENT PROGRAM OF REFORESTATION DIVISION, BRITISH COLUMBIA FOREST SERVICE, 1972-73

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The Reforestation Division of the British Columbia Forest Service is responsible for providing all planting stock for reforestation in the province. At present, its activities in tree improvement are limited to establishing and maintaining seed orchards. Greatest emphasis to date has been put on coastal Douglas-fir, for which three orchards, totalling 36 acres, are established. All but 10 acres of these orchards are seedling plantations because of the widespread breakdown of grafted Douglas-fir. An additional 25-acre seedling orchard will be established in 1974.

During 1972, stands in the Coast-Interior transition zone were examined for Douglas-fir of superior size, form and cone production growing at elevations between 2,500 and 4,000 feet. Scion material was collected from 88 trees and grafted in 1973. A rooting trial with some of the same material is established at the Pacific Forest Research Station in Victoria. The clonal material will be utilized to develop improved breeds for second-phase seed orchards.

Plans are being made to establish seed orchards for Interior species. Lodgepole pine and "Interior" spruce orchards will be located in 1973 for planting in 1974.

A general review of seed sources and predicted requirements was undertaken in 1972. Recommendations to increase the effort to obtain improved seed via seed orchards and breeding are under review.

Seed orchards are supervised by foresters hired during the year, one on the Coast (Duncan) and one in the Interior (Prince George).

BREEDING PSEUDOTSUGA IN COASTAL BRITISH COLUMBIA

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INTRASPECIFIC CROSSES WITH DOUGLAS-FIR

The results of both the nursery and the early field measurements for the crosses made from 1966 to 1969 and of the measurements made in the nursery for the 1971 crosses have been recently published (Orr-Ewing et al. 1972) and so need no detailed reiteration. In summary, there seems to be no incompatability to prevent the making of successful crosses between trees separated by many thousands of miles and growing in completely different environments. Viable seed was always obtained, germination was excellent, and no abnormal seedlings were produced. Twenty-eight test sites covering a wide range of elevation, site and climate have been established on Vancouver Island and the Lower Mainland with the crosses made from 1966 to 1968. At this early stage of the program, the most promising crosses have been made between maternal and paternal parents from coastal British Columbia and coastal Washington and Oregon respectively. In spite of genotype-environment interaction on the test sites, some of the best crosses show much adaptability to widely different conditions. Height measurements are being made at 3-year intervals on all the test sites, and the first diameter measurements are made in the sixth year from planting.

INBREEDING STUDIES WITH DOUGLAS-FIR

In summary, 23 inbred lines are now established at Lake Cowichan, and 21 trees from five of these lines have been selfed to the S2 generation. Several of the S2 inbreds are already producing male and female strobili, and in 1971 one was successfully selfed to the S3 generation. The seedlings are healthy and were transplanted in 1973. Efforts are being made to produce more inbred lines with particular emphasis on all the trees used in the intraspecific crossing program. This objective is limited by the sporadic production of both male and female strobili at Lake Cowichan, but some selfings were possible in 1973.

REFERENCE

Orr-Ewing, A.L., A.R. Fraser, and I. Karlsson. 1972. Interracial crosses with Douglas-fir, early field results. B.C. For. Serv. Res. Note. 55. 33 pp.

TREE IMPROVEMENT AT THE PACIFIC FOREST RESEARCH CENTRE

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WESTERN HEMLOCK TREE IMPROVEMENT

Previous reports to the Committee (1970, 1971) have dealt, in detail, with the objectives, approaches and initial progress of this study. Early emphasis is being directed toward the testing, over a range of environments, of selected hemlock populations from coastal British Columbia. The performance of half-sib families is being studied concurrently, as are the propagation and subsequent use of rooted cuttings derived from the seed trees used in these studies.

The main outplanting was undertaken in the spring of 1971, when more than 100 acres of test plantations were established. Field survival was subsequently assessed after 1 year. On the more northerly sites of Vancouver Island, survival rates were high, averaging 75 to 80%, some individual plots exceeding 90%. These sites generally had a good fireweed cover. The more southerly sites, especially those that were recently slash-burned and consequently lacked adequate fireweed cover, had much poorer survival, averaging 45 to 50%. Containerized stock was used on all sites; in fact, had "plug" seedlings not been used, survival would probably have been much poorer.

