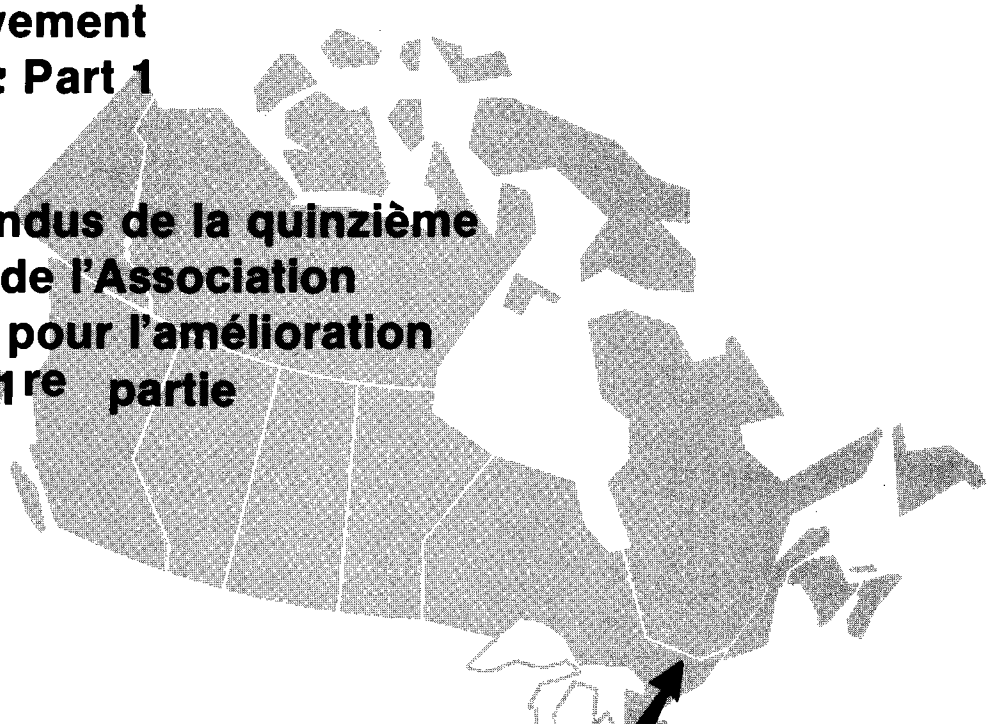
Proceedings of the fifteenth meeting of the Canadian Tree Improvement Association: Part 1

Comptes rendus de la quinzième conférence de l'Association canadienne pour l'amélioration des arbres: 1re partie



Petawawa Forest Experiment Station
Chalk River, August 18-22, 1975

Forêt expérimentale de Petawawa
Chalk River, du 18 au 22 août 1975

PROCEEDINGS

OF THE

FIFTEENTH MEETING

OF THE

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 1

MINUTES AND MEMBERS' REPORTS

HELD JOINTLY WITH THE
LAKE STATES FOREST TREE IMPROVEMENT CONFERENCE
AND
CANADIAN INSTITUTE OF FORESTRY WORKING GROUP 7

PETAWAWA FOREST EXPERIMENT STATION
CHALK RIVER, ONTARIO
AUGUST 18-22, 1975

EDITORS: C. W. YEATMAN AND K. ILLINGWORTH

Part 1 Minutes and Members' Reports. Distributed to Association members and available to others on request.

Part 2 Seminar: Applied Genetics in Forest Management. Distributed worldwide to persons and organizations actively engaged or interested in forest genetics and tree improvement.

Produced by the Canadian Forestry Service,
Department of the Environment, for the
Canadian Tree Improvement Association
Ottawa, 1976

COMPTES-RENDUS

DE LA

QUINZIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR

L'AMÉLIORATION DES ARBRES

1RE PARTIE

PROCÈS-VERBAUX ET RAPPORTS DE MEMBRES

TENUE CONJOINTEMENT AVEC LA
LAKE STATES FOREST TREE IMPROVEMENT CONFERENCE
ET
LE GROUPE DE TRAVAIL NO 7 DE L'INSTITUT CANADIEN DES FORÊTS

FORÊT EXPÉRIMENTALE DE PETAWAWA
CHALK RIVER, ONTARIO
DU 18 AU 22 AOÛT 1975

RÉDACTEURS: C. W. YEATMAN ET K. ILLINGWORTH

1re partie — Procès-verbaux et rapports de membres. Distribués aux membres de l'Association. Distribution au public sur demande.

2e partie — Séminar: la génétique appliquée à l'amenagement des forêts. Distribué à l'échelle mondiale aux personnes et organisations activement engagées ou interessées dans la génétique forestière et l'amélioration des arbres.

Publié par le Service canadien des forêts,
ministère de l'Environnement, pour
l'Association canadienne pour l'amélioration des arbres
Ottawa, 1976

PROCEEDINGS OF THE FIFTEENTH MEETING OF

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association

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

The Sixteenth Meeting of the Association will be held in Winnipeg, Manitoba, June 1977, in conjunction with the Canadian Botanical Association and the Genetics Society of Canada. The theme of the C.T.I.A. symposium will be "The Contribution of Forest Genetics to the Quality of the Environment". Canadian and foreign visitors will be welcome. Further information will be distributed in fall, 1976, to all members and to others on request.

