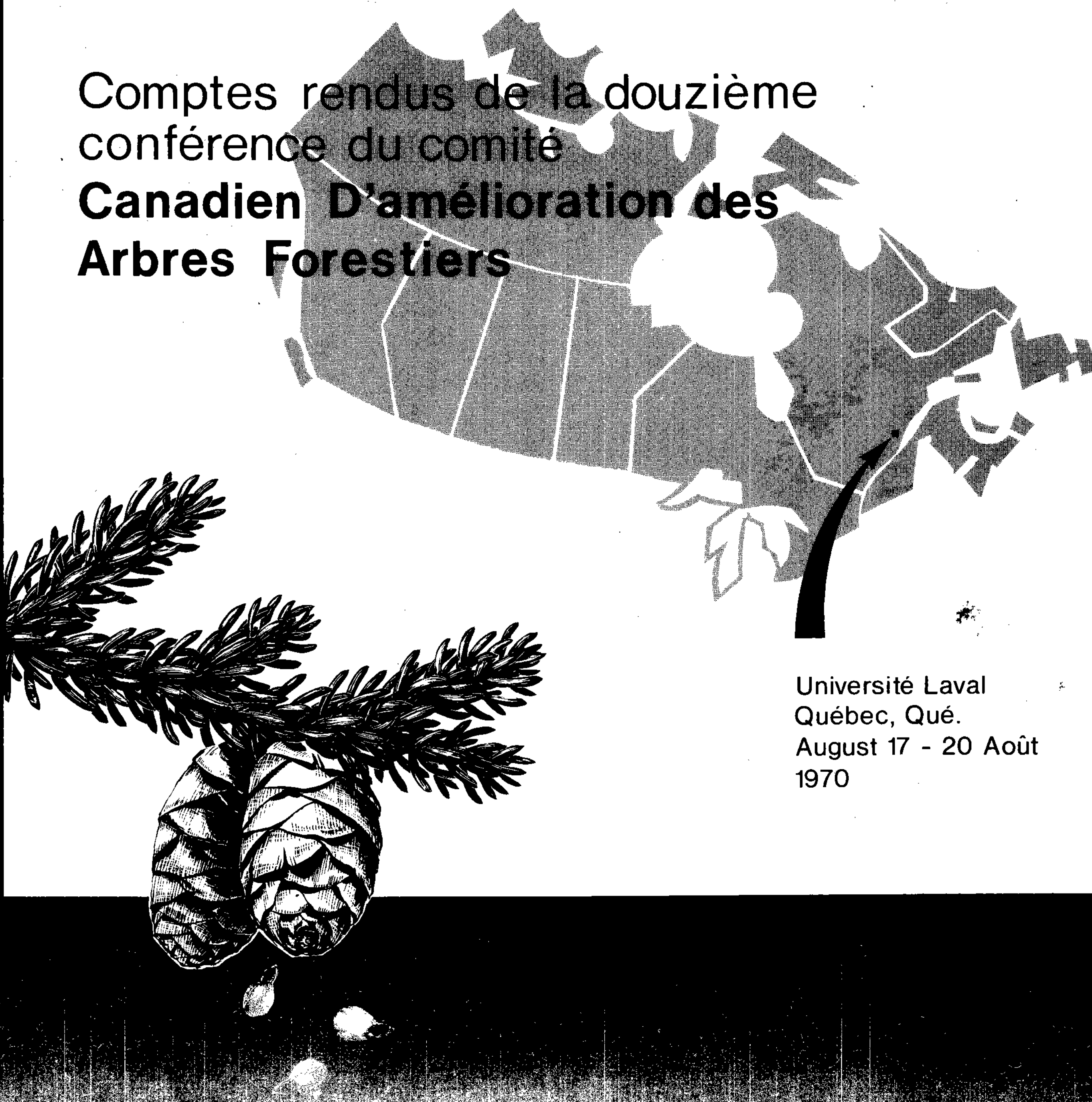
Proceedings of the twelfth meeting of the committee on

Forest Tree Breeding in Canada

Comptes rendus de la douzième conférence du comité

Canadien D'amélioration des Arbres Forestiers



Université Laval
Québec, Qué.
August 17 - 20 Août
1970

PROCEEDINGS OF THE TWELFTH MEETING OF
THE COMMITTEE ON FOREST TREE BREEDING
IN CANADA

With the compliments of the Committee.

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Enquiries may be addressed to the authors or to the Executive Secretary, C.F.T.B.C., Forest Research Laboratory, C.P. 3800, Ste-Foy, Québec, Canada.

The Thirteenth Meeting of the Committee will be held at Prince George, British Columbia, in August 1971. Canadian and foreign visitors will be welcome. Detailed information will be distributed early in 1971 to all members and to others upon request.

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

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PROCEEDINGS OF THE TWELFTH MEETING OF THE COMMITTEE ON FOREST TREE BREEDING IN CANADA

PART 2

REPORTS AND PAPERS

Editor: E.K. Morgenstern

Published by the Canadian Forestry Service
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Part 1, Minutes and Discussions, received restricted distribution to Committee members only.

Part 2, received wider distribution to persons and organizations actively engaged or interested in forest genetics and tree improvement.

LIST OF ACTIVE MEMBERS ON THE COMMITTEE ON FOREST TREE BREEDING IN CANADA, AUGUST 1970

Mr. F.B. Armitage	Department of Fisheries and Forestry, Canadian Forestry Service, British Columbia Region, 506 West Burnside Road, Victoria, B.C.
Dr. M.G. Boyer	York University, Department of Biology, 4700 Keele St., Downsview 463, Ont.
Dr. A. Carlisle	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Mr. A.J. Carmichael	Ontario Department of Lands and Forests, Research Branch, Maple, Ont.
Dr. L.P. Chiasson	St. Francis Xavier University, Antigonish, N.S.
M. Armand Corriveau	Ministère des Pêches et des Forêts, Le Service Canadien des Forêts, Région de Québec, C.P. 3800, Québec 10, Qué.
Dr. W.H. Cram	Department of Regional Economic Expansion, Prairie Farm Rehabilitation Administration, Tree Nursery, Indian Head, Sask.
Mr. B.W. Dance	Ontario Department of Lands and Forests, Research Branch, Maple, Ont.
Dr. André D'Aoust	Ministère des Pêches et des Forêts, Le Service Canadien des Forêts, Région de Québec, C.P. 3800, Québec 10, Qué.
Dr. Yves Desmarais	Jardin Botanique de Montréal, 4101 est, rue Sherbrooke, Montréal, Qué.
Dr. D.J. Durzan	Department of Fisheries and Forestry, Forest Ecology Institute, Montreal Road, Ottawa, Ont.

Mr. W.G. Dyer	Ontario Department of Lands and Forests, Timber Branch, Parliament Buildings, Toronto, Ont.
Mr. K.C. Eng	Ontario Department of Lands and Forests, Timber Branch, Tree Seed Plant, Angus, Ont.
Mr. E.R. Falkenhagen	University of British Columbia, Faculty of Forestry, Vancouver 8, B.C.
Dr. J.L. Farrar	University of Toronto, Faculty of Forestry, Toronto 5, Ont.
Dr. D.P. Fowler	Department of Fisheries and Forestry, Canadian Forestry Service, Maritimes Region, P.O. Box 4000, Fredericton, N.B.
Dr. D.A. Fraser	Sir George Williams University, Department of Geography, 1435 Drummond St., Montreal 107, Qué.
Dr. R. Girouard	Ministère des Pêches et des Forêts, Le Service Canadien des Forêts, Région de Québec, C.P. 3800, Québec 10, Qué.
Dr. A.G. Gordon	Ontario Department of Lands and Forests, Research Branch, P.O. Box 490, Sault Ste. Marie, Ont.
Mr. M.C. Heaman	British Columbia Forest Service, Research Division, Victoria, B.C.
Mr. M.J. Holst	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Dr. Martin Hubbes	Ministère des Pêches et des Forêts, Le Service Canadien des Forêts, Région de Québec, C.P. 3800, Québec 10, Qué.
Mr. K. Illingworth	British Columbia Forest Service, Research Division, Victoria, B.C.

Mr. G.K. Kiss	British Columbia Forest Service, Research Division, Prince George, B.C.
Dr. J.I. Klein	Department of Fisheries and Forestry, Canadian Forestry Service, Prairie Region, 5320 - 122 St., Edmonton, Alta.
Dr. J.L. Ladell	Ontario Research Foundation, Sheridan Park, Ont.
Mr. H.C. Larsson	Ontario Department of Lands and Forests, Research Branch, Maple, Ont.
Mr. C.H. Lindquist	Department of Regional Economic Expansion, Prairie Farm Rehabilitation Administration, Tree Nursery, Indian Head, Sask.
Mr. K.T. Logan	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Mr. H.G. MacGillivray	Department of Fisheries and Forestry, Canadian Forestry Service, Maritimes Region, P.O. Box 4000, Fredericton, N.B.
Mr. S.A.M. Manley	Department of Fisheries and Forestry, Canadian Forestry Service, Maritimes Region, P.O. Box 4000, Fredericton, N.B.
Mr. J.A. McPherson	Kimberly-Clark Pulp and Paper Co. Ltd., Longlac, Ont.
Dr. E.K. Morgenstern	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Dr. A.L. Orr-Ewing	British Columbia Forest Service, Research Division, Victoria, B.C.
Dr. Louis Parrot	Université Laval, Faculté de Foresterie et de Géodésie, Québec, Qué.

Mr. R.F. Piesch	Department of Fisheries and Forestry, Canadian Forestry Service, British Columbia Region, 506 West Burnside Road, Victoria, B.C.
Dr. D.F.W. Pollard	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Miss Rose Marie Rauter	Ontario Department of Lands and Forests, Research Branch, Maple, Ont.
Dr. L. Roche	Ministère des Pêches et des Forêts, Le Service Canadien des Forêts, Région de Québec, C.P. 3800, Québec 10, Qué.
Dr. K.J. Roller	Department of Fisheries and Forestry, Canadian Forestry Service, Maritimes Region, P.O. Box 4000, Fredericton, N.B.
Mr. J.B. Santon	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Mr. R.L. Schmidt	British Columbia Forest Service, Research Division, Victoria, B.C.
Dr. C.R. Sullivan	Department of Fisheries and Forestry, Canadian Forestry Service, Forest Insect Laboratory, P.O. Box 490, Sault Ste. Marie, Ont.
Dr. O. Sziklai	University of British Columbia, Faculty of Forestry, Vancouver 8, B.C.
Dr. A.H. Teich	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Dr. Gilles Vallée	Ministère des Terres et Forêts du Québec, Le Service de la Recherche, 875 rue St-Amable, Québec 4, Qué.

Mr. B.S.P. Wang	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Dr. C.W. Yeatman	Department of Fisheries and Forestry, Canadian Forestry Service, Petawawa Forest Experiment Station, Chalk River, Ont.
Dr. L. Zufa	Ontario Department of Lands and Forests, Research Branch, Maple, Ont.

CONTENTS

TREE IMPROVEMENT IN NEWFOUNDLAND

J. Nicholson
Canadian Forestry Service,
Forest Research Laboratory, St. John's, Nfld.

Tree improvement work continued to center around the local black spruce [*Picea mariana* (Mill.) B.S.P.] and trials of exotic species and races.

BLACK SPRUCE

Seed collections for a provenance study of local black spruce was initiated in 1967 and a nursery experiment was sown in the spring of 1968. Measurements of height and observations on dormancy were made in the fall of 1969. In general, there was a decrease in height growth with increase in latitude of the seed source. This was especially apparent with provenances from the Northern Peninsula which were significantly shorter than the others. They also set buds up to a month earlier than the other provenances. The distinct behavior of this group of provenances is thought to be related to the climate of that region which has comparatively colder winters and cooler, shorter summers.

Other work on black spruce was the sowing in the spring of 1970 of bulked seedlots of local provenances for outplanting experiments, and provision of local seed and acquisition of mainland seed for the cooperative all-range provenance experiment being coordinated by Dr. E.K. Morgenstern of PFES.

SITKA SPRUCE

A Sitka spruce [*Picea sitchensis* (Bong.) Carr.] provenance experiment was initiated in 1965. Twelve provenances, including a local black spruce control, were established in each of seven plantations in 1969 and two plantations in 1970. Plantation sites were selected on the better site types in most of the important forest growing regions of the Island. The experimental design was an eight-replicated randomized block with 16 trees per plot.

A combination spacing-fertilizer experiment using the black spruce and two of the Sitka spruce provenances was established in three locations. This project is being done in cooperation with a silviculturist.

WHITE SPRUCE

A plantation containing 31 white spruce [*Picea glauca* (Moench) Voss] provenances from the Great Lakes - St. Lawrence Region was established, in cooperation with Mr. Mark Holst of P.F.E.S., in central Newfoundland in 1963. A measurement at age of 10 years from seed was carried out in 1968. Survival of all provenances was generally good. Those showing the best height growth were from southeastern Ontario and southwestern Quebec, i.e. Algonquin Park and Beachburg, Ont., and Grandes Piles and Cushing, Qué.

TREE BREEDING IN THE MARITIMES REGION, 1968-69

D.P. Fowler, H.G. MacGillivray,
S.A.M. Manley and J.M. Bonga
Canadian Forestry Service,
Forest Research Laboratory, Fredericton, N.B.

INTRODUCTION

The objectives of the Tree Improvement and Reforestation Support Area are as follows:

1. To provide direct support to the problem area programs of the Region by consultation, by supplying genetically improved tree materials, and by carrying out research on specific projects within defined problem areas.
2. To obtain information on the genetic variability of native and exotic species considered to be of present or future importance in the Region. This information will be used to produce improved strains or types of trees for reforestation and will provide a basis for genetic manipulation of existing forest stands.
3. To assist the provincial governments and industries of the region to develop economically sound methods of mass producing tree seeds and seedlings of improved genetic quality.

During 1968 and 1969, tree breeding work in the Maritime Region was concentrated on four projects: Breeding and breeding systems of forest trees - D.P. Fowler; Provenance and progeny testing - H.G. MacGillivray; Genecology of red and black spruce - S.A.M. Manley; Haploid and homozygous diploid trees - J.M. Bonga and D.P. Fowler.

BREEDING AND BREEDING SYSTEMS OF FOREST TREES

The objective of this project is to obtain the necessary information and breeding materials to make possible the mass production of genetically superior trees for the Maritimes Region. An understanding of the natural and potential genetic variability of native and promising exotic species is essential if genetic improvement is to be maximized.

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

Picea

Picea glauca (Moench) Voss (white spruce), *P. mariana* (Mill.) B.S.P. (black spruce), and *P. rubens* Sarg. (red spruce) are sympatric over much of the region. Hybridization and introgression between red and black spruce have been shown to be important features of the forests of the region (Manley 1969). No evidence of gene exchange between white spruce and red or black spruces has been found in the region, although white-black spruce hybrids have been reported elsewhere.

To further elucidate the genetic relationship between the three native spruces and to provide material for further genecological work, a series of controlled pollinations were attempted. In 1968 and 1969, all possible crosses between the three spruces were attempted. The summarized results are presented in Table 1. Only a few full seeds were obtained from any of the interspecific white spruce crosses (morphological examination of the seedlings will be required to determine if any hybrids were obtained). Considerable tree to tree variation in interspecific crossability was observed in black and red spruces. On the average, red and black spruces appear to be 25-50% cross-compatible. Self incompatibility is greater than interspecific incompatibility.

Table 1. Interspecific Hybridization Between Three Native Spruces - Average Number of Full Seeds per Cone.

Female parent		Male parent			
Species	Trees	*P. glauca*	*P. mariana*	*P. rubens*	Self
P. glauca	8	2.2[a]	0.01	0.01	0.71
P. mariana	4	0.07	9.3	4.0	3.1
P. rubens	4	0.05	2.5	9.8	0.65

[a]Open pollination.

In 1969, all possible crosses were attempted between three sets of the following phenotypes: pure black spruce, 25% red spruce, 50% red spruce, 75% red spruce, and pure red spruce. The results of these crosses have yet to be analyzed.

As part of a study to determine the interspecific relationship between the eastern Canadian spruces and exotic spruces, a number of controlled pollinations were attempted in 1968 and 1969. The summarized results are presented in Table 2. Seed yields from these crosses were very low and evaluation will be dependent on morphological examination of seedlings.

<u>Larix</u>

Due to their rapid juvenile growth, good form, high wood density, and ease of handling in the nursery, *Larix* species are of potential value for reforestation within the region. On the basis of species trials and provenance tests, it is evident that selected strains of *Larix laricina* (Du Roi) K. Koch, *L. leptolepis* (Sieb. and Zucc.) Gord., and *L. decidua*

Table 2. Interspecific Hybridization Using White Spruce as Female Parent.

Male parent	Crosses yielding full seed	Full seeds per cone	Total number of full seeds
1968			
P. asperata	6	0.20	106
P. koraiensis	5	0.01	7
P. koyamai	6	0.08	8
P. omorika	4	0.01	8
P. orientalis	4	0.01	6
1969			
P. omorika	3	0.01	4
P. schrenkiana	8	0.09	107

Mill. are promising. That interspecific *Larix* hybrids are often heterotic, has been well documented, thus species hybridization appears to be the most promising approach to *Larix* improvement.

The objective of the *Larix* improvement work is to determine the magnitude and pattern of variation in *L. laricina*, and to select or develop a superior strain or hybrid suitable for the Maritimes Region. Over the past decade, a good collection of *Larix* species and strains has been accumulated at the Acadia Forest Experiment Station. Much of this material is just beginning to produce ovulate flowers in the quantities required for controlled pollination work.

Five populations of the hybrid (*Larix laricina* x *leptolepis*) x *L. decidua* were produced in 1967. At the end of the second growing season, one of these populations appears heterotic in that it is clearly superior in height (avg 112 cm) to comparable populations of the three parent species (avg less than 100 cm for the next best population).