In the spring of 1972, approximately 1,200 3-year-old rooted cuttings were outplanted in the field. The planting was designed to serve as both a clone bank and a clonal test. Survival during the subsequent summer was good, although limited irrigation was required. In 1973, a number of ramets representing several clones produced seed cones, and a few produced pollen cones. It has been reported (Piesch 1972) that even 1-year-old rooted cuttings of western hemlock are capable of cone production and of yielding viable seeds. To further develop control-pollination techniques and obtain full-sib progenies for subsequent genetic variation and heritability determinations, a crossing program was undertaken with the 1973 cone crop produced by the cuttings. A partial diallel mating design was used, including seven selfs of the 39 total crosses made.

Seed was collected from two additional populations in 1972: 1) a high elevation source (3,000 ft) on the British Columbia mainland near Mission City and 2) a Queen Charlotte Islands source. This seed has been stored pending additional collections to be made from other populations this year.

A comprehensive report has been drafted covering the establishment phase of the entire western hemlock tree-improvement program.

CERTIFICATION OF FOREST REPRODUCTIVE MATERIAL IN BRITISH COLUMBIA UNDER THE O.E.C.D. SCHEME

In 1970, the Government of Canada nominated the Canadian Forestry Service as the Designated Authority to implement the O.E.C.D. (Organization for Economic Cooperation and Development) scheme for the control of forest reproductive material moving in international trade. The C.F.S. delegated responsibility for the operation in respect of seed collected in British Columbia to the Director, Pacific Forest Research Centre.

In line with O.E.C.D. regulations, a scheme providing for the certification of origin of forest tree seed from British Columbia was developed and implemented in 1970. In 1971, local rules for operation of the scheme were revised to improve control of collection operations (Piesch and Phelps 1971).

Of the several categories of forest reproductive material recognized and distinguished under the O.E.C.D. scheme, only the "source-identified" category is currently certified in Canada. The source must be related to Forest Region and Section as defined by Rowe (1959) and be defined within specified limits of latitude, longitude and elevation. Collections must be made under the direct supervision of a representative of the seed-exporting company. To ensure that seeds are collected, processed and distributed in compliance with the rules that apply, the Canadian Forestry Service, through contractual arrangements, undertakes inspections and audits of collection and processing operations.

Since implementation of the scheme, certificates of provenance have been issued for more than 100 seedlots covering a number of British Columbia conifers. The estimated value in the overseas market of the seed certified to date is $400,000 to $500,000.

In response to demands for seed from areas of Canada other than British Columbia, operation of the scheme in Canada has been made more national in scope than regional. It has recently been extended to include seed collected in Alberta, the Yukon and Northwest Territories. Rules providing for operation of the scheme on a national basis were prepared for publication.

REFERENCES

Piesch, R.F., and V.H. Phelps. 1971. Certification of source-identified British Columbia tree seed under the O.E.C.D. scheme. Can. Forest. Serv. Inf. Rep. BC-X-60.

Piesch, R.F. 1972. Cone and seed production of one-year-old cuttings of western hemlock. Can. Forest. Res. 2:370-371.

Rowe, J.S. 1959. Forest regions of Canada. Dep. North. Aff. Nat. Resour., For. Branch Bull. 123. 71 pp.

SYMPOSIUM: INTERSPECIFIC AND INTERPROVENANCE HYBRIDIZATION IN FOREST TREES (PROCEEDINGS, PART 2)

LIST OF AUTHORS AND TITLES

CONTENTS

C.T.I.A. - N.E.F.T.I.C. FIELD TRIPS

Visit to J.D. Irving Ltd., Reforestation Area, Black Brook Depot
20 miles northeast of St. Leonard, N.B.

On the evening of August 30, 29 members of the N.E.F.T.I.C.-C.T.I.A. group drove to St. Leonard, N.B., where they spent the night. The following morning they drove to Black Brook, where they transferred to a bus for the tour.

Mr. Niels Kreiberg and Mr. Pat Marseau of J.D. Irving Ltd., directed the tour of the company's reforestation operations. They demonstrated, by visits to various planting areas, the evolution of the company's planting program from the very small scale underplanting of red spruce, through species trials and trials of various methods of site preparation, to the large-scale planting of greenhouse-produced container stock.

In 1973, J.D. Irving Ltd. produced approximately 10 million seedlings, mostly black spruce and jack pine, in its nursery at Juniper, N.B. Almost all these seedlings were planted on company-owned or company-controlled lands. Black Brook is one of the company's major planting areas. To date 30 million seedlings have been planted at Black Brook. Very briefly, the reforestation system now in use is to clear-cut and harvest all merchantable material. The cutover is next flattened with large crushers in an effort to control vegetation and to make the planting site more accessible. The area is then planted, mainly to black spruce, with bare-root or container-grown stock. One or two years after planting, control of competing vegetation is attained with an aerial application of herbicide. These reforestation methods have resulted in large acreages of very successful plantation - unique in the northeast.