If your name, title or address appearing on the address label is incorrect or incomplete, please fill in and return this correction slip.

Others interested in receiving Proceedings, notices of meetings, etc. may return the slip to be listed as Corresponding Members (Canadian) or be placed on the mailing list for the Proceedings only (libraries, institutions, foreign addressees).

TO: Mr. J.C. Heaman, Executive Secretary, Canadian Tree Improvement Association, Research Division, British Columbia Forest Service, Victoria, B.C., Canada.

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

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Signed ....

COMPTES RENDUS DE LA QUINZIÈME CONFÉRENCE DE

L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

Gracieuseté de L'Association

Les demandes de renseignements peuvent être adressées aux auteurs ou encore à M. J.C. Heaman, secrétaire du Conseil de la direction, A.C.A.A., Research Division, British Columbia Forest Service, Victoria, C.-B., Canada.

La seizième conférence de l'Association aura lieu à Winnipeg, Manitoba, en juin 1977, conjointement avec l'Association canadienne de botanique et la Société de génétique du Canada. Le thème du colloque de la A.C.A.A. sera le suivant: "La contribution de la génétique des forêts à la qualité de l'environnement". Les visiteurs canadiens et autres seront les bienvenus. De plus amples reseignements seront communiqués à l'automne 1976 aux membres et autres personnes qui en feront la demande.

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Dr. Mme
M. Mlle ....Titre...................

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Signé ....

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ACTIVE MEMBERS

1974

CANADIAN TREE IMPROVEMENT ASSOCIATION

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Dr. G.R. Powell	University of New Brunswick Faculty of Forestry Fredericton, N.B.
Rose Marie Rauter	Ontario Ministry of Natural Resources Research Branch Southern Research Station Maple, Ont.
Dr. W.G. Ronald*	Canada Dept. of Agriculture Research Station Morden, Man.

Mr. J.B. Santon	Canadian Forestry Service Petawawa Forest Experiment Station Chalk River, Ont.
Mr. D.A. Skeates	Ontario Ministry of Natural Resources Research Branch Southern Research Station Maple, Ont.
Mr. R.D. Stevens	MacMillan and Bloedel Ltd. Forestry Division 65 Front Street Nanaimo, B.C.
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Dr. G. Vallée	Ministère des Terres et Forêts Service de la recherche 875 rue St-Amable Québec 4, Qué.
Mr. B.S.P. Wang	Canadian Forestry Service Petawawa Forest Experiment Station Chalk River, Ont.
Mr. N.C. Wheeler	British Columbia Forest Service Red Rock Nursery R.R. #5, 15-Mile Road Prince George, B.C.
Dr. C.W. Yeatman	Canadian Forestry Service Petawawa Forest Experiment Station Chalk River, Ont.
Dr. F. Yeh	British Columbia Forest Service Research Division, Victoria, B.C.
Dr. L. Zsuffa	Ontario Ministry of Natural Resources Research Branch Southern Research Station Maple, Ont.

* Nominated for active membership subsequent to 15th Meeting

BUSINESS MEETING - MINUTES

Dr. C. W. Yeatman chaired the business meeting which was called to order at 7:10 p.m., August 19, 1975. Twenty-three members attended. The agenda was read by K. Illingworth.

162. MINUTES OF THE LAST MEETING

Motion: That the minutes be adopted as published. Moved by D. Fowler, seconded by C. Lane. Carried.

163. MEMBERSHIP

The names of prospective and resigning members were presented as follows:

a) New Members

Sponsoring

Dr. P. J. Murphy,	University of Alberta

Active

Dr. B. Dancik	University of Alberta
Dr. D. G. Edwards	Canada Forest Service
Mr. J. Konishi	B.C. Forest Service
Mr. R. D. Stevens	MacMillan Bloedel Ltd.
Mr. R. Hallett	Canada Forest Service
Mr. J. F. Coles	Canada Forest Service
Dr. F. Yeh	B.C. Forest Service
Mr. N. Wheeler	B.C. Forest Service
Mr. R. Calvert	Department of Mines, Resources and Environmental Management, Manitoba
Dr. G. Murray	Lakehead University
Dr. R. J. Hilton	University Arboretum, Guelph
Dr. J. W. Andresen	University of Toronto

Corresponding

Mr. W. Burry	Forest Service, Newfoundland
Dr. G. Fleischman	Director General, Policy and Programs Development Directorate, Ottawa
Mr. E. E. Sawka	Department of Mines and Natural Resources, Manitoba
Mr. J. Pouliot	The Donohue Co. Ltd., P.Q.
Mr. R. Girard	The Donohue Co. Ltd., P.Q.
Mr. G. D. Morrison	The James Maclaren Co. Ltd., P.Q.
Mr. P. N. Au	Proctor and Gamble Cellulose Ltd., Alta.
Mr. A. Duchesne	Anglo Canadian Pulp and Paper Ltd., P.Q.
Mr. R. Marois	Anglo Canadian Pulp and Paper Ltd., P.Q.
Mr. D. Baird	Ontario Ministry of Natural Resources
Mr. J. C. Davidson	Fraser Companies Ltd., N.B.