In 1968, all possible crosses (including self-pollinations) were made between two selected trees of each of *L. laricina*, *L. leptolepis*, and *L. decidua*. In addition, the hybrid *L. laricina* x *leptolepis* was backcrossed to both parent species. The summarized results are presented in Table 3.

Table 3. Results of 1968 Controlled Pollinations with Larch. Percentage of Full Seeds.

Female parent	Male parent					
	L. laricina		*L. leptolepis*		*L. decidua*	
	Tree 495	Tree 119	Tree 7	Tree 10	Tree 19	Tree 27
L. laricina (495)[a]	5.3	34.6[b]	0.0	0.9	28.1	1.4
L. laricina (119)	21.7	1.1	3.8	3.5	2.6	4.5
L. leptolepis (7)	0.2	0.0	4.9	78.3	2.2	5.1
L. leptolepis (10)	0.2	0.0	71.7	28.3	13.2	1.5
L. decidua (19)	0.8	0.0	24.0	37.5	0.3	12.2
L. decidua (27)	0.5	0.7	14.2	32.6	51.3	0.5
L. laricina x *leptolepis* (368)	12.5	-	-	10.2	-	-
L. laricina x *leptolepis* (352)	5.4	-	-	6.0	-	-

[a]Tree number in parentheses.
[b]Underlined numbers denote populations with living seedlings at age 4 months.

Pollen from two selected *L. decidua* trees was used in crosses with *L. laricina*, *L. leptolepis*, and *L. decidua*. The results are given in Table 4.

Although *L. laricina* can be crossed with both *L. leptolepis* and *L. decidua* (and often produces heterotic progenies), the very low seed yield, as well as differences in flower phenology will make mass production of hybrids difficult. Only if early evaluation of individual hybrids is successful and if commercially acceptible methods of vegetative propagation can be developed, will it be possible to produce these hybrids in quantity.

Pinus resinosa

Three small studies of maternal effects in *Pinus resinosa* Ait. were concluded in 1969. It was concluded that maternal effects, other than seed size, could cause approximately 10% variation in height growth of young red pine seedlings. Estimates of genetic variation based on evaluation of young provenance or one-parent progeny materials should be reduced accordingly.

Table 4. Interspecific Hybridization of Larch Species, with *L. decidua* as Male Parent - Number of Cones Harvested.

	Female parent		Male parent	
Species	Provenances	Trees pollinated	Tree 29	Tree 30
L. laricina	3	11	645	622
L. leptolepis	8	15	385	422
L. decidua	2	2	123	109
L. laricina x *leptolepis*	-	3	145	136

It is recommended that controlled pollination studies, including reciprocal crossing should be employed in future genetic evaluation of this species (Fowler 1970).

PROVENANCE AND PROGENY TESTING

The objective of this work is to determine the amount and nature of genetic variation within populations of desirable tree species, and to use this variation to improve wood production in the Maritime Region. The objectives of the individual experiments are diverse, but each has its place within the overall objective. The experiments include tests for volume of wood produced, insect resistance, suitability for adverse sites, all-range variation, and suitability for Christmas trees.

Picea

An all-range study of 1,100 provenances of *Picea abies* (L.) Karst. was planted in May 1968 at the Bronson Burn, near Chipman, N.B. This study is being conducted in cooperation with Dr. Olof Langlet and Mr. Peter Krutzsch of Stockholm, Sweden. Dr. Klaus Stern, Schmalenbeck, Germany assisted with the design. The Bronson plantation contains 11 randomized blocks each with 25 trees from each of 100 provenances for a total of 27,500 trees. The roots of the trees were washed free of soil in Germany and shipped air freight to New Brunswick. Despite this and the considerable handling they received in Germany and on their arrival in New Brunswick, survival in August 1969 was 80%.

Two replicated trials of provenance of *P. sitchensis* (Bong.) Carr. were established as coastal windbreaks, one in southern Nova Scotia, the other in northwestern Prince Edward Island. A third replicated provenance test of this species was planted at the Acadia Forest Experiment Station. Unreplicated observation plots were established in southern Nova Scotia.

Seed collections of *P. mariana* were made in the Maritimes for the all-range provenance study that is being directed by Dr. E.K. Morgenstern, PFES.

During 1968-69, data was collected from provenance tests of *P. abies* (partial range), *P. glauca* (one all-range and one partial range), and *P. rubens* (one all-range and one partial range). The data have not yet been analyzed.

Larix

Significant differences in average height and average basal areas (10 years from seed) were found among 20 provenances of *L. leptolepis* planted at Acadia Forest Experiment Station. This study also included two provenances of *L. laricina* and three provenances of *L. decidua*. Trees from the best *L. leptolepis* provenances were taller and of greater diameter at breast height than the *L. laricina* or *L. decidua*. The five best provenances of *L. leptolepis* were

Village	Prefecture	Elev m	Avg height m	Avg dbh cm
Nakawa	Nagano	1920	4.32	4.8
Tsumakoe	Gumma	1900	4.31	5.5
Kawakami	Nagano	1500	4.23	4.7
Kilamaki	Nagano	1750-1800	4.21	4.7
Mitake	Nagano	1380	4.19	4.8

Survival ranged from 83 - 92% for all provenances. Porcupines showed a definite preference for *L. decidua* over *L. leptolepis* or *L. laricina*. In *L. leptolepis*, no correlations were established between average heights and the seed source factors of latitude, longitude, or elevation.

Abies - (Christmas trees)

Abies balsamea (L.) Mill. free of damage by the balsam gall midge (*Dasineura balsamicola* Lint.) were selected by personnel of the Forest Insect and Disease Survey. These selections were made in areas where there were heavy infestations of this insect. Susceptible trees were also selected in each area for use as controls. Both the apparently resistant and the susceptible trees were propagated by rooting cuttings and by grafting. This material will be inoculated with gall midge to test further the apparently resistant clones.

Attacks by the balsam gall midge were more intensive on *A. balsamea* than on several non-native *Abies* growing in plantations at Acadia Forest Experiment Station. *A. homolepis* Sieb. and Zucc. appeared to be immune, apparently because its buds burst and needles flushed much later than *A. balsamea*, the normal host species in New Brunswick. The other non-native firs, whose phenology was closer to that of *A. balsamea* (*A. grandis* (Dougl.) Lindl., *A. koreana* Wil., *A. concolor* (Gord.) Engelm., *A. fraseri* (Pursh) Poir, and *A. sibirica* Ledeb.), also appeared to be less susceptible to attack by the gall midge.

A replicated nursery experiment was established in the spring of 1969 to determine if *A. balsamea* provenances from Newfoundland produce trees with superior foliage color for Christmas trees. No marked differences in foliage color were observed during the first growing season.

A replicated test of 13 provenances of *Pseudotsuga menziesii* (Mirb.) Franco, along with several *Abies* species (*A. balsamea*, *A. veitchii* Lindl., *A. sachalinensis* Mast.), and several provenances of *Pinus sylvestris* L. was planted at Acadia Forest Experiment Station. Observation plots of *P. menziesii* were planted by cooperating growers in the Maritimes.

Other species

Tests in coastal windbreaks involving several species and varieties of *Pinus* were planted in two locations in Nova Scotia and one on Prince Edward Island. Dead and missing trees were replaced in two all-range tests of *P. banksiana* Lamb. at the Blackville Fire Tower and near Little Bald Mountain. This was also done for the test of interprovenance hybrids of *P. banksiana* and hybrids of this species with *P. contorta* var. *latifolia* S. Wats.

An all-range provenance study in *Betula alleghaniensis* Britt. was established in the spring of 1968, in cooperation with Dr. K. Clausen, Institute of Forest Genetics, Rhinelander, Wisconsin. Some trouble was experienced in the spring of 1969 with white grubs that stripped the roots of the seedlings.

GENECOLOGY OF RED AND BLACK SPRUCE

Red spruce is highly susceptible to defoliation by spruce budworm (*Choristoneura fumiferana* Clem.); black spruce is relatively resistant. An assessment of the hazard to defoliation by cover type is difficult due to the array of intermediate types between red and black spruce. Difficulties in distinguishing the two species have been attributed to extensive hybridization. Morgenstern and Farrar (1964) presented convincing evidence to show that hybridization and further introgression are common where species are sympatric.

The objectives of this project are to develop satisfactory field methods for distinguishing red, black, and intermediate spruces; to establish the frequency and distribution of natural hybridization in central

New Brunswick and elsewhere in the Maritimes; and to evaluate ecological implications of hybridization.

A hybrid index, supplemented by quantitative measurements, was developed from study of experimental hybrids, provenance material, and natural stands (both pure and introgressed) and was used to identify individual trees and stands. Differences described in the index included needle configuration, apex shape, and color; twig ridges, bark color, and hair type; bud color and scale tips; color of mature and immature cones; cone shape, scale edges, stalk, flexibility, persistence, and location; branch size; mature bark; and crown shape.

The largest area of contact for the two species in New Brunswick proved to be the New Brunswick Lowland. The Lowland is a gently undulating plain, characterized by elevated bogs and hills with just enough elevation to support red spruce-tolerant hardwood mixtures. Contact is common along the gentle slopes and is further increased by the extensive disturbance that has occurred in the area. Selection of sample areas was related to configuration of landforms. Transects of plots were established along slopes reaching from red spruce-hardwood upland to black spruce bogs or flats. Continuous stands of "spruce" were described with a large local sample. Fifty plots were established. Two transects and a local sample were studied outside the Lowland to ascertain the effect of topography. Each site of the 50 sample plots was described in terms of:

1. Hybrid index of trees (12 trees were chosen at random in bogs or tolerant hardwood sites, 24 trees at the edges of "pure" stands, on intermediate slopes, or on flats).

2. Moisture regime (according to Hills, 1950).

3. Ground vegetation (percentage cover of each species on 0.1-acre plots).

4. Soil pH, soil profile, and forest cover type.

Data indicated that red and black spruces have hybridized extensively in the New Brunswick Lowlands. Introgressed stands and hybrid swarms were identified on all intermediate slope positions and flat plateaus. Introgression was two-directional but more frequently in favor of black spruce. Parental species remained phenotypically pure in their respective ecological niches. Logging and frequent fire, and possibly periodic budworm damage to red spruce, may be responsible for the predominance of black spruce. In several areas, introgressed stands and hybrid swarms represent the most common forest cover type over as much as 100 to 200 square miles. Hybridization was confined to areas where topography does not adequately separate red and black spruce. Large introgressed populations were not found in the central Highlands of New Brunswick. Field work in southern New Brunswick and Nova Scotia indicates similar trends.

Habitat relationships indicated that hybridization is closely correlated with site factors. Hybridized populations were found on sites that had combinations of the characteristics that are associated with the parental species. Wet, acid, sphagnum-dwarf shrub, or dry, acid, dwarf shrub sites characterized black spruce samples. Well-drained, moderately high pH, herb-rich sites characterized red spruce samples. The frequency of dwarf shrub vegetation increased with the frequency of black spruce types. In individual transects, the hybrid composition was related to moisture regime (M.R.) and pH. Lower pH values (3.5-4.5) and dry or wet sites (M.R. 2 or 5-6) were associated with black spruce. As moisture conditions improved, the proportion of red spruce types increased. Black spruce could be found in all but herb-rich sites after fire, a situation probably dependent on local forest composition and severity of the fire.

It was demonstrated that the severity of budworm damage was related to the genotype of individual trees. Sixty-six trees in a transect near Napodogan, N.B., were rated for budworm damage by personnel of the Forest Insect and Disease Survey. These same trees were scored by the hybrid index and it was found that the more closely an individual tree resembled red spruce, the greater was the severity of budworm damage (Manley and Fowler 1969).

On many intermediate sites, the species composition of the understory was observed to differ from that of the mature stand. Sapling hybrid index scores indicated a trend towards red spruce. To determine the successional trends, and to test the response of the parental species and intermediates to a shade factor, all possible crosses between three replicated sets of five trees intergrading from red to black spruce in 25% classes were control crossed to obtain hybrid progeny. The seedlings will be planted in natural stands (both pure and introgressed) for observation and measurement. The first crosses have been completed, and the seed is being extracted. The experiment will be repeated this year, provided there is adequate flowering.

The extent of hybridization in other areas of the Maritimes is being examined at present. Random samples were collected from spruce populations in parts of Nova Scotia. This work will be continued. Some line transect work over areas as large as 100 square miles is expected to determine more accurately the frequency of hybrid types.

HAPLOID AND HOMOZYGOUS DIPLOID TREES

Young mega- and microsporangiate strobili were collected at weekly intervals in late spring and early summer. Megagametophytes and microsporophylls carrying immature microsporangia, were dissected aseptically and transferred to a variety of culture media.

Megagametophytes collected between 2 weeks before and 2 weeks after fertilization grew in culture. Most growth was obtained on White's medium supplemented with casein hydrolysate and coconut milk. On this medium, small calluses developed from the gametophytic tissues. Inside the gametophytes, layers of spindle-shaped cells were formed in various locations.

Abundant callus was obtained in cultures of the microsporophylls. Some of this callus originated from the diploid sporophyll and sporangial tissues, and some developed from the immature microspores. Smear preparations of samples of the calluses from the microspores showed haploid mitotic configurations. These haploid calluses grew better on Brown and Lawrence's medium than on the supplemented White's medium. Cultures of pollen matured on the tree failed to produce callus.

The calluses derived from the immature microspores did not show any differentiation, but were considerably larger than those from the megagametophytes.

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INTERACTION OF GIBBERELLIC ACID AND PHOTOPERIOD ON REPRODUCTIVE AND VEGETATIVE GROWTH OF WHITE CEDAR SEEDLINGS (THUJA OCCIDENTALIS L.)

D.A. Fraser
Dept. of Geography, Sir George Williams University, Montreal, formerly of the Petawawa Forest Expt. Station, Chalk River, Ont.

Gibberellic acid (GA_3) has induced early flower formation in many plants including the western red cedar (*Thuja plicata* Donn) Pharis and Morf 1968) and eastern white cedar (Fraser 1969). Whereas Pharis and Morf did not treat their seedlings until they were 1 year old, Fraser was especially interested in the differential responses inherent with seedling age. To ascertain the earliest time of potential cone formation after the germination of seeds, freshly germinated seedlings were grown under different photoperiods (PP) in growth chambers at 21°C and treated weekly with an aqueous-Tween-20 foliar spray of 100 ppm GA_3.

Under 8-hr PP the seedlings grew about 5 mm in 3 weeks and then ceased growth (Fig. 1). The apical growth of the very young seedlings was completely inhibited by a combination of an 8-hr PP and GA_3 treatment. Under 16-hr PP growth continued indefinitely, but when GA_3 was applied, apical growth reached 10 mm in 3 weeks and then ceased. Under 24-hr PP, growth was again continuous. When GA_3 was applied to seedlings under this PP, apical growth continued for the first 3 weeks, then stopped for 7 weeks, to be resumed after this time. GA_3 usually has an inhibitory effect which is accentuated during the shorter PP. The initial GA_3 inhibition diminishes after 7 weeks of continuous treatment under the long PP.

The inhibitory effect of GA_3 is also evident when treatment is postponed until the seedlings are 2 months old (Fig. 2). Inhibition is again greatest under the shorter PP. That the length of the dark period is also critical for growth of white cedar was evident when growth under 6-hr Light (L) : 6-hr Dark (D) : 6-hr L : 6-hr D was compared with that under 12-hr L : 12-hr D PP. Elongation was greater under the 6 hr regime.

The above experiments have indicated that white cedar from Petawawa is sensitive to PP when the whole range of light and dark periods is investigated. The reaction to GA_3 varies with plant species and concentration, and this is even more distinct between softwoods and hardwoods (Fraser 1958).

Cone production has been induced within 3 months of seed germination under GA_3 and long PP treatment. Both the usual two seeds per cone-scale and more prolific multiples (3) were formed (Figs. 3 and 4). Investigations are continuing on the production of viable seed within a reduced time period from seed germination. The practical applications are obvious both for breeding purposes and quick seed production within a limited space. The application of foliar sprays of different sugars increases growth and food reserves.

White Cedar

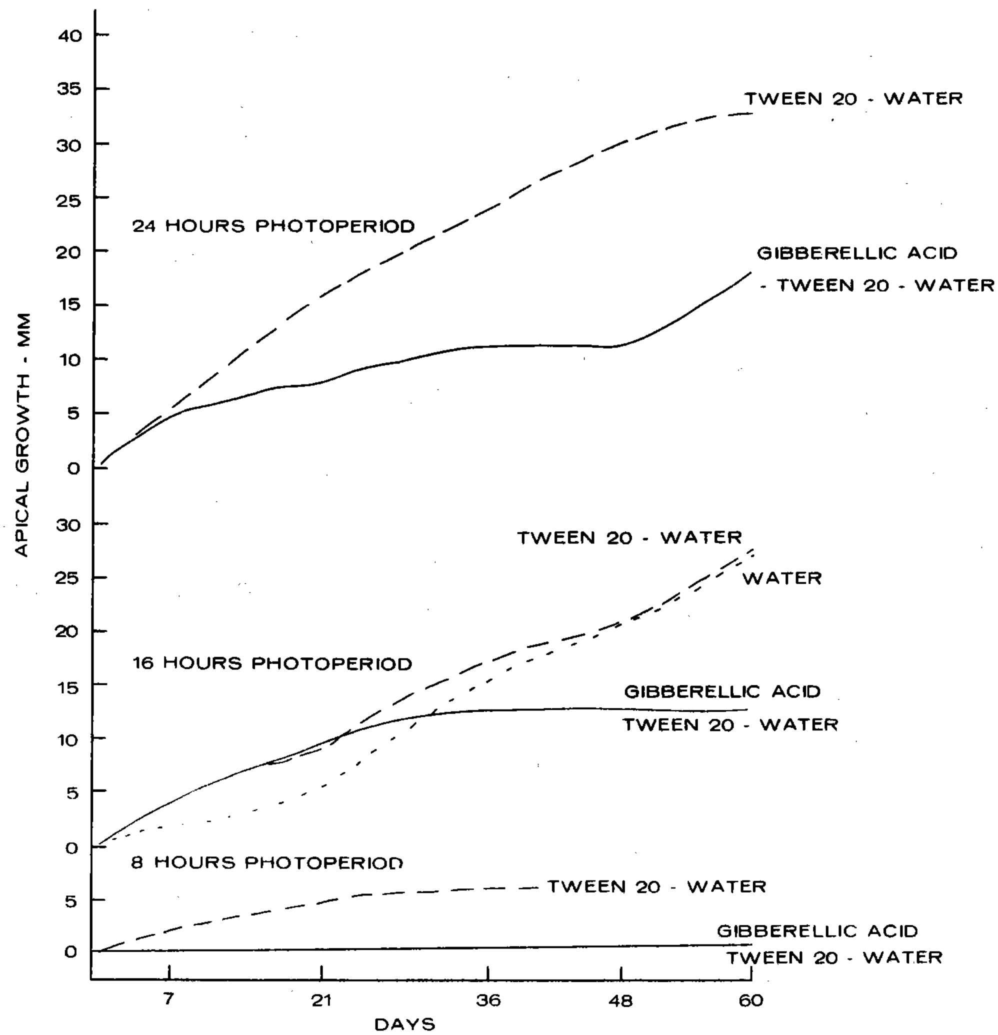

Figure 1. Growth of white cedar seedlings for 60 days after seed germination. Treatments included three photoperiods at an air temperature of 21°C and a foliar spray of 100 ppm GA_3 every week.