Visit to Acadia Forest Experiment Station
15 miles east of Fredericton, N.B.

Canadian Forestry Service staff led a tour of the tree-breeding research facilities, the nursery and some field plantings at the Acadia Forest Experiment Station on the afternoon of August 30. S.A.M. Manley described part of his work on the genecology of red and black spruce. H.G. MacGillivray discussed the nursery aspects of a range-wide provenance trial of black spruce and D.P. Fowler led the group through the research facilities. The group then visited a number of trials of native and exotic species ending in a very promising trial of Japanese larch. The prospects of larch as a reforestation species in the northeast were discussed.

The hospitality of J.D. Irving Ltd. and the Maritime Forest Research Centre, Canadian Forestry Service, in organizing these trips and providing excellent lunches was greatly appreciated by all the participants. Special thanks is extended to Niels Kreiburg and Pat Marseau of J.D. Irving Ltd.

ATTENDANCE

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ABSTRACTS OF N.E.F.T.I.C. PAPERS

(See 21st N.E.F.T.I.C. Proceedings for papers and discussion)

NUTRIENT CONTENT OF AUSTRIAN PINE AS AFFECTED BY SOURCE AND LOCATION

Franklin C. Cech,[1] David H. Weingartner,[2] and John P. Capp[3]

The use of fly ash as a strip-mine soil amendment has been tested by the U.S. Bureau of Mines at several locations in West Virginia. Application of 150 tons per acre of fly ash with a pH of 11.0 + raised the pH of strip soil from 3.5 to 7.0. Soils were then fertilized with a 10-10-10 granular fertilizer at the rate of 1,000 pounds per acre and planted to Austrian pine (*Pinus nigra*). Analysis of tissue samples revealed significant difference in nutrient absorption among sources for most elements tested, which agrees with several previous reports. There was no correlation, however, between levels of nutrient in the foliage and levels of nutrient in the soil after one growing season. New evaluations of soil and foliage at the end of the second and third growing seasons will determine if the correlation changes with seedling age.

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EFFECTS OF FERTILIZATION ON VEGETATIVE GROWTH AND EARLY FLOWERING AND FRUITING OF SEED ORCHARD BLACK CHERRY

Donald E. Dorn[1] and L.R. Auchmoody[2]

Seventeen half-sib families of black cherry in a Pennsylvania seed orchard received annual applications of nitrogen and phosphorus. Growth response within families varied substantially after 2 years of treatment, indicating considerable genetic variability in nutrient requirements for maximum production. If fertilization will be a common timber management practice in the future, attention should be given to selecting families that will respond to this treatment. Fertilization also promoted early flowering in at least four families, with the first flower clusters observed only 4 years after planting.

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PHENOTYPIC SELECTION OF SUGAR MAPLES FOR SUPERIOR SAP-VOLUME PRODUCTION

William J. Gabriel[1]

Certain tree characteristics such as stem diameter and live crown ratio are correlated with high sap-volume yield. However, no single character or combination of characters explains the total observed variation in sap production. It is our feeling that at least a portion of the unaccounted for variation could be inherited. Sap-flow rate has been shown to be correlated with total sap volume, and trees with a flow rate 70 percent greater than surrounding standards were included in the program, providing the tree was not too dissimilar phenotypically from the standards. During the first year of this study, 2,375 trees in seven states were tested and 55 trees were selected for the program. No attempt has been made to determine patterns of variation between states or areas within states, but large differences are present between trees in the same sugar bush.

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REALIZED AND ESTIMATED EFFICIENCY OF EARLY SELECTION IN HYBRID POPLAR CLONAL TESTS

Ronald C. Wilkinson[1]

Selection of hybrid poplar clones for total height at 1 or 4 years in clonal tests may result in negative selection differentials at 15 years. Genetic gains in total 15-year height increased with increases in the ages at which selections are made, but were quite variable from one plantation to another. Broad-sense heritabilities and genetic correlations are reliable for predicting the mature response to early selection, but they are applicable only to a limited range of sites and genotypes. When genetic correlations between early and mature performance are low, selection intensities utilized in an early selection program may have to be reduced considerably to preserve the best performing clones at 15 years.