Mr. M. Aquires	Price (Nfld.) Pulp and Paper Ltd.
Mr. D. W. Nixon	Proctor and Gamble Cellulose Ltd., Alta.
Mr. C. A. Dickinson	Valley Forest Products, N.B.
Mr. J. D. Brophy	Ontario Paper Co.
Mr. F. Caron	Sainte-Foy, Quebec
Mr. V. A. Sundstrom	B.C. Forest Service
Dr. R. F. Sutton	Canadian Forestry Service

b) Resignations

Dr. J. B. Scarratt
Mr. J. E. Liersch
Mr. H. Parnell
Mr. R. H. Armstrong

O. Sziklai pointed to inconsistencies in the current published list of members (March, 1975). Yeatman referred to the difficulty of maintaining accurate lists without the full co-operation of those concerned. Customarily, the names of individuals applying for membership are forwarded immediately for inclusion on the membership list, subject to their acceptance at the next business meeting. Steps were being taken to update the listing, and the anomalies mentioned would, together with any others, be investigated and corrected.

Motion: That the individuals applying for Sponsoring, Active and Corresponding Membership, as listed in the membership report, be duly elected. Moved by K. Illingworth, seconded by C. Larsson. Carried.

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

The Chairman of this subcommittee, C. W. Yeatman, called for action by the C.T.I.A. based upon its policy statement on the conservation of forest gene resources (Prince George, 1971) and upon the need, principles and methods outlined in papers by Yeatman (Tokyo, 1972) and by Maini, Yeatman and Teich (Rome, 1975). He emphasized that it is the principles of gene pool conservation which need to be fully understood by forest administrators. It is not for the C.T.I.A. to specify the particular ways and means. These must be developed by local administrators and integrated with existing programs of management and conservation.

In pledging his support for the proposal, Mr. B. Armitage stressed that the policy of the C.T.I.A. should be to support the efforts of its members, working in their respective provinces, to ensure the conservation of potentially valuable, balanced gene complexes.

While admitting that certain endangered populations require protection, D. Fowler questioned the immediate need for a nation-wide programme of gene pool conservation.

O. Sziklai referred to Europe where many natural gene pools have been irrevocably altered or destroyed, and to the difficulties which European foresters consequently face when required to select from adapted populations for reforestation and breeding. Canadians, he warned, have a last opportunity to avoid the problems of Europe and elsewhere.

After prolonged debate, a vote was taken on the issue.

Motion: That the Canadian Tree Improvement Association supports the principles of need and method outlined in the paper "Gene Pool Conservation for Applied Breeding and Seed Production" presented by Dr. C. W. Yeatman (Tokyo, 1972), and recommends that the urgent need for action on this matter be brought to the attention of all Canadian forest services and other concerned public and private agencies.

Moved by B. Armitage, seconded by S. Swan. Carried.

S. Swan suggested that the Executive should determine the most effective and appropriate means of bringing the report to the attention of the several organizations concerned.

O. Sziklai proposed the establishment of a sub-committee to study the priorities and needs of native species.

D. Fowler pointed out that the existing working party could follow up these suggestions.

Motion: That the Working Party, on the Conservation of Endangered Arboreal Germ Plasm, comprising, C. W. Yeatman, W. Dyer, K. Illingworth and S. Swan, be retained as an active committee.

Moved by D. Fowler, seconded by A. Gordon. Carried.

165. UNIVERSITY EDUCATION IN GENETICS - POLICY, PLANNING AND SUPPORT

A. Carlisle drew the attention of members to the difficulty being experienced by government agencies in Canada in filling vacancies for researchers in tree improvement. Prospective employers are especially conscious of the shortage of Canadians trained in the quantitative genetics of eastern species.

Several forestry schools offer courses in genetics, but post-graduate training to the Ph.D. level is available only at the University of British Columbia, where the emphasis is on western species.

Many people go outside Canada for their post-graduate training, and government agencies are being forced to look outside Canada when recruiting. Tree improvement needs are on the upswing, and in the near future more well-trained people will be needed.

The proposal was made, therefore, that the C.T.I.A. should make every effort to persuade the Universities, both in eastern and western Canada, to include in their programs more post-graduate training in tree improvement, including training in depth in quantitative genetics to the Ph.D. level.

In the ensuing debate, R. M. Rauter reported that, in consequence of a similar motion at the Niagara Falls meeting of the Canadian Institute of Forestry, she had sent letters to the Deans of Canadian Forestry Schools expressing the Institute's support for an increase in the genetics content of forestry curricula. From the responses obtained, she doubted whether this action has been effective.

O. Sziklai pointed out that, since the inclusion of forestry genetics in the undergraduate courses at the University of British Columbia in 1975, some 550 students had received training in the subject. These were capable of working as effectively with eastern as with western species. While agreeing with the importance of genetics training, Sziklai contended that any increase in genetics content should be a reflection of increased job opportunities and, particularly at the post-graduate level, financial support from government sources, e.g. scholarships. During the past year neither had been forthcoming.