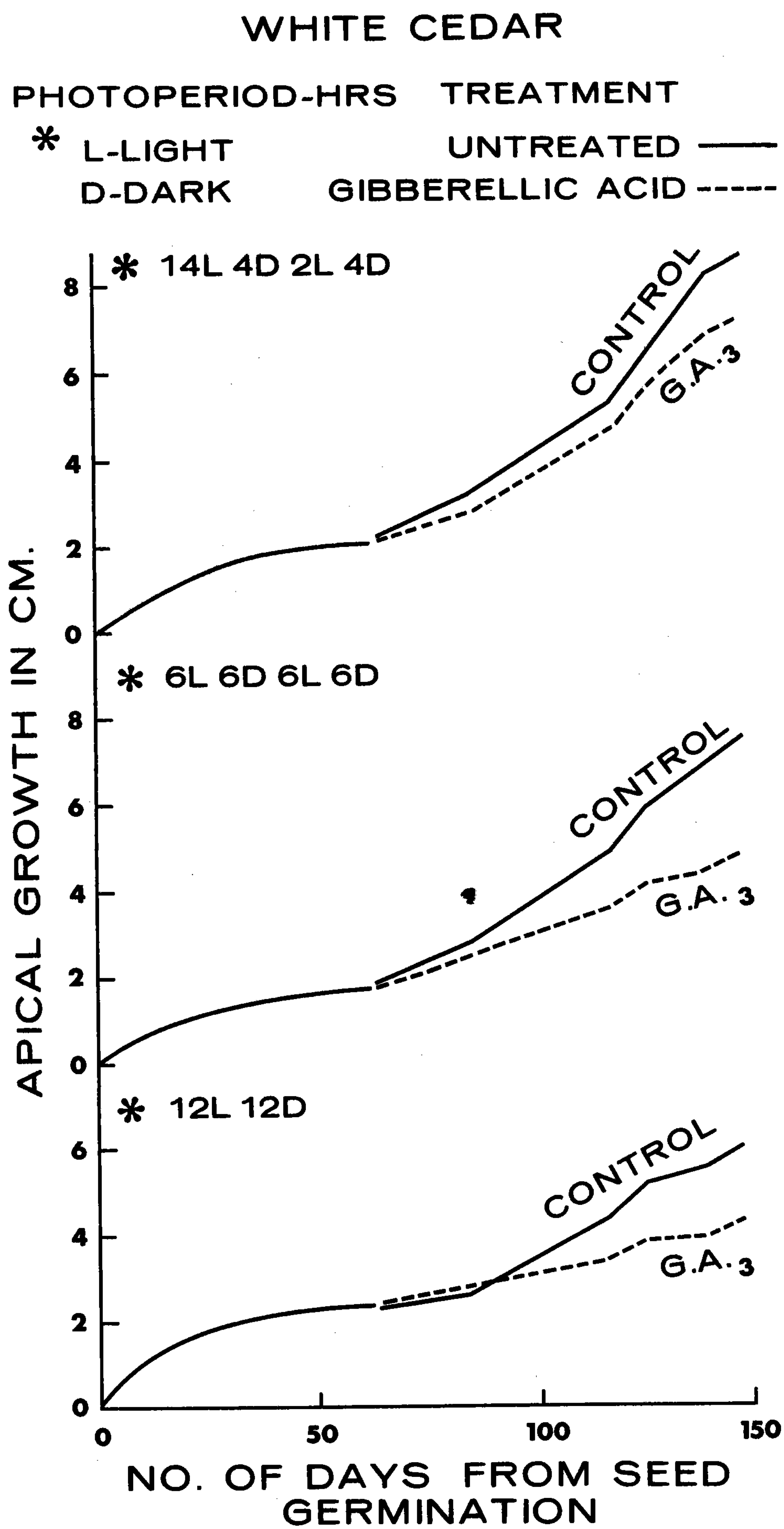

Figure 2. Growth of white cedar seedlings for 150 days after seed germination. Seedlings grown under three photoperiods at an air temperature of 21°C. Weekly GA_3 foliar treatments started when the seedlings were two months old.

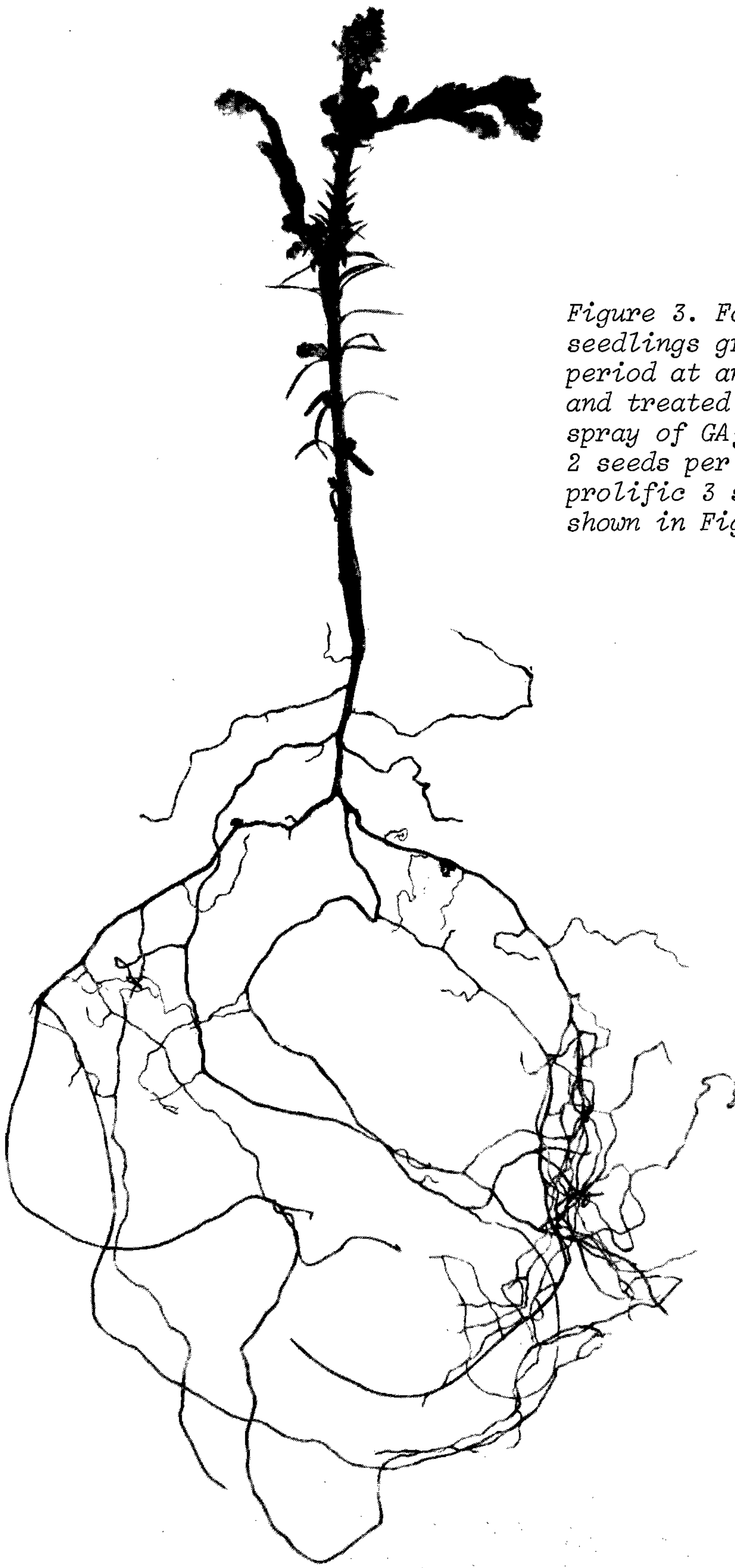

Figure 3. Four month old white cedar seedlings grown under 24-hr photoperiod at an air temperature of 21°C and treated with a weekly foliar spray of GA_3. Formation of the usual 2 seeds per cone scale and the more prolific 3 seeds per cone scale are shown in Figure 4.

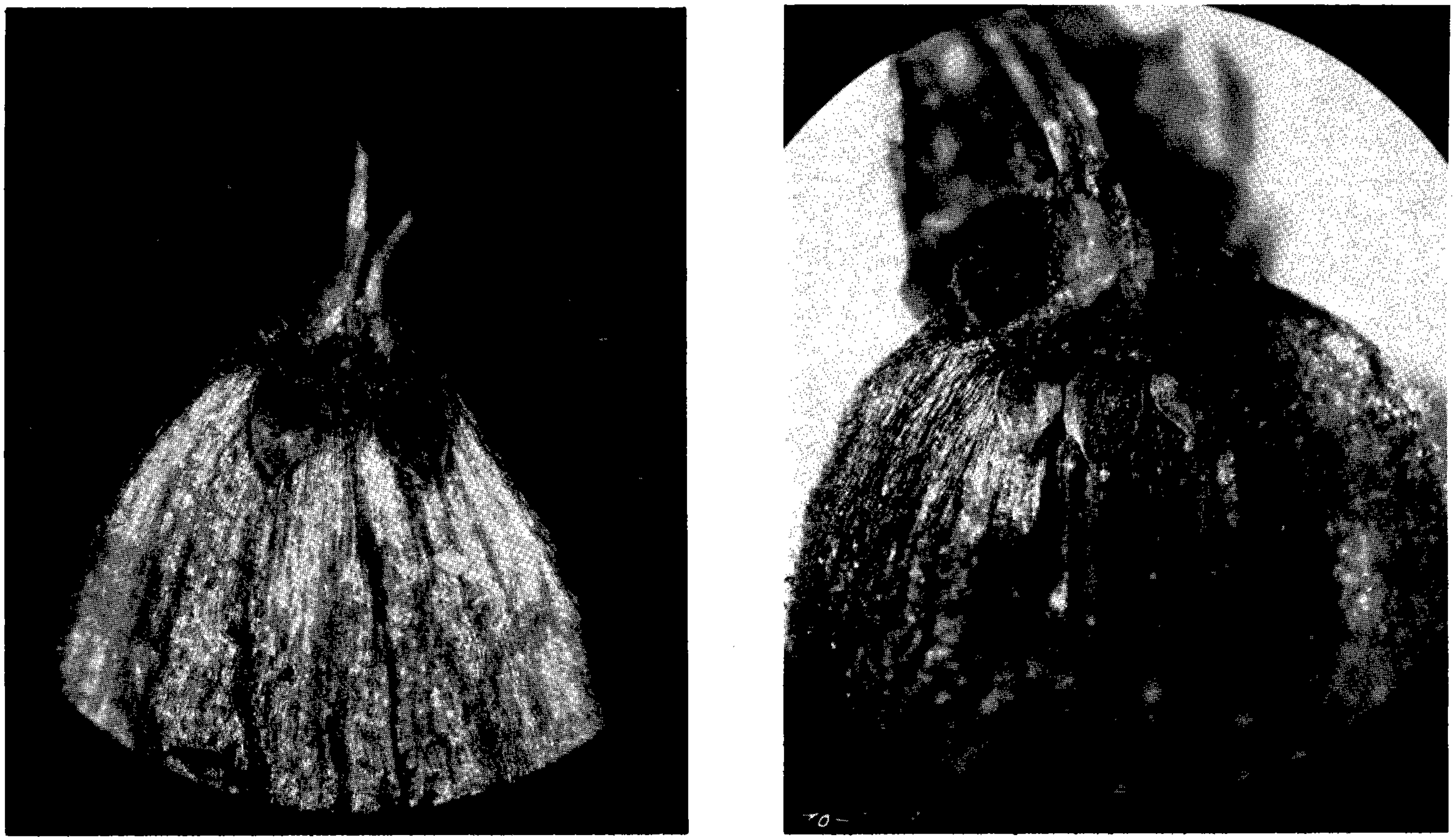

Figure 4. Formation of the usual two seeds per cone scale (left) and the more prolific three seeds per cone scale (right).

Investigations with other coniferous species, notably black spruce (*Picea mariana* (Mill.) B.S.P.), have shown promise. Foliar sprays with indole-3 acetic acid have produced copious side branch development. This is of practical significance, for such seedlings will provide more abundant material for reproduction of new individuals by layering. The use of photo- and thermoperiod, as described earlier by Fraser (1969), has proven effective in the stimulation of abundant cone production. Again a practical application is indicated by the abundant production of reproductive buds in a young plantation of black spruce in 1969, followed by their development into healthy cones in 1970 on the Corry Lake Tree Physiology Area at PFES.

ACKNOWLEDGMENTS

Members of the former tree physiology Section at the Petawawa Forest Experiment Station assisted in the conduct of the experiments and Graphic Services of the Department of Fisheries and Forestry helped in the preparation of the figures.

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SUMMARY REPORT ON FOREST TREE IMPROVEMENT 1968 - 1969

L. Parrot
Faculté de Foresterie et de Géodésie, Université Laval, Québec, Qué.

HARDWOODS

Juglans nigra

A well defined pattern of genetic variation in winter hardiness among 17 provenances of black walnut and an old provenance plantation with significant resistance of the remaining trees after almost a century of growth led to the conclusion that some individuals that originated from the northern part of the natural range of black walnut can thrive in our latitude when the soil is also carefully selected.

These individuals constitute good material for breeding and could make possible the production of genetically improved trees.

In 1967, some of the best genotypes were then crossed, using five different female parents. A total of 493 nuts was produced. Nut collection in the fall of 1967 was followed by nursery stratification and sowing.

In 1968, a total of 329 seeds germinated and seedlings (1 - 0) were planted in the field the following year. Survival is 90% for this full-sib progeny test.

Grafting of black walnut met with little success - only 12% take.

Juglans cinerea

A genecological study was initiated in 1969 with material covering the entire natural range of the species. The preliminary data are recorded by M.D. Robert, graduate student.

Acer saccharum

Sugar content study. A 5-year study to evaluate the variation in sugar content of the sap led to the conclusion that significant variation although rare, exists (Parrot 1969).

Provenance study. A provenance plantation of some 26 origins has been established in 1969 in cooperation with the Northeastern Forest Experiment Station, Burlington, Vt., U.S.A.

CONIFERS

Picea glauca (Exp. 292-E)

In cooperation with Ministère des Terres et Forêts, Service de la Recherche, Québec, and the Department of Fisheries and Forestry, Québec

Region, three plantations, involving 40 provenances were established in different locations in western, central and eastern Québec. In western Québec, the material was divided into two large plantations: the first one being at Trécesson Co. of Abitibi-ouest (48°35'N); the second being at N-D-du-Nord Co. of Abitibi-est (47°35'N) near Lac Témiscamingue.

Picea abies (Exp. 310-A-4 and 277-D)

These two different experiments were also established in the same locations described above. The number of provenances for each experiment is 22.

Pinus resinosa (Exp. 216-D)

All data concerning yield, height, and phenology were taken during 1968-69 and correlated with climatic data. After eight growing seasons, heights ranged from 84 inches (210 cm) for No. 3140 to 113 inches (286 cm) for No. 3139. By extrapolation, a 30% increase in volume at the time of logging by planting the best provenances would be expected.

Pinus banksiana (255-A-5-I)

All data concerning leaf analysis of the main elements and height were taken and correlated.

ACADEMIC PROGRAM

The undergraduate course on forest genetics and tree breeding is given each year. Five students are preparing their thesis in this field.

Lectures at the graduate level were given last year and two graduate students are working for their Master's degree.

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FOREST GENETICS AND TREE IMPROVEMENT RESEARCH, IN QUEBEC

L. Roche
Canadian Forestry Service,
Forest Research Laboratory, Ste-Foy, Que.

Following the establishment of a seed laboratory for processing relatively large numbers of small seed lots, emphasis was directed towards the assessment of geographic variation in Quebec's major commercial species, black spruce (*Picea mariana* (Mill.) B.S.P., balsam fir (*Abies balsamea* (L.) Mill.), and yellow birch (*Betula alleghaniensis* Britton).

The justification for this approach may be stated as follows. First there is a pressing need for the establishment of seed zones so that the genetic potential of each seed lot used in expanding reforestation programs is fully exploited. Secondly, it is assumed that it is highly desirable to have a knowledge of genetic variation within the species before initiating a program of selection and breeding. A further assumption is that an introduced species may show superior growth in regions for which no suitable indigenous species is available.

Seed collections have been completed, and processed for both black spruce and yellow birch, and in the spring of 1969, 400 progenies representing 40 provenances of yellow birch were sown in six replications at the Valcartier research nursery. In the spring of 1970, 100 provenances of black spruce seed were sown in six replications in the same nursery, and black spruce seed was forwarded to four collaborators. Seed collections are not yet completed for balsam fir.