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GEOGRAPHIC VARIATION OF GROWTH AND WOOD PROPERTIES IN EASTERN WHITE PINE - 15-YEAR RESULTS

Chen Hui Lee[1]

Fifteen seedlots of eastern white pine were planted in southwestern Lower Michigan as part of a larger study initiated by the U.S. Forest Service. At the end of the 1971 growing season (15 years from seed) height and diameters were recorded. In addition, a large size increment core was extracted from the stem of each tree and specific gravity and tracheid length were determined by standard techniques. Between-seedlot differences in growth rate were highly significant. In general, the southern Appalachian provenances grew fast and were free of winter injury at this location although some interesting changes have taken place since the previous data were recorded. The difference between the tallest and the shortest seedlots had declined from 90 to 23 percent in 10 growing seasons. There were also significant differences among seedlots in specific gravity, but the differences were not large and followed no geographic pattern. The between-seedlot differences in tracheid length were not significant, and no geographic trends were present.

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VARIABILITY OF YELLOW BIRCH IN THE WESTERN GREAT LAKES REGION

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Abstract not submitted.

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LARSON'S OWN - A SPECTACULAR HYBRID LARCH

David B. Cook[1]

A general discussion of larch hybridization is followed by a description of a vigorous hybrid between *L. europae* x *L. leptolepis*. The hybrid, produced by Dr. Syrach Larsen, and known as LARSON'S OWN, was planted at Cooxrox Forest near Albany, New York. After 20 growing seasons, the tree is 12.2 inches in diameter and 61 feet tall and has an evenly tapered stem and a compact crown. While production of male flowers has been consistently heavy, this tree has produced very few female flowers.

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A JACK PINE SEEDLING SEED ORCHARD PLANTATION OF UNUSUAL DESIGN

Jerome I. Klein[1]

An experimental seedling seed orchard was planted in June 1972, using open-pollinated families. Each of 24 blocks contains one tree from each of 220 families, divided into 11 plots of 20 trees. Initial spacing was 2 x 2 feet, with a 4-foot space between plots. The 20 families represented in each plot are from one source area. A series of selection thinnings will reduce the 20 trees in each plot to one tree. Selection will thus be exercised among trees having little or no coancestry but having a common geographic source. Because each source area is represented in only one plot of each block, mating will be predominantly between sources. Seedlings were assigned to blocks according to size ranking within families, in the expectation of reducing the influence of nursery environment variation on the selection outcome.

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PARENT-PROGENY CORRELATION OF BUDBREAK IN WHITE SPRUCE AT PETAWAWA, ONTARIO

C.W. Yeatman[1] and C.S. Venkatesh[2]

The time of budbreak was recorded in five trees of white spruce (*Picea glauca* [Moench] Voss) in a 60-year-old natural stand and their half- and full-sib progenies grown in a replicated nursery experiment. The parental trees differed by 4 days and the seedlings by up to 13 days in time of budbreak. The families were best differentiated in the early stages of budbreak. Parents and progenies were highly correlated in time of flushing ($r^2 = .91$), as were cross-, self- and open-pollinated progenies of the same 5 trees. The potential significance of these findings in selective genetic improvement of white spruce is discussed.

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SEEDLING SEED ORCHARDS FOR JACK PINE

Christopher W. Yeatman[1]

Jack pine provenance experiments have already demonstrated strong clinal variation associated with climate and additional variation within climatic zones. The creation of seed zones is recommended to take advantage of the climatic variation, but better populations within regions should also be located and utilized. A seedling seed orchard program for jack pine is outlined in detail. Emphasis is placed on selection intensity in the parent stands and in the progeny test plantings.

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EFFECT OF STORAGE UPON BALSAM FIR POLLEN VIABILITY AND SEED DEVELOPMENT

William J. Lowe[1]

One problem that tree breeders have is the maintenance of adequate pollen supplies for controlled pollination work. This preliminary study indicates that balsam fir pollen can be stored for at least 2 years at relative humidity attained with either a supersaturated salt solution of potassium acetate or sodium/iodide at either 30°F or -6°F temperature. Pollen viability did not affect sound seed number. There was an indication that pollen viability may have had an effect on seed weight. Pollen storage treatments did have a significant effect upon seed germination. Seed obtained with pollen that was stored under these conditions showed better germination than seed produced from pollen stored at higher temperatures and lower relative humidities.

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POPLARS CAN BE BRED TO ORDER FOR MINI-ROTATION FIBER, TIMBER AND VENEER PRODUCTION AND FOR AMENITY PLANTINGS

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Abstract not submitted.

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