D. Fowler affirmed that a course in forest genetics should be available to all biologically oriented undergraduates, regardless of job opportunities. Since, however, some forestry schools do not have the capability to support a Ph.D. programme in forest genetics, he recommended that the proposal be amended to read (a) "undergraduate" for "graduate" and (b) "graduate" for "Ph.D". Carlisle subsequently concurred with these amendments.

J. Farrer agreed with B. Dancik that compulsory courses are being phased out of forestry curricula. At the University of Toronto, genetic ideas are now being incorporated into a number of undergraduate courses. At the post-graduate level, however, the concept of "centres of excellence" has been espoused. Canada already has such a centre at the University of British Columbia. Support for the existing centre of excellence would be more appropriate than setting up new ones.

G. Murray suggested that a shortage of Canadian expertise can be found in other forestry disciplines besides forest genetics and, in terms of obtaining government funding, it might be unrealistic to attempt to establish more Ph.D. programs in tree improvement.

Objection was raised by Sziklai to the specification of quantitative genetics in Carlisle's proposal on the grounds that it would restrict the development of expertise in other areas, e.g. tissue culture, which is likely to be required in the future.

Carlisle, however, stressed that the critical scarcity is in the field of quantitative genetics. This being the core of his proposal, he wished it to stand.

Stating that the proposal was before the house for acceptance in principal, Yeatman read the amended form and called for a vote.

Proposed by A. Carlisle, seconded by R. M. Rauter, that the C.T.I.A. should make every effort to persuade the Universities, both in eastern and western Canada, to include in their programs more undergraduate training in tree improvement, including training in depth in quantitative genetics to the graduate level. Carried.

On a suggestion from S. Swan and B. Armitage, it was agreed that the Chairman of the C.T.I.A. should write to the Deans of the Forestry Facultities of the Universities concerned, to the Director General of Forestry for Canada and to the Chairman of the Association of Schools of Forestry in Canada, conveying C.T.I.A. acceptance of the principles expressed in Carlisle's proposal.

In elaboration, Armitage stated that it would be timely if this message was conveyed immediately in view, not only of Canadian Forestry Service concern for future staffing, but also because of representations recently made by the several Deans of Forestry to the Federal Government concerning the lack of support and resources to carry on needed research and training programs. Also in collaboration with the Universities and National Research Council, the Canadian Forestry Service is currently making a review of federal support to the Universities.

166. TECHNOLOGY TRANSFER

This topic was discussed briefly after its introduction by Yeatman who questioned whether forest genetics research was being utilized by forest managers. Is there a problem and, if so, how can it be overcome?

R. Calvert expressed the view that communication is a perennial problem which can only be solved through personal contacts. Forest managers in his experience, are usually too busy to read much. Verbal communication is most effective. G. Kokocinski added that it is necessary to maintain contact and, by repetition, essentially to brainwash managers, especially those controlling funding.

S. Swan suggested that the key to the problem lay in being able to demonstrate success in terms of a return on dollars and cents invested. He illustrated his point by describing a tour of co-operative tree improvement operations in the southeast states, which was made by 23 Canadian foresters of various backgrounds, mostly company and administrative, during February, 1975. Delegates could not help but be impressed by statistics such as investment returns of 17-21 percent, seed valued at $600. per lb., and the implications of a company such as Bowaters Ltd. moving seed orchard trees twenty miles at a cost of $300. per tree. Swan regretted that more foresters were not able to join this tour, but hoped that more would have exposure to what was learned during a meeting of management foresters at Ottawa in November, 1975.

167. PROPOSAL FOR A CANADIAN FOREST GENETICS EXHIBIT AT THE I.U.F.R.O. THIRD WORLD CONSULTATION ON FOREST GENETICS, AUSTRALIA, 1977

B. Armitage introduced this topic. The organizers of the Third World Consultation on Forest Genetics have invited countries and organizations around the world to contribute displays to a small exhibition or international display, which they propose to set up in Canberra on the occasion of the meeting.

During a Canada Forest Service discussion of the invitation, Armitage had expressed the thought that it would be appropriate for Canada to participate in this activity by sending an audio-visual presentation of some suitable piece of work, or a series of vignettes of tree improvement work across Canada. To this end, the C.F.S. would be prepared to put up a small sum of money, of the order of $2,000, and to undertake the organizational work necessary to put such a display together. Armitage requested an expression from C.T.I.A. members as to whether this would be appropriate, and an indication from the industrial and provincial agencies as to whether they would make available contributions in the way of ideas, photographs or other material.

K. Illingworth stated that the British Columbia Forest Service would welcome the opportunity to participate in such a display.

Members gave, by a show of hands, an expression of support in principle for the proposed exhibit.

Yeatman reminded members that the Consultation is scheduled for March 21-26, 1977, and that any presentation would need to be ready by the end of 1976.

168. MEMBERS' REQUIREMENTS FOR SETS OF ADDRESS LABELS FROM C.T.I.A. LIST

C. W. Yeatman advised members that sets of mailing labels could, for a nominal sum, be made available from the C.T.I.A. mailing list. Such labels would be useful, for example, for distributing reprints to addressees in Canada or abroad.

With an initial outlay of approximately $300, a program could be obtained which would print the labels from C.T.I.A. address listings. Thereafter, sets of labels could be produced for a mere $10-20 per set of some 600 labels. However, since any request from members for this service would necessarily be open-ended, it was not feasible, for budgetary reasons, for the Canadian Government to undertake it.