In addition to the major investigations referred to above, other provenance trials of native and exotic species involving small numbers of provenances were either measured or established. These included white spruce (*Picea glauca* (Moench) Voss), red spruce (*P. rubens* Sarg.), Engelmann spruce (*P. engelmannii* Parry), Norway spruce (*P. abies* (L.) Karst), jack pine (*Pinus banksiana* Lamb.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), and *Larix* and *Abies* species. Many of these species trials have been established with material supplied by the Petawawa Forest Experiment Station, and there is close cooperation between this Station and the Quebec Laboratory in regard to provenance investigations.

Inbreeding and intra- and inter-specific crosses have been completed using diverse provenances of red and black spruce. Laboratory studies of seed quality by X-ray and other techniques are continuing.

Genecological, breeding and seed quality investigations have provided experimental material and criteria for research projects which are now being developed within the same problem area research program. These include propagation of spruce by cuttings and physiological studies on seedlings of diverse black spruce provenances in controlled environments.

The principal objective of all studies within the Tree Improvement Problem Area Research Program in the Quebec Laboratory is to provide the silviculturist and forest manager with information which will allow the maximum utilization of the genetic potential of the species being planted. Thus the program is being developed in close cooperation with representatives of the Quebec Department of Lands and Forests, of Industry, and of the University of Laval.

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RAPPORT AU COMITÉ CANADIEN D'AMÉLIORATION DES ARBRES FORESTIERS

Gilles Vallée
Section de la génétique, Service de la recherche, ministère des Terres et Forêts du Québec, Qué.

INTRODUCTION

Devant l'importance grandissante du reboisement au Québec et de la ligniculture dans le monde en raison de la consommation croissante du bois, le Service de la recherche du ministère des Terres et Forêts a mis en oeuvre un "Programme général pour l'amélioration des arbres forestiers au Québec" rédigé par le Dr G. Vallée (1969), dont la rédaction était terminée en novembre 1969. Le programme fut présenté, et fut par la suite accepté par le Comité de coordination du Service de la recherche et par les autorités du Service de la restauration et de la Direction générale de la planification au ministère des Terres et Forêts. Dans ce programme, l'auteur expose les principes généraux qui devraient être observés dans les projets de recherche et d'application en amélioration des arbres forestiers au Québec.

Le programme a été soumis à la critique de spécialistes ou de praticiens directement ou indirectement reliés à ce sujet. Généralement, les personnes consultées ont été enthousiasmées par le programme et y ont été favorables, et leurs remarques et suggestions constructives ont permis d'apporter des modifications bénéfiques.

Entre-temps, des démarches ont été faites pour la création d'un "Comité technique de coordination des recherches en génétique forestière au Québec", sur demande des chercheurs et autres personnes intéressées par le sujet. La réalisation de ce comité et l'acceptation finale du programme sont entre les mains du "Conseil de la recherche et du développement forestiers du Québec".

Pendant ces deux dernières années, l'équipe de la section de génétique du Service de la recherche s'est appliquée à l'élaboration de l'infrastructure et à la mise en marche des projets de recherche conformes aux besoins immédiats du ministère des Terres et Forêts et de l'industrie forestière.

C'est ainsi qu'une pépinière répondant aux exigences de la recherche et deux serres avec une annexe sont en voie de parachèvement à Duchesnay, situé à 25 milles au nord-ouest de Québec. De plus, un réseau de secteurs expérimentaux a été commencé dès l'été 1969; il comprendra 22 stations réparties sur le territoire forestier du Québec. Ces secteurs nous permettront de regrouper les plantations comparatives faites au Québec pour une surveillance et un entretien plus attentifs et afin d'obtenir des informations pouvant être généralisées.

Le personnel actuel de la section de génétique, qui s'occupe de la réalisation des projets en cours, est composé de trois chargés de recherche, MM. Claude Chouinard, A. Stipanicic et Gilles Vallée, de deux techniciens, MM. Richard Dubé et Borromée Gaulin, ainsi que d'un coopérant technique français, M. Daniel Cornu, ingénieur agronome.

L'auteur tient à remercier tout ceux qui par leurs conseils et leur confiance l'ont encouragé à oeuvrer dans le domaine de l'amélioration des arbres forestiers.

PROGRAMME GÉNÉRAL POUR L'AMÉLIORATION DES ARBRES FORESTIERS AU QUÉBEC PROJET EN COURS DE RÉALISATION

PROGRAMME : 1

Sélection et établissement de peuplements semenciers "plus" dans les espèces autochtones et exotiques les plus utilisées dans les reboisements.

Plusieurs projets d'établissement de peuplements semenciers sont en voie de réalisation. Ces travaux sont coordonnés par des ingénieurs du Service de la restauration du Ministère qui veillent à faire respecter des normes strictes dans le choix et l'aménagement des peuplements.

PROGRAMME : 2

Sélection d'arbres "plus" et réalisation de vergers à graines.

Projet Sg 68-1 (*2 Po ai ta*)*. Sélection de peupliers des sections *Aigeiros* et *Tacamahaca* et leurs hybrides.

Dans une première étape, on a surtout réuni en pépinière quelques 175 clones provenant d'arbres croissant naturellement au Québec et appartenant aux espèces *Populus deltoides*, *P. nigra* et *P. balsamifera* et leurs hybrides. Au printemps 1969, trois plantations comparatives ont été établies, dont deux au populetum de Matane et une sur sol tourbeux à Duchesnay. Quelque 30 clones furent utilisés pour ces plantations, dont 10 sont des clones exotiques connus et 20 sont des clones provenant de la vallée du Saint-Laurent et qui semblent les plus prometteurs parmi la collection faite en 1968.

En septembre 1969, une première observation sur les maladies des feuilles a été faite, parmi les clones récoltés dans la vallée du Saint-Laurent; 18 de ces clones semblent totalement résistants ou peu vulnérables. D'autres observations seront faites en 1970 pour nous assurer de la résistance des clones aux maladies des feuilles et aux déformations de la pousse

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*Sg 68-1 (*2 Po ai ta*) signifie que c'est un projet de la division sylviculture (S) et de la section génétique (g) commencé en 1968 (68) en tant que premier projet (1) du programme 2 portant sur les *Populus* des sections *Aigeiros* et *Tacamahaca (2 Po ai ta)*.

terminale. Tous les clones ne montrant pas une résistance suffisante seront rejetés.

En ce qui regarde l'aptitude au bouturage, nous devons mentionner une très forte variation dans les populations de *Populus deltoides*.

Dans le bassin de la rivière Matane, des superficies de terrain ont été aménagées pour l'établissement d'un populetum. Les caractéristiques de ce secteur expérimental sont données aux tableaux 1 et 2. Ce populetum a été créé dans le but de sélectionner des clones et entreprendre des recherches sylviculturales sur le peuplier pour répondre aux besoins de la région où une usine de cartonnage est installée.

Pour 1970, nous prévoyons poursuivre la récolte de clones au Québec en utilisant la méthode de bouturage des pousses feuillées de l'année (Koster 1968), ce qui permettra de sélectionner des sujets exempts de maladies foliaires. De plus, nous espérons faire une récolte de lots de graines sur des peupliers poussant naturellement ou en plantation; ces graines seront ensemencées à la pépinière de Duchesnay en vue de sélection sur les semis.

Projet Sg 69-4 (2 *Po lc*). Sélection de clones de peupliers de la section *Leuce*.

Des semences de *Populus alba* et *P. tremula* ont été semées au printemps 1969 et ont donné 400 plants sur lesquels sera pratiquée une sélection.

Durant l'été 1969, nous avons trouvé 15 plants hybrides, probablement entre *P. alba* et *P. grandidentata* ou *P. deltoides*, dont certains étaient de très belle venue avec une croissance comparable à celle des plants de *P. deltoides* poussant aux mêmes endroits. Malheureusement, les essais de bouturage n'ont pas réussi mais nous comptons reprendre l'échantillonnage en 1970 et utiliser la méthode de Koster pour les bouturer.

Par l'entremise des accords de coopération technique France-Québec, nous espérons accueillir en 1970 du personnel français qui travaillera à la sélection de clones de *Populus tremuloides, P. grandidentata* et *P. balsamifera* à l'intérieur d'une région de l'est du Québec.

Projet Sg 69-9 (2 *P g*). Verger à graines réalisé à Duchesnay sur sol tourbeux à partir de semis 3-0 de *Picea glauca* (Moench) Voss obtenus d'une sélection massale. Ces semis proviennent de peuplement de belle venue de la pépinière de Grandes-Piles.

Projet Sg 69-8 (2 *P ab*). Verger à graines réalisé à Duchesnay et à Parke à partir de semis 3-0 de *Picea abies* (L.) obtenus d'une sélection massale. Ces semis proviennent des plantations de la région de Grandes-Piles, considérées comme une très bonne provenance.

PROGRAMME : 3

Projet Sg 68-2 (*3 spp*). Introduction d'espèces exotiques et création d'arboreta.

Nous avons écrit à environ 50 organisations de différents pays pour obtenir des semences d'espèces forestières pouvant présenter un intérêt, soit pour les reboisements au Québec, soit comme source de gènes. A date, nous avons reçu les semences de 60 espèces de 300 provenances différentes.

Au printemps 1969, nous avons ensemencé 25 espèces, issues de 65 provenances, à la pépinière de Berthierville. Nous prévoyons ensemencer 35 autres espèces au printemps 1970 à la pépinière de Duchesnay.

PROGRAMME : 4

Test de provenances et de descendances.

Projet Sg 69-5 (*4 P ab*). Test sur 22 provenances de Pologne et 22 provenances d'Europe de *Picea abies* (L.).

Projet Sg 69-6 (*4 P g*). Test sur 41 descendances de *Picea glauca* (Moench) Voss provenant surtout de la vallée de l'Outaouais.

Ces tests furent réalisés en collaboration avec le Dr L. Parrot et le Dr L. Roche. Trois dispositifs ont été installés par le Dr Roche à la Station de Valcartier tandis que nous en avons installé trois à l'arboretum de Trécesson, deux à celui de Guigues et trois à celui de Saint-Ignace-des-Lacs.

Les semis 2-2 utilisés pour les plantations comparatives ont été obtenus de la Station forestière expérimentale de Petawawa à qui nous adressons nos remerciements.

Les dispositifs de Trécesson et de Guigues seront étudiés par le Dr L. Parrot tandis que ceux de Saint-Ignace-des-Lacs seront suivis par le Dr Gilles Vallée et l'ingénieur Claude Chouinard.

Projet Sg 69-7 (*4 Ps me*). Test de provenances sur *Pseudotsuga menziesii* (Mirb.) Franco.

En 1969, nous avons obtenu 59 provenances de Sapin de Douglas du *Working Group for Procurement of Seed for Provenance Research* auquel a adhéré le Service de la recherche du ministère des Terres et Forêts du Québec.

Au printemps 1970, un dispositif à blocs complets comprenant quatre répétitions sera ensemencé à la pépinière de Duchesnay. L'étude de ce dispositif nous permettra d'élaborer et de planifier les tests qui seront entrepris sur ces provenances.

Projet 69-10 (*4, 2 Pi bk*). Test de provenances et de descendances sur *Pinus banksiana* Lamb.

Une récolte de semences par arbre a été commencée à l'automne 1969 et sera continuée en 1970 et 1971.

Pour chaque provenance nous avons choisi une vingtaine d'arbres de belle venue sur lesquels des cônes et des ramets sont récoltés et gardés séparément pour chaque individu. Ce test nous permettra de constituer des vergers à graines par la sélection de famille et de semis tout en fournissant des informations sur la population du Pin gris au Québec. Nous remercions M. J.M. Conway, ing.f., de la Consolidated-Bathurst, qui a facilité une récolte de graines dans le bassin de la rivière Mattawin.

PROGRAMME : SE

Projet Sg 68-SE. Réalisation d'un réseau de secteurs expérimentaux pour l'amélioration des arbres forestiers.

Le titulaire de ce projet est M. Claude Chouinard. Les principes suivis pour la réalisation de ce réseau ont été exposés dans le "Programme général pour l'amélioration des arbres forestiers".

Ces secteurs sont destinés aux études suivantes: (a) introduction d'espèces exotiques, (b) tests de provenances et de descendances, (c) vergers à graines, (d) "pool" de gènes et (e) sélection clonale. Les superficies de terrain réservées pour les secteurs sont aussi disponibles pour les chercheurs et praticiens d'autres organisations.

Les secteurs expérimentaux seront distribués en fonction des grands écosystèmes afin d'obtenir une représentation adéquate des diverses conditions écologiques du Québec forestier, nous permettant ainsi de généraliser les résultats obtenus. Ces secteurs seront établis sur les sols les plus représentatifs des sections forestières tout en tenant compte de l'utilisation future de ceux-ci.

Pour répondre aux objectifs fixés, chaque secteur expérimental comprendra une superficie d'au moins 500 acres. Graduellement, des superficies de terrain seront préparées (dégagement du terrain et scarifiage des sols) pour permettre l'établissement de dispositifs expérimentaux.

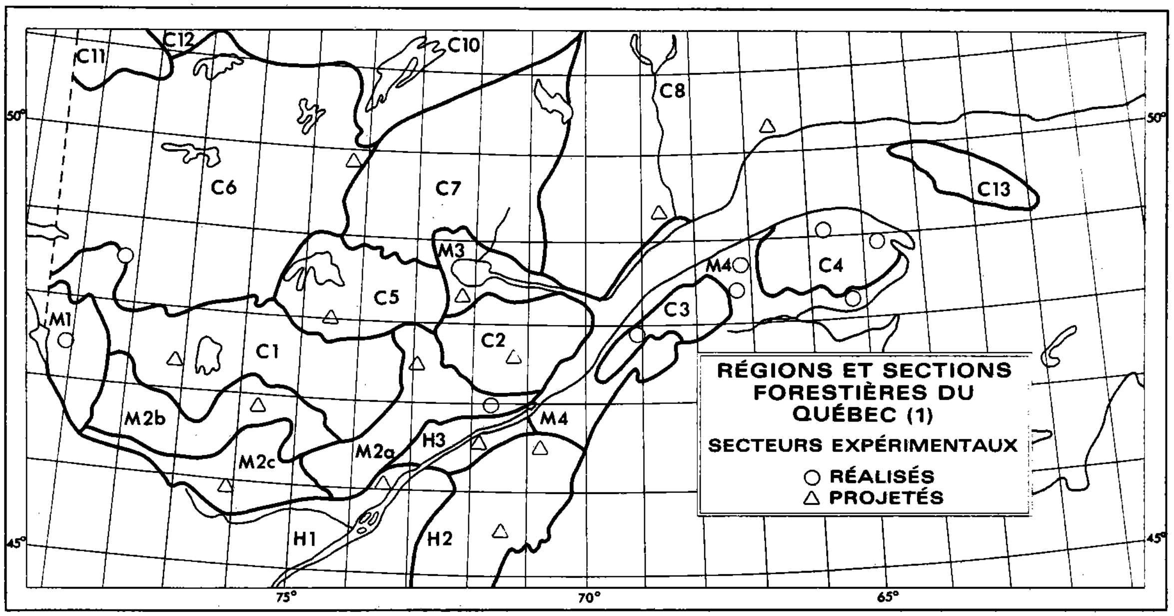
On trouvera ci-joint une carte montrant la distribution des secteurs et deux tableaux donnant les caractéristiques écologiques, climatiques et géographiques des secteurs actuellement établis.

RÉFÉRENCE ET PUBLICATIONS

Koster, R. 1968. Outdoor propagation from leaf cuttings of *Populus deltoides*, balsam poplar and hybrids. FAO, Fo: CIP/13/3.

Vallée, G. 1969. Programme général pour l'amélioration des arbres forestiers au Québec. Service de la recherche, Direction générale de la planification, ministère des Terres et Forêts, Québec.

Vallée, G. 1969. La culture de l'arbre peut accroître considérablement la production ligneuse au Québec. Papetier, février 1969.



D'Après Villeneuve 1946 (Quebec Dept. Lands and Forests, Meteorol. Bur. Bull. 6) et Rowe 1959 (Can. Forest. Br. Bull. 123).

Tableau 1. Caractéristiques écologiques des secteurs

Arboreta	Lieu	Principales séries	Bioclimat	Vocation	Dépôts de surface	Drainage
Parke	Cté Kamouraska, Canton Parke, rangs C et B, Réserve cantonale de Parke	Sapinière à Bouleau blanc	Froid, continental	Forestière	Till limono-schisteux	Bon
Matapédia	Cté Matapédia, Seigneurie du Lac Matapédia	Érablière à Bouleau jaune	Frais, continental	Agro-forestière	Till limono-calcaireux	Assez bon
Lac-St-Ignace	Cté Gaspé-Nord, Canton Tourelle, rang XI, lots rétrocédés	Sapinière à Bouleau blanc	Froid, continental, humide	Forestière	Till schisteux avec blocs erratiques	Très bon
Gaspé	Cté Gaspé-Nord, Canton Baie de Gaspé-Sud, Forêt domaniale de Gaspé	Sapinière à Épinette noire	Très froid, continental, humide	Forestière	Till grèseux et schisteux avec blocs erratiques	Très bon
Bonaventure	Cté Bonaventure, Canton Cox, rangs XIII et XII, lots vacants	Sapinière à Érable rouge et érablière à bouleau jaune	Relativement chaud, maritime	Agro-forestière	Till calcaire mince	Bon
Matane (Populetum)	Cté Matane, Canton Cuoq, rang III, lots 17 à 21	Sapinière à Bouleau jaune	Très frais, continental	Forestière	Till schisteux fluvio-glaciaire et dépôts alluvionnaires	Bon
Duchesnay	Cté de Portneuf	Érablière à Bouleau jaune	Relativement chaud, continental, humide	Forestière	Till indifférencié granitique sur substratum rocheux	Très bon
Trécesson	Cté Abitibi-Est, Canton Trécesson, rangs I et II	Épinette noire	Très froid, continental, relativement sec	Forestière	Dépôts lacustres argileux et sablonneux	Variable, très bon à médiocre
Guigues	Cté Témiscamingue, Canton Guigues, rangs III et IV	Érablière à Bouleau jaune	Relativement chaud et sec	Agro-forestière	Dépôts fluviaux et lacustres argileux à limon sablonneux	Bon

Tableau 2. Caractéristiques géographiques et climatiques des secteurs expérimentaux.

Secteurs expérimentaux	Altitude	Latitude	Longitude	Température F		Précipitation annuelle (pouces)	Longueur de la saison sans gel (jours)
				moyenne juin, juillet, août	minimum absolue		
Bonaventure	500-800	48°10' N	65°20' O	60.7	- 33	45	100-120
Duchesnay	500-1100	46°52' N	71°37' O	59.7	- 43	46	120-140
Gaspé	660-1100	48°50' N	64°40' O	61.2	- 44	36	100-120
Guigues	600-700	47°37' N	79°30' O	62.9	- 45	37	120-140
Lac St-Ignace	1500-2150	49°00' N	66°20' O	58.9	- 44	39	100-120
Matapédia	600-800	48°30' N	67°25' O	60.1	- 45	35	80-100
Matane (popul.)	300-1000	48°40' N	67°15' O	57.5	- 45	35	80-100
Parke	1100-1200	47°30' N	69°30' O	61.2	- 43	39	80-100
Trécesson	1000-1200	48°40' N	78°30' O	59.0	- 56	33	80-100

SEED ORCHARDS AND SEED PRODUCTION AREAS IN ONTARIO

W.G. Dyer
Timber Branch,
Ontario Department of Lands and Forests, Toronto, Ont.

SEED ORCHARDS

There were no additional seed orchard sites established in the past two-year period. A proposed seed orchard site for white and black spruce of Site Region 4W source has been located in Pearson Township, Thunder Bay District. Initial plantings at this location are being considered for the spring of 1971. Seed orchards previously established were enlarged in 1969 and 1970. Table 1 shows the number of clones and acreage planted in the last 2 years and total to date.

Table 1

		Planted 1969		Planted 1970		To Date	
Species	Location	No. of Clones	Acres	No. of Clones	Acres	No. of Clones	Acres
White Pine	Lindsay District Orono Nursery	x	refill	-	-	x	24.5
Red Pine	Swastika District Grenfell Township	11	1.0	-	-	59	23.0
White Spruce	L. Simcoe District Nursery	5	refill	7	refill	21	4.0
White Spruce	Thunder Bay District Camp 503	21	4.0	20	3.0	31	15.0
Black Spruce	L. Simcoe District Midhurst	11	refill	8	1.0	29	7.0
Black Spruce	Thunder Bay District Camp 503	15	2.0	17	2.0	52	12.0

White Pine

In 1969, a small collection of cones was made from the white pine seedling seed orchard, Nepean Township, Kemptville District. The collection yielded 26 oz containing 36,700 viable seeds. This was an open-pollinated collection from resistant x resistant trees which should give an estimated 20% resistance in the progeny.

Red Pine

The red pine seed orchards in Gurd Township, Parry Sound District and Grenfell Township, Swastika District are at the final size at 11.0 and 23.0 acres respectively. No additional clonal seed orchards in red pine are planned. Grafting is confined to provision of refill stock. A small collection from the Gurd Township seed orchard in 1969 yielded 5.1 g of seed, 510 viable seeds. Trees are 6 years old from planting.

White and Black Spruce

Progeny testing for general combining ability began in 1969 at the black spruce seed orchard, Midhurst Nursery and in 1970 at the white and black spruce seed orchards, Thunder Bay District. This work is being carried out with the assistance of Miss R.M. Rauter, Tree Breeding Unit, Research Branch, Maple. A tentative site for out-planting of the progeny has been selected in Gurd Township, Parry Sound District.

SEED PRODUCTION AREAS

Three seed production areas have been established and one area was enlarged in the past 2 years as follows:

Table 2

Species	Location	Site Region	Acres	Development
Red Pine	Pembroke District, Head Twp.	5E	enlarged from 32 to 56 acres	Thinning 1970
White Spruce	Thunder Bay District, O'Connor Township	4W	12.0	Thinned 1969 1970
Black Spruce	Kenora District, Satterly Township	4S	13.0	Thinning 1970
Red Spruce	Tweed District, Effingham Township	5E	15.0	Partial thinning 1968

Red Pine - Willington Township

A collection of 49 bushels of cones from this seed production area in 1969 yielded 883,000 viable seeds weighing 254 oz. This represents 13% of the red pine seed in storage for Site Region 5S.

Red Pine - Lynn Tract - Oro Township

Collections of 34 bushels and 151 bushels were made from this seed production area in 1968 and 1969. The latter collection yielded 4.8 million viable seeds weighing 1,555 oz. This represents 16% of the red pine seed in storage for Site Region 6E.

An estimated 140 bushels can be collected from this area in 1970. With a collectable cone crop on the area for 3 years in succession, it would appear that the annual ammonium nitrate application and periodic brush control is assisting in overcoming the problem of periodicity in red pine seed crops. Cultural treatments are at least tending to level off the wide swings from failure to heavy crops. In view of the changed emphasis from seed orchards to seed production areas in red pine, confirmation of this trend will be of considerable benefit in the management of red pine stands for seed production purposes.

Jack Pine - Meglund Township

A 1969 collection of 6 bushels from a high quality stand in the Dryden area at the time of logging yielded 228,000 viable seeds weighing 27 oz.

SEED COLLECTION

In 1968 and 1969, 8,240 and 17,725 bushels of cones and rough seed, respectively, were collected. Seed requirements for the fall of 1970, to maintain the necessary reserve, are for the equivalent of 23,700 bushels of cones and rough seed.

The seed inventory as of 1 June 1970 at the Ontario Tree Seed Plant at Angus, is 2.38 billion viable seeds of 47 species weighing 12.5 tons. 1968 was a poor crop year for most species. About half of the volume collected was black walnuts. 1969 was a poor crop for spruce. However, 4,130 bushels of red pine were collected, the largest quantity collected in at least the past 25 years. There is still a shortage of red pine seed. 6,350 bushels are required in 1970.

TREE IMPROVEMENT AT THE ONTARIO TREE SEED PLANT

K.C. Eng
Timber Branch,
Ontario Department of Lands and Forests, Angus, Ont.

GRAFTING PROGRAM

The grafting program at Angus in the past three seasons is summarized in tables 1 and 2.

Table 1. White Spruce

Season	Total No. of Grafts	No. of Clones New	No. of Clones Established	No. of Clones Total	Survival in Greenhouse %	Survival in Nursery 1 year %	Survival in Nursery 2 year %
67-68	1,114	22	11	33	96	95	50
68-69	3,127	25	-	25	81	92	77
69-70	2,158	12	28	40	90	91	-

Table 2. Black Spruce

Season	Total No. of Grafts	No. of Clones New	No. of Clones Established	No. of Clones Total	Survival in Greenhouse %	Survival in Nursery 1 year %	Survival in Nursery 2 year %
67-68	1,914	21	30	51	97	94	83
68-69	2,962	25	-	25	90	90	59
69-70	1,743	21	39	60	94	95	-

Red Pine and White Pine

In the spring of 1969, 155 red pine grafts and 42 white pine grafts made at Midhurst nursery were transferred to and lined out at Angus. The 1-year survival was 91% and 99%, respectively.

In the 1969-70 season, 33 red pine grafts were made from three old clones for re-filling purposes. Percent success in the greenhouse was 100.

White Spruce and Black Spruce

For both white and black spruce, air freight was used to ship scions to Angus whenever possible. Scions could be collected and attached to the rootstock within the same day. Fresh scions tend to take more successfully.

In an attempt to improve survival in the nursery, grafts were planted in sided frames and covered with slat shades at the outset. The shades were removed in early August and put back on after the first snow fall.

SEED PRODUCTION AREA

Cone Collection

The red pine seed production area at the Lynn Tract, Simcoe County Forest, produced a light crop of cones in 1968 and a medium crop in 1969. Cones were harvested from this area in both years. All trees (708 on 7 acres) were numbered before collection and the number of cones picked from each tree was recorded.

In the fall of 1968, 34 bushels were collected from 196 trees. Number of cones from individual trees ranged from 20 to 810.

In the fall of 1969, 151 bushels were picked from 626 trees. Number of cones from individual trees ranged from 10 to 1,023.

To mechanize the picking operation, an "Uppup" (portable utility platform) was tried out in both years. This unit consists of a platform (3 x 2.5 feet) resting on a telescoping hydraulic cylinder and is powered by a 3,000 watt portable generator. Raising and lowering the platform was controlled by a foot switch operated by the persons on the platform. Its maximum extended height was 24 feet. The unit was mounted on a two-wheeled trailer, towed by a tractor.

Supervised by Department staff, inmates from the Department of Reform Institutions field camp picked cones with the Uppup during the week and high school students were hired on the weekends.

Due to the roughness of the ground and the low crown of the trees, the Uppup could not be moved as freely as it should be. Collecting the cones from each tree required two or three settings of the machine, and took a total of 20 to 30 minutes.

The collection costs for the two seasons are summarized in Table 3.

In 1969 a comparison was made between collecting cones with the Uppup and with ladders. It was found that, on a per-man basis, men on the Uppup generally picked twice as many cones as those using ladders. It was also found that there was a difference among pickers. One picker consistently

Table 3. Collection Costs

		1968		1969	
Collection Dates		8 Sept.-7 Oct.		18 Sept.-20 Oct.	
Total Volume Picked (bu)		34		151	
Salaries	permanent	508.12		1,205.84	
	students	186.24		2,442.39	
	inmates	-		-	
sub-total		$694.36		$3,648.23	
cost per bushel			$20.42		$24.16
Rental Uppup		330.00		330.00	
Generator		144.00		144.00	
Trailer		26.00		26.00	
Prov. tax		25.00		25.00	
Repairs		5.00			
sub-total		$530.00		$525.00	
cost per bushel			$15.58		$ 3.47
Grand total		$1,224.36		$4,173.23	
Total cost per bushel			$36.00		$27.63

picked more cones than the others did. The potential of the Uppup in cone picking was well demonstrated in the Lynn Tract. Two units were purchased by the Timber Branch in the winter of 1969. In the Lynn Tract, in order to direct more nutrients to the cone bearing upper crown and to facilitate the movement of cone picking machines, all trees were pruned to a height of 8 feet right after cone collection in 1969.

OBSERVATIONS ON CONE AND SEED CHARACTERISTICS

During the cone picking operations in Lynn Tract, observations were made on the cone-tree relationships. Tree height and dbh were measured on randomly selected trees. Twenty-four years after planting, the trees were 20 to 39 feet tall with diameters ranging from 6 to 12.5 inches. Sizes of cones from sample trees were measured. Their average and the percentage of large cones were compared. Correlation coefficients were calculated from the data. A summary of the results and their significance are given as Table 4.

It appears from the table that larger trees tend to produce more cones, that trees producing more cones also produce larger cones and a higher percentage of them.

Table 4. Correlation Coefficients for Some Red Pine Cone-tree Relationships in Lynn Tract, 1968 and 1969.

Relationship	No. of Trees Measured		Correlation Coefficient	
	1968	1969	1968	1969
No. of cones per tree vs dbh	53	158	0.263	0.576**
No. of cones per tree vs tree height	53	158	0.227	0.379**
No. of cones per tree vs average cone size	53	156	0.603**	0.524**
No. of cones per tree vs % of cones above 45 mm in length	53	-	0.513**	-

** Significant at 1% level.

Cone boring insects have been present in the Lynn Tract for many years. They infested part of the cone crop to different degrees and thus reduced seed yield. To find out the extent of damage done by these insects, 10 trees were selected randomly in each year. The cones from each sample tree were sorted and separated into two lots - sound or infested. Each lot was measured, weighed and extracted separately. Seed germination was carried out with Jacobsen test. One hundred seeds from each lot were stratified at 38°F for 30 days and were then germinated at 80°F under a 16-hr photoperiod. From the 6th day on, germination counts were made at 2- or 3-day intervals. Table 5 shows the results from the averages of 10 trees.

Table 5. Comparison of Red Pine Seed Yield and Seed Quality from Sound and Infested Cones in Lynn Tract, 1968 and 1969.

Year	No. of Trees Sampled	Cone Quality	% of Cones	Cone Length mm	Wt of 100 Cones kg	No.of Seed/ Cone	Wt of Seed mg	Germination %
1968	10	sound	83.6	42.3**	0.98**	40.1**	6.9	93.7
		infested	16.4	37.6	0.70	5.1	7.5	90.5
1969	10	sound	80.8	46.1**	1.28**	38.8**	8.6	85.2
		infested	19.2	41.3	0.87	9.0	8.6	83.0

**Difference significant at 1% level.

It is evident that most of the cones harvested were sound, and that sound cones were usually larger and heavier than the infested ones. However, the most significant difference between sound and infested cones lies in the average number of seeds per cone. Sound cones produced from 4 to 8 times the seed produced by infested cones.

It was observed during the extraction process that although an infested cone was deformed only on a small area, many scales on the sound portion did not open and the seeds below it were small and shrunken. This seemed to indicate that the damage done to the cone extended beyond the boring path of the insect.

The average germination percentages of seeds from sound cones were higher. However, the differences in both years were non-significant. It appears that as long as an embryo can go through all the developmental stages and become a seed, it will be viable either in a sound or infested cone.

In the 1969 picking operation, opportunity was present for an observation on seed quality from cones collected on different dates. Five trees were randomly selected and marked for this purpose. Five cones were picked from each sample tree at weekly intervals. All cones picked in each week were pooled for measurement and testing. Results are summarized in Table 6.

Table 6. Relationship of Red Pine Seed Quality to Characteristics of Cones Collected on Different Dates, 1969

Date of Collection	Cone Appearance	Float in 50:50 Kerosene Linseed Oil %	Average sp gr	Germination %
26 Aug.	green	0	1.07	40.0
2 Sept.	green with purple-tipped scale	0	1.02	82.0
9 Sept.	purplish, scale tips brown	0	0.97	92.5
16 Sept.	deep purple	12	0.89	89.5
23 Sept.	dark purple	56	0.83	90.0
30 Sept.	brown	72	0.80	92.0
7 Oct.	brown	96	0.76	91.5
14 Oct.	light brown some scales open	100	0.66	74.0

According to the results, the period between 2 Sept. and 7 Oct. seemed to be the optimal time to collect red pine cones in Lynn Tract. Before the last week of August the cones had not ripened. After 14 Oct, the seeds started to lose their viability.

SEED ORCHARD

Progeny Test

In the fall of 1967 open-pollinated cones were collected from 20 clones of the timber-type Scotch pine seed orchard near Midhurst nursery and from 14 clones of the Faulkner series Scotch pine at Angus nursery. The cones were extracted according to clones and the seeds were stored separately. Seeds from the 34 clones were sown as an unreplicated 1-parent progeny test in Midhurst nursery in October 1968. Germination counts and subsequent observations were made by establishing random plots within the clones. The germination percentages tallied in the spring of 1969 of the timber-type clones ranged from 47.1 to 99% with an average of 69.2%. Those of the Faulkner clones ranged from 17.4 to 84% with an average of 54.3%. The beds were thinned to about 40 seedlings per square foot in the fall of 1969. The over-winter survival from all clones was over 95%. In the spring of 1970 first-year heights were obtained by measuring 10 randomly selected seedlings in each plot. The average height among the clones in the timber-type series ranged from 3.60 cm to 6.81 cm. The clonal average in the Faulkner series ranged from 5.02 cm to 6.88 cm. There was a definite difference in foliage color between the two series. A blue tinge appeared on the Faulkner series which indicated possible Christmas tree quality in addition to their fast growth.

OBSERVATIONS ON REPRODUCTIVE PHENOLOGY

During the springs of 1969 and 1970, reproductive phenology in the Site Region 3E white and black spruce seed orchard in Vespra Township was followed by regular observations. Male and female flowers produced by each tree were counted and recorded. Results showed that, on both species, certain clones were particularly fertile with many ramets producing female flowers in both years. It was also found that many grafts start to produce male flowers. Summaries of the dates on which different stages were observed in the two seasons are given in Table 7.

Table 7. Reproductive Phenology in the Site Region 3E White and Black Spruce Seed Orchard in Vespra Township in 1969 and 1970

Species	Female Flower				Male Flower						
					Scale		Strobili	Pollen Flight			
	Swelling	Open Tip	Early Receptive	Full Receptive	Thickening	Closed	Succulent	Initial	Full	Late	Fade
White Spruce	May 5	May 8	May 11-16	May 15-20	May 19-28	May 22 June 2	May 8	May 9-11	May 11-15	May 15-19	May 21
Black Spruce	May 11-15	May 13-19	May 19-23	May 21-28	May 28-30	June 2	May 19-23	May 21-28	May 25-30	June 2	June 5

A NEW LOOK AT THE WHITE PINE WEEVIL[1]

C. Heimburger
80 Haddington Ave.,
Toronto 12, Ont.

A 3-acre plantation of *Pinus strobus* was established in 1957 and field-grafted in 1961, 1962 and 1963, in 3 series, with 2320 scions of 51 clones of *P. strobus* and related species and hybrids, previously found resistant to *Cronartium ribicola*. Observations on weevil (*Pissodes strobi*) attack were made in 1963 to 1967, including annual determination of leader size, as a basis for weevil attack during the following year. The grafts were maintained in a one-leader condition by pruning, with an average overall frequency of weevil attack of 17 per cent. Screening for weevil resistance, based on combined frequency of attack and recovery from attack, resulted in the selection of 9 clones of *P. strobus* and one clone of *P. peuce*. The results were interpreted with Painter's three general resistance mechanisms - tolerance, non-preference and antibiosis - applied to these materials as a working hypothesis. It was concluded that old-field white pine is tolerant to the weevil and its present abundance is one of the long-term ecological consequences of a land use favorable to the establishment and maintenance of open-grown stands. Examples of the non-preference and antibiosis reaction types were found in the more advanced stages of succession from open-grown to closed stands. Some guidelines are presented to breeding for weevil resistance, in the work cited in the footnote, as in the long run being more important than breeding for resistance to weevil attack. At present, clones combining the non-preference and antibiosis reactions are the most desirable for use in eastern Canada. Under more advanced silvicultural conditions, the use of the antibiosis type, more open to attack, but with high recovery rates from largely unsuccessful attacks, could result in a more or less self-regulating weevil resistance situation. Several exotic species and hybrids showed poor survival after grafting and poor weevil resistance, possibly because of poor adaptation.