In reply to a question from D. A. Fraser, B. Armitage said that a C.T.I.A. survey of members to determine and subsequently to inform the Federal Government as to the extent of the service requested would be a reasonable and acceptable approach.

Motion: That a survey of members of the C.T.I.A. be made as to their requirements for an address labels service; when the survey has been completed, that an estimate of the costs involved be forwarded to the Canadian Forestry Service for their consideration.

Moved by D. A. Fraser, seconded by O. Sziklai. Carried.

169. DESIGN FOR C.T.I.A. LETTERHEAD

Members were informed that J. Maini had accepted from the F.A.O., on behalf of the C.T.I.A., the sum of $250 in remuneration for a joint paper by Maini, Teich and Yeatman. This money had been deposited in a bank account in the name of the C.T.I.A., and the suggestion was made by the authors that it might well be used to have stationery printed with a name and symbol characterising the C.T.I.A. Dr. Yeatman, therefore, invited suggestions from members for an appropriate logos. If one was not received in the near future, letterhead paper would be printed simply with the association's name in French and English. Should the need arise subsequently, a logos could be used in a second printing.

Members concurred with this proposal.

170. LOCATION, DATE AND THEME OF NEXT MEETING

Two proposals were considered for the 16th meeting of the association: an invitation from Dr. M. A. K. Khalil to meet in St. John's Newfoundland, and a suggestion that the association should meet with the Canadian Botanical

Association in Winnipeg, sometime in June, 1977. Although only tentative enquiries had been made regarding the latter and preference was expressed for August rather than June, members voted in favour of meeting in Winnipeg.

Khalil suggested that an appropriate theme would be "The contribution of forest genetics to the improvement of the environment". Yeatman said that this and any other suggestions would be considered by the incoming Executive, but the final decision must rest with them.

171. ELECTION OF OFFICERS, 1976-77

E.K. Morgenstern presented the report of the nominating committee. There being no further nominations, the following were elected to office:

Chairman: Dr. J. I. Klein
Vice-chairman i/c Local Arrangements: Mr. R. Calvert
Vice-chairman i/c Symposium: Dr. A. Corriveau, M. Y. Lamontagne
Executive Secretary: Mr. J. C. Heaman

172. REPORT ON SEED TESTING WORKSHOP, GUILDFORD, 1975

Mr. B.S.P. Wang presented the following report on the first International Seed Testing Associations' workshop on forest tree seed testing. This was held at the University of Surrey, Guildford, England, from July 6 to 12, 1975.

The workshop owes its success to the excellent planning and organization by the host country's Forestry Commission staff. The 6 day workshop was attended by 33 delegates from 20 countries. The objective was to obtain uniform interpretation of the recently amended international rules for tree seed testing and to discuss mutual problems in this field.

The revised international rules for seed testing will take effect on July 1, 1976, in the northern hemisphere, and on January 1, 1977, in the southern hemisphere. The workshop program covered the following subject areas:

1. Sampling and purity analysis
2. Standard germination tests and seed dormancy
3. Rapid tests - tetrazolium, excised embryo and x-ray
4. Moisture content determination
5. Tropical seeds

The following decisions were made:

1. Size of seedlot, 100 Kg or 5000 Kg, is considered too large for forest tree seed and should be reduced.

2. The working sample should contain at least 2500 seeds.

3. A seedling evaluation handbook describing normal and various types of abnormal germination will be published.

4. Normal epigeal germination of tree species was redefined as when the primary root and hypocotyl together exceed four times the length of

the seed, provided all structures which have developed appear normal. Although the new definition seems to have clarified some past confusion, it is still based on viability rather than germinability as not all viable seeds are necessarily germinable.

5. Laboratory test results should be correlated to field or preferably greenhouse emergence. Criteria of germinability can be established from such correlation tests.

6. Alternative methods for rapid tests should be developed for seed of dormant species that requires more than two months of pretreatment and testing. The working group on seed dormancy was asked to conduct comparative tests for dormant-seed species in combination with x-radiography, tetrazolium and excised embryo techniques.

7. The seed x-radiography working group will recommend practical procedures for the routine use of x-rays in seed testing.

8. Rapid tests by tetrazolium and excised embryo techniques are urgently needed, but require more refinement before they can be uniformly interpreted.

9. More precise descriptions are needed for hardwood seed germination tests.

10. Immediate steps should be taken to remove the distillation method for moisture content determination of Abies, Cedrus, Fagus, Picea, Pinus and Tsuga seed and to relax the tolerance limit between duplicated samples according to seed size.

11. The seed moisture and storage working group was asked to test the efficiency of electric and electronic moisture meters which are being used by forest tree seed testing laboratories.

12. There is an urgent need to develop the best method of preparing large seeded hardwood seed for moisture content determination.