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[1]Summary of the paper entitled "Screening of *Haploxylon* Pines for Resistance to the White Pine Weevil (*Pissodes strobi* Peck). II. Further Observations on the Resistance of *Pinus strobus* L. and Related Species and Hybrids" by C.C. Heimburger and C.R. Sullivan, 1970. Based on the results of experiments established by the Ontario Department of Lands and Forests, at Thessalon, Ontario and evaluated in cooperation with Dr. C.R. Sullivan, Department of Fisheries and Forestry, Ontario Region, Sault Ste. Marie, Ontario.

SPRUCE BREEDING AT THE SOUTHERN RESEARCH STATION, MAPLE, ONTARIO

R. Marie Rauter
Research Branch,
Ontario Department of Lands and Forests
Maple, Ont.

The spruce program has two broad objectives, both designed to produce genetically improved trees for Ontario. The first objective is aimed at improving the spruce species through breeding, hybridization, and selection in order to produce hybrid material which will exhibit superior characteristics such as faster growth, better form, improved wood quality, and resistance to pests. The second is the development of clonal material on it's own root system by means of vegetative propagation of cuttings so that each promising variety can be properly evaluated and the superior material quickly propagated.

ACQUISITIONS

The following material was acquired in the form of scions:

Species	Origin	No. of Clones	No. Successful Grafts
P. sitchensis	Coastal B.C.	1	8
P. smithiana	Brett Pinetum, Conn.	2	13
P. mariana	Calgary, Alta.	10	104
P. mariana x *rubens*	Fredericton, N.B.	10	92
P. abies	Finland	20	195
P. obovata	Finland	1	8
P. glehnii	Finland	1	1
P. mariana	Geraldton, Ont.	16	123
P. mariana	Kapuskasing, Ont.	5	44

The following material was acquired in the form of seed:

Species	Origin	No. of Populations	No. of Seedlings
P. abies	Wellington County, Ont. open pollinated	1	54
P. glauca	Southern Research Station, Maple open pollinated	1	18
P. koyamai	Winchester, England open pollinated	4	122
P. mariana	St. Williams, Ont. open pollinated	1	54
P. pungens	Southern Research Station, Maple open pollinated	1	31
P. schrenkiana	Winchester, England open pollinated	4	80
P. mariana	Northern Ontario open pollinated	30	several hundred

SELECTION

The following material was selected, regrafted, and (or) used in hybridization:

Species	Locality	No. of Trees
P. abies	Midhurst, Ont.	1
P. asperata	Maple, Ont.	11
P. sitchensis x *glauca*	Petawawa, Ont.	9
P. rubens	Maple, Ont.	49

HYBRIDIZATION

The following crosses were made in 1968 and 1969:

Parentage	No. of Female Clones (= No. of (Crosses)	No. of Cones	Total No. Seed	No. Full Seed	No. of Seedlings*
1968					
P. abies x *glauca*	3	23	4154	0	0
P. abies x *mariana*	3	9	1588	0	0
P. abies x *rubens*	3	19	3087	0	0
P. asperata x *glauca*	1	6	828	0	0
P. asperata x *mariana*	1	1	197	0	0
P. jezoensis x *glauca*	1	19	1030	3	0
P. jezoensis x *mariana*	1	16	856	0	0
P. schrenkiana x *rubens*	2	2	371	0	0
P. (*sitchensis* x *glauca*) x *abies*	1	0	0	0	0
1969					
P. glauca x *abies*	4	138	12140	1	1
P. glauca x *sitchensis*	4	141	8453	2898	1964
P. glauca x *jezoensis*	4	139	7884	434	262
P. glauca x *mariana*	4	293	11536	1	0
P. glauca x *asperata*	4	70	2911	1	0
P. glauca x *schrenkiana*	5	115	4803	5	3
P. jezoensis x *glauca*	1	11	711	41	33
P. koyamai x *omorika*	1	1	167	0	0

*Authenticity of hybrids yet to be verified.

APOMICTIC PROPAGATION

Apomictic propagation was started in an attempt to produce clonal material by means of rooted cuttings. The purpose of this study was to determine the variation in rooting ability between and within species. Since August 1967, several series of experiments have been established, many with very encouraging results.

Experiments were started in the spring of 1968, summer 1968, winter 1968/69, spring 1969, and winter 1969/70. Species which have been used in these trials are *P. glauca*, *P. mariana*, *P. schrenkiana*, *P. glehnii*, *P. koyamai*, *P. abies*, *P. omorika*, and *P. schrenkiana* x *glauca*. Unconfirmed hybrids obtained from Williamstown, Mass. this past winter include *P. glauca* x *jezoensis*, *P. glauca* x *engelmannii*, *P. jezoensis* x *glauca*, *P. omorika* x *koyamai*, *P. omorika* x *orientalis*.

To date high rooting percentages have been obtained in many of these species of spruce, but greater variation seems to occur within a species than between species. Large differences occur even with progeny originating from the same population. Although material used has been from 1- to 16-year-old stock, efforts have been concentrated on the younger stock in an attempt to find the best means to vegetatively propagate the most promising hybrids for clonal testing.

Initially the cuttings were placed in beds of coarse sand and covered with a tent of aluminum painted plastic. The cuttings were manually watered at frequent intervals. With each succeeding set of experiments, methods were modified so that presently flats containing 200 cuttings in plastic tubes are placed in a misting chamber. An outdoor chamber was erected in the nursery for the spring and summer experiments, an indoor chamber in the greenhouse for the winter experiments.

In the summer of 1968, cuttings of *P. mariana* were used to compare age differences and IAA treatments. Three-year-old material averaged 55% rooting, whereas 15-year-old material averaged 7%. High concentrations of IAA (200 ppm) were detrimental to rooting, although lower concentrations had little effect. In another experiment involving 3-year-old material of *P. glauca*, *P. schrenkiana*, *P. glehnii*, and *P. koyamai*, the rooting percentages varied from 96% for *P. glauca* to 76% for *P. koyamai*.

In the winter of 1968/69, cuttings taken from the same *P. mariana* trees as were used in the summer experiment demonstrated quite different results in rooting. No IAA treatment was used in this series. The average of the 3-year-old material dropped to 28%, the 15-year-old material to 6%.

Experiments established in the summer of 1969 again showed *P. glauca* and *P. schrenkiana* to consistently produce a high percentage of rooted cuttings. Five-year-old stock of *P. mariana* from 18 populations averaged 44% rooted. Some of these clones had 0% rooted, whereas others had 95% rooted. No population trend was evident, only that tree-to-tree variation for this species is extreme with respect to rooting ability.

The rooted cuttings will be kept and observed for 3 years to determine growth habits such as bud break, topophysis, growth rate, and lateral shoot development.

DISCUSSION

Since the spruce program was established in 1964, the work has branched into several important fields in attempts to improve the spruce species. Previously interspecific breeding was done mainly on an exploratory level, to determine the crossability patterns of this genus. Now, more emphasis is being placed on interspecific breeding of known combinations to improve silvicultural characteristics and to extend the range of the native species.

Although the results for the vegetative propagation of spruce are encouraging, much work has yet to be done. It will be useful to determine the rooting capabilities of the various species and their hybrids, the differences in rooting of individuals of different age classes, and the variations in rooting ability within the same population. If a particular method can be established and a selection for rooting accomplished then it will provide possibilities for clonal testing of the hybrids and provide good clones for the field faster and cheaper.

In the cooperative work with our Timber Branch, through plus tree selection and seedling seed orchard establishment, variation and heritability studies will be made and superior material for breeding work will be acquired.

SUMMARY REPORT ON POPLAR AND PINE BREEDING IN 1968 AND 1969

L. Zufa
Research Branch,
Ontario Department of Lands and Forests
Maple, Ont.

The objectives of the aspen, cottonwood, white pine and hard pine breeding programs, and the work accomplished in 1968 and 1969 are described in this report.

ASPEN

The improvement of native aspens and the development of hybrid aspen clones and varieties of superior growth, good form and desired wood quality, resistant to pests and suitable for the future needs of aspen timber production under varying conditions in Ontario are the objectives of this program.

The following methods are being used: (i) population studies; (ii) selection in native populations; (iii) acquisition of gene pools of exotics and development of breeding arboreta; (iv) interspecific crosses; (v) polyploidy induction; (vi) progeny testing and heritability studies; (vii) vegetative propagation; and (viii) field testing.

In 1968 and 1969 the work concentrated on: (i) selection of superior trees in the plantations of hybrids and in native stands; (ii) production of *P. tremuloides* x *tremula* and *P. tremuloides* x *sieboldii* F_1 hybrid generations with desired characteristics for central and northern Ontario's conditions; (iii) multiple crosses of unrelated hybrid parents to produce heterogeneous populations with outstanding individuals which could be used for the development of superior clonal varieties for southern and central Ontario's conditions; (iv) *Leuce* x *Aigeiros* and *Leuce* x *Tacamahaca* intersectional crosses from which the production of entirely new types of poplar hybrids and the induction of rooting ability is expected; (v) rooting trials and vegetative propagation of superior genotypes to secure a clonal basis for field testing; and (vi) acquisition of population samples of exotic poplars.

Acquisitions

Species	Origin	No. of One-Parent Progenies
P. alba	Romania	3
P. alba	Hungary	4
P. alba	Italy	1
P. canescens	Italy	1
P. canescens	Romania	7
P. tremula	Hungary	1
P. tremula	Czechoslovakia	2
P. tremuloides	Prairie Provinces, F.B. Armitage's collection	50

Selection

Species or Hybrid	No. of Trees Selected
P. tremuloides	34
P. alba x *grandidentata*	21
P. alba x *davidiana*	24
P. alba x *sieboldii*	6
P. grandidentata x *alba*	10
P. grandidentata x *davidiana*	1
P. canescens x (*alba* x *grandidentata*)	9
P. canescens x (*alba* x *tremuloides*)	1
P. alba x *adenopoda*	1
P. canescens x *grandidentata*	4

These trees were selected in native stands and in plantations of hybrids, and vegetatively propagated for the purpose of clonal testing.

Hybridization

Parentage	No. of Crosses Made		Total
	successful	unsuccessful	
P. tremuloides x *tremula*	5	2	7
P. tremuloides x *sieboldii*	3	1	4
P. tremuloides x *deltoides*	1	1	2
P. tremuloides x (*tacamahaca* x *deltoides*)	1	1	2

Parentage	No. of Crosses Made successful	unsuccessful	Total
P. tremuloides x *trichocarpa*		1	1
P. tremuloides x *balsamifera*		4	4
P. tremula x *tremuloides*	13		13
P. tremula x *deltoides*	2	2	4
P. tremula x (*tacamahaca* x *deltoides*)	1	3	4
P. grandidentata x *alba*		1	1
P. grandidentata x *canescens*	1		1
P. alba x *grandidentata*	1		1
P. alba x *sieboldii*	2		2
P. alba x *deltoides*	1		1
P. alba x (*tacamahaca* x *deltoides*)		1	1
P. alba x *trichocarpa*	1		1
P. canescens x *alba* x *grandidentata*)	1		1
P. canescens x (*alba* x *sieboldii*)	1		1
P. canescens x (*alba* x *davidiana*)	1		1
P. canescens x (*alba* x *adenopoda*)	1		1
P. canescens x *deltoides*	1		1
P. canescens x (*tacamahaca* x *deltoides*)	1	1	2
P. sieboldii x *canescens*		1	1
P. sieboldii x (*alba* x *tremula*)	1		1
P. sieboldii x (*alba* x *grandidentata*)	1		1
P. sieboldii x (*alba* x *adenopoda*)	1		1
P. sieboldii x (*alba* x *davidiana*)	1		1
P. (*alba* x *grandidentata*) x *canescens*	4	1	5
P. (*alba* x *grandidentata*) x (*alba* x *davidiana*)	2		2
P. (*alba* x *grandidentata*) x (*alba* x *sieboldii*)	1		1
P. (*alba* x *grandidentata*) x (*alba* x *adenopoda*)		1	1
P. (*alba* x *grandidentata*) x (*alba* x *tremula*)	1		1

Parentage	No. of Crosses Made		Total
	successful	unsuccessful	
P. (*alba* x *grandidentata*) x *sieboldii*	1		1
P. (*alba* x *grandidentata*) x *davidiana*	1		1
P. (*alba* x *grandidentata*) x *deltoides*	1	1	2
P. (*alba* x *grandidentata*) x (*tacamahaca* x *deltoides*)		1	1
P. (*alba* x *grandidentata*) x *trichocarpa*		1	1
P. (*alba* x *sieboldii*) x (*alba* x *grandidentata*)	1		1
P. (*alba* x *sieboldii*) x *grandidentata*	1		1
P. alba x *davidiana* - self pollinated	1		1
P. alba x *tremula* - self pollinated		1	1
P. (*grandidentata* x *davidiana*) x (*alba* x *grandidentata*)	1		1
P. (*grandidentata* x *davidiana*) x (*alba* x *tremula*)	1		1
P. (*grandidentata* x *davidiana*) x (*alba* x *sieboldii*)	1		1
P. (*grandidentata* x *davidiana*) x (*alba* x *adenopoda*)		1	1
P. deltoides x *tremuloides*	2	3	5
P. deltoides x *tremula*		2	2
P. balsamifera x *tremuloides*		1	1

Irradiated intermediate pollen (10,000 R/min for 20 min to a total of 200,000 R) was used in the intersectional crosses (*Leuce* x *Aigeiros*, *Leuce* x *Tacamahaca*). The self-pollinated poplars were hermaphrodites.

Rooting Trials and Vegetative Propagation

Efforts were made to propagate selected trees by stem cuttings and suckers.

The propagation by stem cuttings was tried with hybrids of silver poplar and aspen parentage. Replicated trials showed significant variation in rooting within and between the families of hybrids. Some genotypes rooted consistently better. The clonal propagation of a larger number of hybrids is underway.

Pure aspens cannot be propagated by stem cuttings. Efforts were made to use their suckering ability for vegetative propagation. Root pieces of selected trees were placed in sand in the greenhouse and the emerging succulent suckers were planted in tubes for rooting. The following observations were made: (i) intensive suckering was observed in a 60-day period; (ii) the rooting of the suckers was successful; and (iii) large within- and between-population variation was observed in suckering as well as in rooting of the suckers. A fast initial propagation can be achieved by using this method. Once this phase of the propagation is achieved, it could be continued in a simpler way in the nursery, by taking advantage of the suckering capacity of the outplanted rooted suckers.

Polyploids

The chromosome counts were continued on the poplar plants which were first produced and treated for polyploidy induction. Fifty-two polyploid and 77 mixoploid plants were found. Some of the plants were analysed for the second or third time. A plantation of the polyploid and mixoploid poplars was initiated in the Maple arboretum area.

COTTONWOOD

The development of fast growing cottonwood clones with superior silvicultural characteristics and a northern extension of the range of cottonwood are the objectives of this program. The following methods are being used: (i) selection; (ii) acquisition of gene pools of exotics and development of breeding arboreta; (iii) breeding; (iv) polyploidy induction; (v) progeny testing and heritability studies; (vi) vegetative propagation; and (vii) nursery and field testing.

During 1968 and 1969 emphasis was on the following works: (i) selection of superior trees in native populations; (ii) interspecific breeding; and (iii) clonal and population testing for winter hardiness.

Acquisitions

Species or Hybrid	Origin	Number
P. nigra	Yugoslavia	10 one-parent progenies
P. nigra	Czechoslovakia	1 one-parent progeny
P. deltoides	Prairie Provinces, F.B. Armitage's selection	74 one-parent progenies
P. deltoides	Ontario	5 one-parent progenies
P. deltoides	Manitoba	7 clones
P. deltoides	Italy	1 clone
P. x *euramericana*	France	9 clones
P. x *euramericana*	Germany	10 clones

Species or Hybrid	Origin	Number
P. x *euramericana*	Holland	2 clones
P. x *euramericana*	Italy	9 clones
P. x *euramericana*	Spain	3 clones

The *P.* x *euramericana* material represents a selection of the best known clones from European countries. The *P. deltoides* seed was collected from selected trees in the Saskatchewan, Missouri and Red River systems, while the cottonwood clones represent a selection from the Prairie Provinces.

Selection from Ontario

Species	No. of Trees Selected
P. deltoides	12
P. x *Jackii*	6
P. balsamifera	3

The majority of these trees were selected by Mr. H.C. Larsson, who kindly provided the scions and cuttings for the vegetative propagation. The propagation of these trees, for the purposes of clonal testing, is underway.

Hybridization

Parentage	No. of Crosses Made		Total
	successful	unsuccessful	
P. deltoides x *nigra*	13	4	17
P. deltoides x *Jackii*	9	3	12
P. deltoides x *trichocarpa*	2	-	2
P. tacamahaca x *deltoides*	-	1	1
P. x *Jackii* x *deltoides*	-	2	2
P. x *Jackii* x *nigra*	2	1	2

P. deltoides and *P.* x *Jackii* were crossed with *P. nigra* in an attempt to induce hybrid vigor, and to obtain resistance to *Marssonina* and to the bacterial canker. By crossing *P. deltoides* with *P. balsamifera* and *P.* x *Jackii* the production of hybrids for a northern extension of cottonwood is expected.

Winter Hardiness Tests

Euramerican poplar clones of European origin were planted in nurseries across Ontario to test their winter hardiness. The majority of these clones were winter hardy in Orono and Kemptville nurseries, but they were seriously frost damaged in Swastika and Thunder Bay nurseries.

Field Testing

Two clonal tests of winter hardy euramerican poplar clones were established in southern Ontario to demonstrate their growing potential and to select the ones which could be recommended for local planting.

WHITE PINE

The objectives of the white pine breeding program are to improve the eastern white pine and to develop hybrid white pine varieties of fast growth and desired silvicultural characteristics, with a reasonable degree of resistance to blister rust and weevil. The following methods are being used: (i) selection; (ii) variation studies; (iii) completion and maintenance of a gene bank and of the breeding arboreta; (iv) intraspecific and interspecific breeding; (v) progeny testing and heritability studies; (vi) vegetative propagation studies; (vii) studies of the pest inoculation techniques and of the nature of resistance; and (viii) field testing.

In 1968 and 1969 efforts were made in the field of: (i) vegetative propagation; (ii) blister-rust-resistance testing and detection; (iii) testing the blister-rust-resistance-transmitting ability of the seemingly resistant *P. strobus* trees; and (iv) *P. griffithii* x *strobus* breeding and testing.

Acquisitions

Species	Origin	Number
P. koraiensis	Japan	1 population
P. monticola	Idaho, U.S.A.	6 populations
P. strobus	Petawawa F.E.S., Ont.	6 populations
P. pumila	Japan	5 trees
P. monticola	Saratoga, N.Y., U.S.A.	10 trees

Selection

The following trees were selected and propagated by grafting:

Species of Hybrid	No. of Trees Selected
P. monticola	7
P. monticola x *peuce*	26
P. peuce x *strobus*	1
P. strobus	26
P. griffithii	8
P. griffithii x *strobus*	3
P. griffithii x *pentaphylla*	2
P. cembra	5

Hybridization

Crosses Made in 1968

Parentage	No. of Crosses	No. of Seeds Total	No. of Seeds Full
P. koraiensis x *lambertiana*	4	12	1
P. strobus x *monticola*	15	1546	49
P. (*strobus* x *griffithii*) x *monticola*	2	147	0
P. (*peuce* x *strobus*) x *monticola*	1	326	75
P. strobus x (*griffithii* x *strobus*)	5	140	16

Crosses Made in 1969

Parentage	No. of Crosses Made	No. of Cones Set
P. griffithii x *strobus*	13	222
P. strobus x *griffithii*	4	124
P. strobus x (*griffithii* x *strobus*)	4	38
P. (*griffithii* x *strobus*) x *strobus*	5	131
P. (*griffithii* x *strobus*) x (*griffithii* x *strobus*)	5	39

Blister-Rust-Resistance Testing and Blister-Rust Detection

Tubed seedlings are being raised in flats and arranged in randomized replications. The seed is sown in January. The blister rust inoculation takes place in late August. The entire test is concentrated in a small area and inoculated at one time. The seedlings are returned to the greenhouse in January, when observations on needle infection are made. In the early summer the seedlings are moved to the cold frames and from there to the nursery. In late August they are again inoculated with blister rust. In January the seedlings are taken back to the greenhouse. In a short time the aecia appear on the seedlings which have completed two seasons of growth. The testing period is significantly shortened.

Observations were made on the needle infection of the 1-year-old seedlings, and bark samples were analysed for the blister rust mycelium. Six months after inoculation the blister rust was present in the stems of all analysed seedlings with heavy needle infection and in the majority of the seedlings with light needle infection. The small seedlings were infected to a significantly lesser degree than the tall seedlings. Significant differences in the intensity of needle infection appeared between the 17 *P. strobus* full sibs in the test.

Significant differences in the number of seedlings with aecia appeared between the same full sibs. The correlation between the intensity of needle infection and the number of seedlings with aecia was positive, but weak.

Vegetative Propagation

Cuttings and needle fascicles were planted in coarse sand in plastic tubes and placed in a plastic tent or in a mist bed in the nursery. The possibilities of rooting cuttings, needle fascicles with fascicular buds and needle fascicles without fascicular buds of *P. strobus* and *P. griffithii* x *strobus* trees of different age were investigated. The within- and between-population variation in rooting ability was studied. The following observations were made: (i) the cuttings and needle bundles taken in early spring and in late summer rooted the best; (ii) the cuttings rooted as well as the needle fascicles; (iii) the needle bundles without fascicular buds rooted better than those with fascicular buds; (iv) the rooting in 3/4-inch diameter, 3-inch-long plastic tubes was as good as in flats. The cuttings rooted in tubes developed an evenly distributed and balanced root system in contrast to the unilateral roots developed in flats; (v) the rooting ability did not decrease when stock up to 10 years of age was used; (vi) within- and between-population variation in rooting ability was observed. and this became more pronounced with age; (vii) *P. griffithii* x *strobus* rooted better than *P. strobus*; (vii) the rooting of the same clones in the consecutive years was not consistent; and (ix) cuttings as well as needle fascicles taken from single trees rooted up to 100%.

HARD PINES

The improvement of red pine by selection and breeding and the development of hybrid hard pines of superior growth, form and wood quality resistant to disease and suitable to Ontario's conditions are the objectives of this project. The methods used involve: (i) selection and intraspecific breeding in red pines, emphasizing the crosses of geographically distant provenances and of evidently distinct genotypes; (ii) completion and maintenance of breeding arboreta; and (iii) interspecific crosses.

In 1968 and 1969 emphasis was on *P. nigra* x *densiflora* x *silvestris* crosses and attempts were made to produce interspecific hybrids of red pine by using irradiated red pine pollen as an intermediate.

Acquisitions

A *P. nigra* provenance trial representing 61 provenances with a total of 5,500 seedlings was received from Schmalenbeck, Germany.

Selection

The following trees were selected from our experimental plantations and grafted for further purposes:

Species	Origin	No. of Trees Selected
P. densiflora f. *erecta*	Korea	1
P. densiflora	Japan	2
P. densiflora	Pennsylvania	1
P. nigra f. *cebennensis*	France	7
P. hwangshanensis	China	1
P. montana f. *uncinata*	France	3
P. leucodermis	Holland	5

Hybridization

Crosses Made in 1968

Parentage	No. of Crosses	No. of Cones	No. of Seeds full	empty
P. tabulaeformis x *leucodermis*	4	32	0	261
P. (*densiflora* x *silvestris*) x *nigra*	8	299	2821	5310
P. (*nigra* x *densiflora*) x *silvestris*	2	19	0	2
P. resinosa x *resinosa*	10	90	2515	821
P. resinosa x (*nigra* + *resinosa* irradiated)	6	49	2*	332
P. resinosa x (*silvestris* x *resinosa* irradiated)	3	17	0	90
P. resinosa *leucodermis* *resinosa*	5	19	0	59

Crosses made in 1969

Parentage	No. of Crosses	No. of Cones
P. resinosa x *resinosa*	11	49
P. resinosa x (*nigra* + *resinosa* irradiated)	8	69
P. resinosa x (*densiflora* x *silvestris* + *resinosa* irradiated)	10	67
P. resinosa x (*silvestris* + *resinosa* irradiated)	7	59
P. resinosa x (*densiflora* + *resinosa* irradiated)	7	62

The pollen was irradiated at 10,000 R/min to a total of 200,000 R.

*The authenticity of the hybrids is not verified yet.

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RESEARCH STUDIES IN THE SWAMPS OF SOUTHWESTERN ONTARIO 1969-70

H.C. Larsson
Research Branch,
Ontario Department of Lands and Forests, Maple, Ont.

The objectives of the swamp silvicultural research program are to develop practical techniques for the selection, mass production, establishment and culture of fast growing veneer-quality phenotypes of the commercially important hardwood species.

To accomplish these objectives, intensive reconnaissance surveys have been underway since 1957 in the major swamps of southwestern Ontario for locating exceptionally fast growing high-quality phenotypes of silver maple (*Acer saccharinum* L.), eastern cottonwood (*Populus deltoides* Marsh.), and Jackii poplar (*Populus* x *Jackii* Sarg.). At the present time 18 silver maple, six eastern cottonwood and four Jackii poplar have been selected for propagation. In addition 16 clones of European willow (*Salix alba* L.) and the progeny of five strains of lumber-type European alder have been grown for out-planting in the swamps.

A hardwood nursery of approximately 0.4 acres was established in the spring of 1969 to accommodate the silver maple progeny and the ever increasing clones and cuttings of eastern cottonwood, Jackii poplar and silver maple. It was expanded to almost 1 acre in the spring of 1970.

A misting bed with bottom heat was also established at the same time to increase the production of the silver maple clones.

SILVER MAPLE

Location and Selection of Phenotypes

No new silver maple phenotypes have been located in southern Ontario over the past 2 years. However, of the 23 that had been selected, four have since been rogued for defects which were not obvious at the time of selection.

Breeding Program

In 1968 seven parent trees were crossed under greenhouse conditions to produce 16 strains totalling about 1,200 seedlings. In 1969 eight parent trees were crossed under similar conditions to produce 18 strains totalling 800 seedlings.

In 1970 a limited breeding program was initiated by crossing only two parent trees of silver maple. However, at the same time a reciprocal cross was successfully made between silver and red maple. The cross was more successful when the silver maple male was crossed with the red maple female than when the red maple male was crossed with a silver maple female.

In all 3 years, the seed from the resultant crosses was sown in the greenhouse in plastic flats in mid-April and transplanted into the hardwood nursery in mid-May of the same year. Here they remain for 2 years before being outplanted in the swamps of southwestern Ontario.

Establishment Studies

A progeny test was established in the spring of 1969 in the Newell Tract of the Beverly Swamp by planting 2-year-old seedlings in a replicated design. The trees were spaced 6 feet apart within and between rows. Testing continued in the spring of 1970, by planting the progeny from seven parents in the Ellice, Beverly, Luther and Greenock swamps. Half of the trees were planted with roots and the other half were planted with only the root zone. The latter method of planting is faster and if successful will greatly reduce the costs of planting silver maple under swamp conditions.

Clonal Studies

Fifteen of the selected phenotypes have been reproduced either by budding, layering or cuttings. Cuttings appear to be the most efficient method of reproducing this species asexually. The best results to-date were procured when greenwood cuttings were planted in a misting bed in July and early August. Unfortunately the first roots which are formed on the cuttings are almost non-functional for the first year. It is therefore important that the young cuttings are not disturbed until May of the following year.

EASTERN COTTONWOOD AND JACKII POPLAR

Location and Selection of Phenotypes

A total of 11 eastern cottonwood and five Jackii poplar have been located since 1967 in the Burford, Beverly, Wainfleet, Luther and Greenock swamps. Of these 16 selections, four of the eastern cottonwood have been rogued either for minor defects or for canker. The remaining 12 trees are being propagated at Maple.

Establishment

One of the Jackii poplar clones was out-planted in the Ellice, Burford, Beverly, Puslinch, Luther and Greenock swamps in the spring of 1970. It will be evaluated as to growth and survival.

Clonal Studies

Over the past 4 years, eastern cottonwood and Jackii poplar have been propagated almost entirely by dormant, hardwood cuttings. Generally they root within 6 weeks of planting and by the end of the first growing season they are from 4 to 8 feet tall.

Greenwood cuttings procured in July from the best eastern cottonwood and Jackii poplar phenotypes were rooted in the rooting bed at Maple. Rooting success was almost 90% but when outplanted in the field in the spring of 1970, only the Jackii poplar cuttings survived. The root system of the eastern cottonwood clone appeared to be rendered non-functional after disturbance by transplanting.

EUROPEAN WILLOW

Sixteen clones of European willow were outplanted in a replicated and randomized design in the Newell Tract in the Beverly Swamp complex in the spring of 1969. The cuttings rooted well and approximately 90% of all cuttings survived the first growing season. Unfortunately there was a mouse epidemic in the winter of 1969-70 and over 80% of the cuttings were completely or partially girdled. The injured cuttings were cut off above the girdle and replanted in the early spring of 1970.

EUROPEAN ALDER

In 1962, seed from five lumber strains of European alder from Germany were procured through the late Dr. F.U. Klaehn of Syracuse University. They were sown in the Orono Nursery in the same year and were outplanted in three swamps in the spring of 1965 under natural conditions. They were measured after five growing seasons. They ranged in mean height per clone from 13 to 19 feet and with a mean diameter per clone from 1 to 2 inches. These trees not only grew well but they were not attacked by mice, rabbits or deer. Such a species might be valuable in a mixture for soil improvement as well as for lumber.

QUALITY CRITERIA FOR BLACK SPRUCE

J.L. Ladell
Ontario Research Foundation, Sheridan Park, Ont.

INTRODUCTION

For several years the Wood Science Section of the Ontario Research Foundation (ORF) has been engaged in research centering on the relationships between the properties of paper and the attributes of the wood from which it is made. Up to the time of writing, the work, which is sponsored by the Ontario Department of Lands and Forests, has been almost entirely with black spruce (*P. mariana*). However, it is planned to carry out some investigations on white spruce (*P. glauca*) and white spruce hybrids in the near future.

A lengthy investigation directed at the establishment of criteria which would allow the quality sampling of standing (black spruce) trees was completed in 1969. In this work the morphological and chemical characters in 16 samples of black spruce wood were examined with a view to determining, by multiple regression analysis, their efficiency as predictors of paper strength. The 16 samples consisted of four samples of like age taken from each of four trees. The four trees were part of a larger sample of 20 randomly selected from a Class 1 site in Parnell Township, Ontario. From each of the trees a 2-foot bolt was removed from the 10-percent, 25-percent, 50-percent and 75-percent-height levels. The present investigation centered on material from the 25-percent-height level. Confirmatory work involving all height levels in all 20 trees is in progress at the time of writing.

While the assessment of the relative efficiency of paper strength predictions was the principal object of the investigation, it was also thought desirable to examine the morphological and chemical characteristics of the 16 samples in some detail, as little is as yet known of the properties of black spruce wood.

Information was obtained on 65 wood characters in all. Determinations made on samples of chips included: specific gravity, both extracted and unextracted, lignin, pentosan and extractive content. Measurements made on macerated fibers included fiber length, fiber diameter, as measured at the mid-point, and the number of bordered pits. Measurements, with a microscope of cross-sections of selected rings included the cross-sectional dimensions of tracheids (fibers), lumens, and cell wall thickness, both tangential and radial and in both early- and latewood, the numbers of early- and latewood fibers per file and the total number of fibers per file, ring width and the width of latewood; the width of medullary rays and their frequency, both absolute and in relation to the number of tracheid files; the frequency of fusiform rays; and the size and frequency of vertical resin ducts. Counts were also made of the number of fibers per unit area, which, together with estimates of cell wall percent, led to expressions of the average cross-sectional dimensions of fibers and average cell wall thickness.

Measurements on tangential sections in selected rings included fiber length, and the height, width and frequency of medullary and fusiform rays.

VARIABILITY OF SAMPLE MATERIAL

Fiber length as determined from tangential sections of the latewood was found to increase from an average of 0.77 mm at the outer boundary of ring 2 to 3.78 mm in ring 100, with fluctuations in the middle years presumably associated with (observed) changes in growth rate. (Rings were counted from the pith.) Average fiber lengths, as determined from macerations, were consistently greater than fiber length in the latewood. Average tangential diameter of earlywood fibers increased rapidly from 13.4 μ in the ring nearest the pith to 20.4 μ in ring 10, with a further steady increase to 24.8 μ in ring 100. Radial diameter of earlywood fibers increased on the average from 15.4 μ in ring 1 to 23.8 in ring 10 and to 30.7 μ in ring 100. Tangential diameter of latewood fibers corresponded closely with that of earlywood cells. Radial diameter of latewood fibers increased from 10.22 μ in ring 1 to 13.92 μ in ring 10 and then increased but little if at all from that ring outward. The thickness of fiber walls in earlywood fibers changed little from ring 1 to ring 100. In latewood fibers the wall thickness increased fairly steadily from ring 1 outwards, to reach a maximum of 5.61 μ in ring 100 in the case of the radial walls and 4.21 μ in the case of tangential walls.

Latewood production was found to be meagre. Average number of latewood fibers produced increased from 8 in ring 1 to 15 in ring 10 with a decline thereafter to an average of 5 in ring 100. Values for latewood percent, calculated on the basis of measured width, were 40% in ring 1, with a decline to 20% in ring 10, and fluctuations thereafter. Values given by basing latewood percent on the relative number of latewood fibers present, a faster method, gave consistently higher percentages.

Medullary ray frequency in the four trees was highest in the ring nearest the pith, decreased rapidly in the first 10 rings, and less rapidly thereafter, so that in ring 100 the frequency of rays was about half that near the pith. From ring 1 to 10 the average height of medullary rays decreased and their average width decreased. Thereafter there appeared to be little change in their dimensions. Total ray cross-sectional area followed the trend for ray frequency. Fusiform rays were sparsely distributed with a frequency 1/40 that of the medullary rays. The average height of fusiform rays increased from the pith outwards. The number of vertical resin ducts was highest in the ring nearest the pith with an average of 7.28 ducts per mm^2. The frequency then fell abruptly to less than 1 duct per mm^2 in ring 10, with minor fluctuations in frequency thereafter. Vertical resin canal diameter, on the other hand, increased steadily from an average of about 30 μ in the ring nearest the pith to over 50 μ in ring 100. Total resin duct area tended to follow the trend for duct frequency.

Cell wall percent was highest in the ring nearest the pith with a sharp decline to ring 10, followed by a less steep decrease to ring 20. Cell wall percent then tended to increase but it never reached the value for ring 1. Specific gravity patterns reflected these trends. Lignin content tended to increase from about ring 25 outwards while pentosan content decreased from pith to bark, as did extractive content.