173. REPORT ON THE I.U.F.R.O. CONFERENCE ON PHYSIOLOGICAL GENETICS, EDINBURGH, JULY 13-21, 1975

Dr. D.F.W. Pollard briefly outlined highlights of this meeting which was attended by some 60 scientists from a dozen mainly European countries. The conference was organized by the Unit of Tree Biology under the aegis of the Growth Processes working party of I.U.F.R.O. It comprised sessions on shoot growth, cambial growth, water stress and water-logging, frost hardiness and mineral nutrition. Discussions revealed certain weaknesses in tree physiology research. For example, physiologists tend to neglect the influence of seed size on the early growth of seedlings. They concentrate on those processes and influences leading to early canopy formation, but neglect the effects of age foliage. In general, there is a need for better communication between physiologists and geneticists.

The conference included excursions to projects and laboratories in the vicinity of Edinburgh, including the Redox project, the Unit Tree Biology Centre and Forestry Commission Research Station at Bush Estate. During visits to upland plantations of Scots pine and Sitka spruce, delegates were impressed by the extent of wind damage to Scottish forests and the amount of research being done on this particular problem.

174. 23RD NORTHEASTERN FOREST TREE IMPROVEMENT CONFERENCE

As the representative of the C.T.I.A. at the Northeastern Forest Tree Improvement Conference, Mr. H.C. Larsson presented a comprehensive review of the 1975 meeting in Massachusetts, details of which will appear shortly in the Proceedings of the NEFTIC group. The 1976 meeting will be held in Maryland.

175. MEMBERS' REPORTS

As anticipated, the agenda of this meeting left no time for the customary presentation of active members' reports. Reports had been received from some thirty members. Collectively, Yeatman observed, these reports represent the most current and complete picture of the 'state of the art' in Canada, and they would be published, as usual, as a part of the Proceedings. Past delays in the publication of the Proceedings were regrettable. The Executive intend to strive for publication within three months of the present meeting.

176. OTHER BUSINESS

Members were invited to express any concern or request for assistance which the association or the members might be able to render, e.g. in the way of seed, scions, support on collaboration.

D. A. Fraser observed that with 135,000 square miles of the James Bay area scheduled for power development it would be appropriate for the association to look into the need for the conservation of gene pools from the region.

177. APPRECIATION

On behalf of all members of the association, O. Sziklai proposed a vote of thanks to the outgoing Executive for their efforts during the past two years.

178. ADJOURNMENT

Motion: There being no other business, that the Fifteenth Business Meeting of the Canadian Tree Improvement Association be adjourned. Moved by G. Kiss, seconded by D. A. Fraser. Carried.

GENETIC IMPROVEMENT OF NATIVE TREE SPECIES IN NEWFOUNDLAND

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INTRODUCTION

The tree improvement program at the Newfoundland Forest Research Centre has been divided into two projects during the two year period since the previous report in August 1973. These projects deal with exotic and native species respectively. This report deals with Project No. NFC 21 - Genetic improvement of native tree species. The object of this project is to determine patterns of genetic variation and heritability of selected traits of local species for identification of superior trees, stands and provenances, delineation of seed zones and commercial production of genetically superior seed.

Three studies were in progress during the period under report. They are described below.

STUDY NO. NFC 21-1. GENETIC IMPROVEMENT OF BLACK SPRUCE IN NEWFOUNDLAND.

The following three approaches have been planned to achieve the objectives of this study.

Regional black spruce provenance experiments

The results of the nursery phase of these experiments reported in 1973 have since been published (Khalil 1973). These provenances were outplanted in seven field experiments in the fall of 1972 (one location) and the spring of 1974 (six locations), which are listed in Table 1. These experiments were laid out in six-replicated randomized complete block design with four-tree square plots, with a spacing of 1.8 m x 1.8 m (6 ft. x 6 ft.).

Table 1. - List of regional black spruce provenance experiments

Forest section*	Location	Latitude °N	Longitude °W	No. of provenances
B.28a - Grand Falls	New Bay Pond	49° 03'	55° 40'	18
	Sandy Brook	48° 57'	55° 50'	37
B.28b - Corner Brook	Big Falls	49° 20'	57° 25'	20
	Little George's Lake	48° 48'	58° 00'	26
	South Brook Valley	48° 55'	57° 30'	39
B.29 - Northern Peninsula	Roddickton	50° 55'	56° 10'	36
B.30 - Avalon	Cochrane Pond	47° 33'	52° 50'	15

*After Rowe (1972)

The data on cone morphology, four-year growth and phenology of the Newfoundland provenances were further analyzed to determine the degree and pattern of variation of important characters in the black spruce populations of insular Newfoundland. Important conclusions are summarized below1/.

1. Variation in cone length, cone diameter and seed-weight is ecotypic with some indication of indirect association of cone length and cone diameter with height growth. Cone length and cone diameter are mutually correlated and are under strong genetic control.

2. Initiation and release of bud dormancy are under strong genetic control with a large intra-provenance variation in both cases. Variation in these characters is ecotypic. The threshold levels of climatic factors for initiation of bud dormancy appear to be temperatures of 1° - 6°C and photoperiod of 11.5-13.3 hours and those for release of bud dormancy appear to be 48-56 degree-days above 6°C, mean daily temperatures of 2-12°C and a photoperiod of 15.7 hours. Soil conditions seem to affect release but not initiation of bud dormancy.