It was concluded from this examination that the core- or innerwood, comprising the region of anomalous wood near the pith, probably does not extend more than 10-15 rings from the pith in black spruce. The volume of corewood produced in relation to the whole merchantable bole would be therefore small, so that from the practical point of view the presence of corewood in the species may probably be safely ignored. From the patterns of variation outward, it was also concluded that black spruce is an unusually uniform wood. With comparatively few latewood cells, the character of the wood is probably dominated by the earlywood fibers, which vary little in wall thickness from pith to bark.

In general, variability outward appeared to be associated with radial distance from the pith, rather than with age or ring width.

CORRELATIONS WITHIN SAMPLE MATERIAL

Correlation coefficients were calculated between all 65 wood characters using averages for the 16 samples (14 df). The correlation coefficient between average ring width in the samples and unextracted specific gravity was -.522* and with extracted specific gravity -.538*. The correlation coefficient between specific gravity, unextracted and extracted, and latewood percent based on width of latewood, was found to be +.434 and +.424, NS. at the 5% level. Latewood percent based on relative number of latewood fibers, however, gave +.534* and +.501*. Latewood percent was negatively correlated with ring width.

Average and latewood fiber length were highly correlated at r = +936***. Average mid-point fiber diameter, as determined on macerations, was found to be more closely correlated with the radial diameter of earlywood fibers (r = +.812***) than with any other cross-sectional fiber dimension. Examination of the 12 correlations linking the radial and tangential measurements of fiber diameter, lumen diameter and cell wall thickness in both early- and latewood fibers showed that the tangential diameter of latewood fibers was significantly correlated with all but two of the 11 other cross-sectional fiber dimensions, and latewood radial wall thickness and the radial diameter of earlywood lumens all but three. On the other hand, the radial diameter of latewood lumens was significantly correlated with only one of the other 11 cross-sectional fiber dimensions. The correlation between average fiber length and average mid-point diameter was found to be r = +.669**. Correlations with precise cross-sectional dimensions were higher with fiber length/tangential latewood fiber diameter giving r = +.830***.

Specific gravity was found to be significantly correlated with only one cross-sectional fiber dimension - radial wall thickness in the earlywood.

No significant correlation was found between the height and width of medullary rays. Total ray area per mm^2(TS) was found to be closely correlated with ray frequency (r = +.840***), less closely correlated with average ray width (r = +.633***), and not significantly correlated with ray height (r = +.049). Ray frequency was strongly correlated with both average and latewood fiber length (r = -.879*** and -.849***), suggesting ray frequency, an easily measured feature, might be used to predict approximate fiber length.

Lignin content was found to be significantly correlated with latewood but not average fiber length (+.564* and +.451 NS). Lignin content was also correlated with radial fiber wall thickness with r = +.605* (earlywood) and +.662** (latewood); but there was no significant correlation with tangential fiber wall thickness (r = -.182 NS and +.337 NS). There was no significant correlation between lignin content and either ring width, age or radial distance from the pith.

Pentosan content was positively correlated with ring width, distance from the pith, ray frequency, and the width of latewood, but not with latewood percent.

Extractive contents were positively correlated with the frequency of medullary and fusiform rays, but negatively correlated with the size and distribution of resin ducts.

RELATIONSHIPS BETWEEN PAPER STRENGTH AND WOOD CHARACTERS

Duplicate cooks of 10 g samples of chips (oven-dry weight) from each of the 16 fractions were carried out in bombs of 150 ml capacity using the bi-sulphite process. Cooking times were 3, 3.5 and 4 hr at 160°C. Cooking of the 96 batches (16 fractions x 3 cooking times x duplicates) was to a predetermined randomised design.

For each of the three paper strength properties obtained, tensile strength (breaking length), burst and tear, linear regression equations were calculated with all 65 wood characters entered as independent variables in sub-sets of one, two and three in all combinations. Four series of regression analyses were made for each paper strength property with the four innerwood fractions included (N = 16) and excluded (N = 12), and with the dependent variables (paper strength) as based on the same cook-time (4 hr) and as based on the same residual lignin content (K = 45).

The analyses were carried out by computer which was programmed to include in the print-out only those regression equations in which each and every independent variable was found to be significant at or over the 5% level. The output included a total of more than 4000 equations. Examination of these showed that almost every one of the 65 independent variables entered was significantly related, either when taken alone or in combination, to one or other of the paper strengths. It was also found that the relative superiority of certain wood characters as predictions of paper strength depended on whether the paper strengths entered were those based on a common cook-time or those corrected for residual lignin; and also on whether the four innerwood fractions were included or not.

The equations were screened firstly for those wood characters, or combination of characters, occurring in all four series of analyses for each of the three paper strengths, i.e. those characters showing a relationship with paper strength, whatever basis was used to arrive at paper strength and whether the innerwood fractions were included or not. These characters would appear to be the most reliable and persistent indicators. A second screening was carried out for characters showing a relation with strength values corrected for residual lignin and appearing both in the presence and absence of the innerwood fraction, i.e. it was no longer required that a relation be maintained whatever the base used to derive paper strengths. A third screening was made for the characters showing strong relationships in the absence of the innerwood fractions (N = 12) and with corrected strength values only. These characters were deemed to be the least reliable. For the sake of simplicity the characters or criteria emerging as a result of the three screenings were termed Grade A, B and C, in decreasing order of reliability. Only the ten 'best-fits' in each category were examined. The three factor combinations giving the 'best-fits' are listed below.

Tensile Strength

Grade A criteria - best fits were given by:

specific gravity (-)***
tangential lumen diameter earlywood fibers (-)**
ratio of tracheid files to medullary rays (+)**
) $R^2\% = 82.5$

lignin content (-)**
total solubles (-)**
width of medullary rays (+)*
) $R^2\% = 81.6$

- other significant combinations included:

tangential diameter latewood fibers (-)
tangential diameter latewood lumen (+)
frequency of medullary rays (-)
radial distance from the pith (+)
age from pith (-)

Grade B criteria - best fit given by:

radial wall thickness latewood fibers (-)***
specific gravity (-)**
frequency of medullary ray cells (-)**
) $R^2\% = 85.3$

- other significant combinations included chemical constituents and medullary ray features as for Grade A, as well as fiber length - latewood (+).

Grade C criteria - best fits were given by:

radial wall thickness latewood fibers (-)***)
frequency of medullary rays (-)**) $R^2\%$ = 86.8
average cross-sectional area of fibers (+)**)

radial wall thickness latewood fibers (-)***)
specific gravity (-)**) $R^2\%$ = 85.3
frequency of medullary ray cells (-)**)

- other significant combinations included:
radial lumen diameter latewood fibers (+)
fiber length/mid-point diameter (-)
area of vertical resin canals (+)
ring width (-)
number of fibers per unit area of cross-section and derived measurements (as in the best-fit combination above)

Burst Strength

Tensile and burst strengths were highly correlated. Values based on common cook time gave r = +.892***. Values corrected for residual lignin gave r = +.920***. As might be expected, there were close similarities between the best-fit equations for the two strength values. Generally speaking the best-fit equations accounted for a higher proportion of the variation in burst, than they did for tensile strength. The Grade A three factor combination giving the best fit for burst strength was:

radial wall thickness latewood fibers (-)***)
radial diameter earlywood fibers (+)***) $R^2\%$ = 91.0
specific gravity (-)**)

A Grade A combination involving chemical constituents was:

lignin content (-)**)
total solubles (-)*) $R^2\%$ = 79.9
width of medullary rays (+)*)

Tear Strength

The number of characters found to be significantly related to tear strength was greater than those found for tensile or burst.

Grade A criteria - none

Grade B criteria - best fits were given by:

tangential diameter earlywood fibers (-)***)
frequency of medullary rays (-)***) $R^2\%$ = 86.3
tangential wall thickness latewood fibers (+)**)

Grade B criteria - alcohol/benzene + alcohol solubles (-)**)
tangential diameter earlywood fibers (-)**) $R^2\%$ = 81.7
latewood percent - by width (-)*)

- other significant combinations included expressions of ray frequency together with cross-sectional fiber dimensions

Grade C criteria - best fit was given by:
pentosan content (+)***)
alcohol/benzene + alcohol solubles (-)***) $R^2\%$ = 95.4
latewood percent - by number of cells (+)***)

- other significant three factor combinations included, besides those in the combination above:
tangential wall thickness of earlywood fibers (+)
cell wall percent (+)
average number of fibers per unit area of cross-section (+)
radial distance from pith (+)

Almost without exception unextracted specific gravity gave better fits than extracted specific gravity. Latewood percent as based on number of cells rather than on width gave superior fits in many cases.

The criteria selected for further testing include the chemical constituents, specific gravity, the frequency of medullary rays and the frequency of fibers per unit cross-sectional area, together with the average fiber dimensions derived from this frequency.

The investigation showed that it was possible to establish statistically strong relationships between wood characters and paper strength even when the amount of wood actually pulped was very small.

Almost every one of the 65 wood characters entered was found to be apparently related to paper strength, either when entered alone or in combination with other characters. In many cases this was presumably due to strong correlations between one character and another. In other cases the reason for the appearance in the output of certain wood characters may have been connected with some underlying non-linear relationship. Such relationships will be looked for in the confirmatory study.

The emergence of so many wood characters as significantly related variables would appear to cast serious doubts on the validity of any conclusions regarding the sources of strength in the paper sheet, when such are based on measurements in the unprocessed wood.

FURTHER WORK

As stated above, a confirmatory study on black spruce covering 20 trees at two height levels is already under way. In this work the relationships between paper strength and a 'short-list' of wood properties will be investigated further. Also planned are investigations of the paper making properties of material from 'plus' black and white spruce and from white spruce hybrids supplied by the Northeastern Forest Experiment Station in connection with a cooperative study between that establishment and the Research Branch of The Ontario Department of Lands and Forests.

BIOSONICS

It may also be mentioned that the ORF has been carrying out work in connection with the effects of ultrasound on living organisms. The Ultrasonics Applications Section of the Department of Metallurgy has been active in the industrial field for several years and has acquired considerable expertise particularly in respect to the development of instrumentation and measurement techniques. Because of this, ORF has recently received funds from the Federal Department of Health and Welfare to carry out a comprehensive literature review of the effects of ultrasound on biological material; while other contract work under way concerns the effects of ultrasound on the growth and development of fish and of domestic chickens. ORF funded pilot studies of the effects of ultrasound on the seeds of Scots pine (*P. sylvestris*) and a dwarf variety of tomato are showing that with certain frequencies an enhancement in the rate of germination may be expected. These studies are continuing and it is hoped that further results of interest will be forthcoming.

AN INDUSTRIAL TREE IMPROVEMENT PROGRAM IN NORTHERN ONTARIO

J.A. McPherson
Woodlands Department,
Kimberly-Clark Pulp and Paper Co. Ltd., Longlac, Ont.

The main area of activity during the past 2 years has been the clonal orchard. It consists of white and black spruce in separate compartments and now contains 681 grafts representing 93 plus trees. Some flowering occurred in 1969 and a limited number of black spruce cones was produced. These were collected and the seed sown in the nursery. There were not enough white spruce cones to warrant collecting.

In June 1969, controlled pollination was carried out on two black spruce clones, using pollen from a single source. In September the cones were collected and the seed was sown in flats in the greenhouse in April 1970.

The white spruce progeny test, started in 1967, is continuing. Approximately 2,000 seedlings, representing nine clones, will be moved to transplant beds in the spring of 1970.

Two hundred superior black and white spruce trees from the nursery have been added to the seedling orchard. Work on the Lydia Lake seed forest has been suspended until an economically feasible method is developed for collecting cones from black spruce 60 - 70 feet high.

RECOGNITION OF DEVELOPMENTAL PATTERNS IN CELL CULTURES OF PINUS BANKSIANA LAMB. AND PICEA GLAUCA (MOENCH) VOSS

D.J. Durzan
Canadian Forestry Service,
Forest Ecology Institute, Ottawa, Ont.

Previous reports (Durzan and Steward 1968, 1970) have established methods to obtain large quantities of freely suspended cells of jack pine and white spruce. This report deals with observations on the behavior of single and multiple cells of jack pine and the morphogenetic patterns that accompany the growth of cells derived from callus (Fig. 1). An attempt is made to recognize potentially organizing, patterns of growth at early stages of development. The approach arises from problems of vegetative propagation of conifers and the need for more information about the adventive embryogeny of somatic cells. For conifers, the latter is yet a distant goal and it is because this achievement would have great possibilities for forestry that a preliminary statement is presented.

From the start (Durzan and Steward 1968, 1970), studies indicated that many patterns of cellular associations could be derived from single cells and that the evaluation of temporal patterns needed a quantititive basis. When cells organized into structures, similar to that of the proembryo, the early patterns appeared to have few alternatives. By contrast, poor patterns, that generated more callus, were unpredictable in their ability to yield organized growth. One approach may be to attribute informational properties to patterns (e.g. Brillouin 1956, Elsasser 1968). Thus any regularities in pattern, e.g. symmetry, which would duplicate or repeat information, could be dealt with by the concept of redundancy.

To show that temporal patterns, which organize into proembryoids[1], have a few alternative courses, a way must be found to produce these patterns consistently that would tell us how many different patterns can be discriminated in the end product. From the total set of cellular patterns, meaningful subsets can hopefully be distinguished in such a way that symmetry becomes a usual concomitant of small subsets of cell pattern as well as redundancy, but not a necessary one. The important relation to be stressed is that poor patterns are unorganized and have many alternatives, good patterns show symmetry and polarity and have few alternatives, and the very best patterns, that would yield proembryoids and successful vegetative propagation, may be unique or at least highly organized. The product of the latter may be at an early stage highly predictable from the initial tactical displacement of cells into a basic pattern.

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[1]Proembryoid is defined as a proembryo-like structure that originates from a cell other than a zygote.

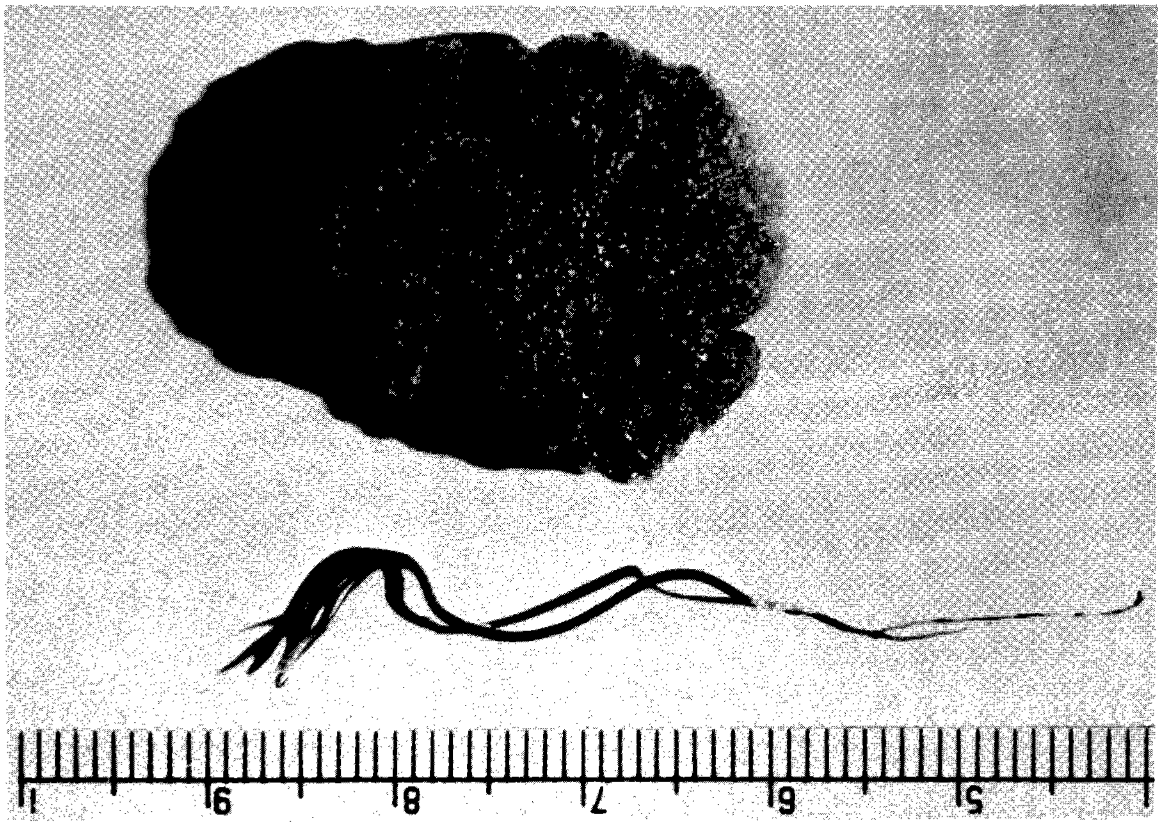

Figure 1. Growth and form of a one-week-old jack pine seedling compared to callus, derived from 2 mg of hypocotyl and grown for 6 weeks on 0.5% agar media containing White's basal supplemented with 10% coconut milk and 5 ppm α-naphthalene acetic acid. The contrast shows the ease by which growth of plant tissue can be disorganized by chemical means.

One approach to the evaluation of temporal patterns derived from the growth of totipotent cells is to generate through appropriate stimuli, specific patterns (e.g. Figs. 2, 3) where each cell could have only one of two possible alternatives (viz. to divide or not to divide) and this choice monitored by time lapse photography. If we were to deal with patterns derived from eight cells then altogether there would be 2^8 or 256 different sequences to deal with. Two of these are shown in Figures 3A and 3B. Clearly from experimental observations, many sequences are meaningless, do not occur, and do not involve organized growth. Of interest is the observation that cleavage polyembrony is an efficient way of eliminating unfit embryos and would presumably delete any deviations from a non-specific developmental pattern (Buchholz 1926).

The growth of somatic cells *in vitro* poses a problem that the observer cannot tell one pattern from another unless the starting point of the sequence is known. If we assume that an organizing pattern of cell associations starts with two cells yielding a specific pattern (e.g. filament) then this can be referred to as a *basic* pattern. Observations of cell