3. Though soil and microclimate have statistically signficant effects on 1-year survival, both 1-year and 2-year survival are under strong genetic control and are mutually correlated. Intra-provenance and intra-replication variances as well as provenance x replications interactions are high. Survival in both years is positively correlated with seed weight and only weakly correlated with latitude, longitude and altitude.

4. Height and root-collar diameter are under strong genetic control. Variation in both characters is ecotypic with a statistically significant contribution from provenances, trees within provenances and provenances x replications interaction. There is a strong positive correlation between seed weight and growth and between growth in subsequent years.

5. Commencement, cessation and rate of annual height growth are under strong genetic and weak environmental control. The genetic control and intra-provenance variation are largest in terms of cessation, weaker on commencement and weakest on rate of annual growth. Variation in all three characters is ecotypic.

<u>All-range black spruce provenance experiments</u>

The 2-2 seedlings of the provenances used in this cooperative study were outplanted at three locations in June 1975, as shown in Table 2.

1/Khalil 1975, unpublished data.

Table 2. - List of all-range black spruce provenance experiments

Forest section*	Location	Latitude °N	Longitude °W	No. of provenances	Experimental design
B.28a - Grand Falls	Millertown Jct. Rd.	48° 45'	56° 15'	72	Six replicated 8 x 9 triple lattice
B.28b - Corner Brook	Little George's Lake	48° 50'	58° 00'	72	
B.29 - Northern Peninsula	Roddickton	50° 55'	56° 05'	64	Six replicated 8 x 8 triple lattice

*After Rowe (1972)

Black spruce progeny trials

Single-tree open pollinated seed collection was extended to 20 locations, which were as evenly distributed in the Island's black spruce forests as possible. Seed was extracted, dewinged and cleaned. Sowing of this seed in the nursery has been deferred in an attempt to reduce the period of producing plantable seedlings using paper pots and greenhouses. An experiment, started in the winter of 1973-74 has indicated that it may be possible to sow the seed in the greenhouse in the October of one year, harden the seedlings in the following spring, summer and fall and plant them out in the field in the next spring. This can reduce the nursery stage from four years to one.

STUDY NO. NFC 21-2. GENETIC IMPROVEMENT OF WHITE SPRUCE IN NEWFOUNDLAND

This study is also divided into two parts and their progress is stated below:

Great Lakes-St. Lawrence region white spruce provenance experiment

The experiment in the North Pond Experimental Area in east-central Newfoundland is one of a series of all-range cooperative provenance experiments. The second measurement at the age of 15 years from seed was conducted in the fall of 1973. The results have been published (Khalil 1974b) and are summarized below:

1. Table 3 shows the distribution of variance among the various components. The high provenances x replications interactions is genetically important.

Table 3.- Summary of analysis of variance

Source of variation	Percentage variance					
	Height in					D.B.H.
	1969	1970	1971	1972	1973	in 1973
Replications	5**	4**	3**	3**	3**	3**
Provenances	11**	11**	10**	9**	9**	11**
Provenances x replications interactions	20**	23**	23**	25**	26**	29**
Sampling error	64	62	64	63	64	57
Total	100	100	100	100	100	100

**Statistically significant ($P > 0.99$)

2. The statistically significant variation due to replications is probably the result of varying soil nutrients and moisture regimes, which are obvious on the site. The decrease in this variation from 1969 to 1973 indicates some reduction of the differences in soil conditions among replications, possibly as a result of recovery from the differential effects of the 1961 accidental fire, or adjustment of the provenances to the different environmental conditions in the replications, or both.

3. The Student-Newman-Keul's multiple range tests and single degree of freedom comparisons between provenances from latitudinal and longitudinal zones show that all the 31 Great Lakes-St. Lawrence region provenances are statistically non-significantly different from each other in height and D.B.H. It is reasonably safe to assume that meaningful differences between more provenances and their geographical groups exist than these tests reveal. This conclusion is supported by the evidence obtained from multiple regression and multiple correlation analyses. This anomaly is due to a large experimental error mean square in the analysis of variance which in turn is caused by large within-plot variation.

4. The following regression equation was established

$$Y = 662.9023 - 7.1122X_I - 1.4930X_2 + 0.0177X_3 - 2.0367X_4 + 0.4082X_5 - 2.4721X_6$$

where Y is height in the fall of 1973 and $X_I - X_6$ are latitude, longitude, altitude, mean annual precipitation, mean number of frost-free days and mean January minimum temperature respectively. The regression equation is statistically significant ($p > 0.99$) with latitude, longitude, and mean number of frost-free days being statistically significant ($p > 0.95$) as well as mean January minimum temperature ($p > 0.99$). These results indicate the fastest growing provenances to exist in the south-east portion of the area sampled.

5. Eight fastest growing provenances have been identified from ranked data and tally with the above results.

Table 4.- Eight fastest growing provenances

Provenance	Height in 1973 Mean (cm)	Height in 1973 % of plant-ation mean	Height in 1973 % of Newfound-land proven.	D.B.H. in 1973 Mean (cm)	D.B.H. in 1973 % of plant-ation mean	D.B.H. in 1973 % of Newfound-land proven.
2447. Grand Piles, Quebec	214.9	118	155	2.0	154	455
2451. Lake Edward, Quebec	205.3	113	148	1.8	138	409
2459. Algonquin Park, Ontario	204.7	113	148	1.8	138	409
2444. Beachburg, Ontario	204.6	113	148	1.7	131	386
2481. Potter, Ontario	200.2	110	145	1.6	123	364
2463. Notre Dame du Luns, Quebec	196.3	108	142	1.6	123	364
2485. Lac Simard, Quebec	195.3	108	141	1.5	115	341
2462. McNally Lake, Quebec	194.5	107	141	1.5	115	341

Note - Plantation mean height = 181.5 cm, D.B.H. = 1.3 cm, Newfoundland provenance, mean height = 138.4 cm, mean D.B.H. = 0.44 cm.

The exceptionally poor growth of the local provenance has to be viewed with caution. Firstly, it was not obtained from phenotypically superior areas like the Exploits Valley. Secondly, the experimental material consisted of 3-5 year old wildings, whose survival and growth are very variable within the provenance and whose recovery from planting shock was very slow.

There are no significant differences among these eight provenances in form quotients, which shows all of them to be equally good. Also, none of them has suffered from frost or winter desiccation. These provenances, or others from the same general locations, have proved superior in height growth in several other provenance experiments (Nienstaedt 1969; Teich 1973). This is a good indication of their stable genetic superiority.

6. Coefficients of correlation between the 1965 and 1967 heights and between 1965 and 1973 heights were 0.6932 ($t = 5.27^{**}$) and 0.5877 ($t = 3.98^{**}$) respectively. This is a good indication of the reliability of early tests in white spruce provenance experiments.

Genetic variation in white spruce in the Exploits Valley in central Newfoundland

The results reported in the previous meeting have since been published (Khalil 1974a). The first two years' survival and growth data have been analysed from which the following conclusions have been derived:

1. All classes of trees in the Frenchman's Pond area are genetically superior to the corresponding classes in the Lake Douglas area.

2. With one minor exception statistically significant differences between "ordinary" and "plus" trees do not exist at either location.

3. The phenotypic superiority of "plus" over "ordinary" trees may be due to a higher degree of inbreeding in the latter than in the former.

STUDY NO. NFC 21-3. CLONAL TRIALS OF LOCAL TREMBLING ASPEN

Root sections of 23 phenotypically superior clones of native trembling aspen (*Populus tremuloides* Michx.) were collected and treated according to the established technique used at the Research Branch, Forestry Division, Ontario Ministry of Natural Resources for obtaining rooted plants. Shoots were obtained but most of them died later. Experiments are now in progress to modify this technique, if necessary. Experiments have also been conducted to induce branch cuttings to produce roots with the help of root-producing hormones. These experiments have been partially successful with indole-acetic acid, indole-propionic acid and indole 3-butyric acid.

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TRIALS OF EXOTIC SPECIES AND PROVENANCES IN NEWFOUNDLAND

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INTRODUCTION

During the two-year period since the previous report in August, 1973, the tree improvement research program at the Newfoundland Forest Research Centre has been divided into two projects dealing with exotic and native species respectively. This paper reports the progress on Project NFC 20 - Trials of exotic species and provenances - to determine the suitability of selected exotic species and provenances for use in afforestation and reforestation in Newfoundland to speed up the economic development of the province.

Seven studies are currently in progress under this project, whose status is reported below.

STUDY NO. NFC 20-1. TRIALS OF EXOTIC AND HYBRID POPLARS

Multiplication of planting material by branch cuttings, 20-25 cm (8-10 in.) long, continued in summers of 1973 and 1974, using cuttings from all clones except those which did not have shoots of adequate size or which were known to lack rooting ability. Survival and height growth data were collected in the falls of 1973 and 1974. The clones were grouped into nine classes, Alba, Balsamifera, Canescens, Deltoides, Euramericana, Euramericana (Italian hybrids), Granidentata, Jackii and Tremuloides. Table 1 shows the relative performance of these classes in 1973. The 1974 data are being analysed and the results will be published together with those of the previous two years.

Some other important results are stated below:

1. There were considerable differences in survival among different clones, ranging from 14 to 100 percent. The 12 clones with over 75 percent survival were in the Jackii, Euramericana (including Italian hybrids) and Deltoides classes.

2. In spite of differences in survival and in the quality of the planting material in 1972 and 1973, there was very little within clone variation in height, the standard errors of which were below ±5 cm (2 in.) with one exception.

TABLE I. Ranking of classes of exotic and hybrid poplars on the basis of mean height in the fall of 1973

Unrooted cuttings planted 6/72 cut back 6/73	Mean hgt. (cm)	Proven NS dif. from ea other at 0.05 level	Proven NS dif. from ea other at 0.01 level	Unrooted cuttings planted in 6/73	Mean hgt. (cm)	Proven NS dif. from ea other at 0.05 level	Proven NS dif. from ea other at 0.01 level	Rooted cuttings planted 6/72 not cut back	Mean hgt. (cm)	Proven NS dif. from ea other at 0.05 level	Proven NS dif. from ea other at 0.01 level
Jackii	118.6 (46.7)		a	Jackii	47.3 (18.6)	a	a	Tremuloides	149.9 (59.0)	a	a
Euramericana	109.6 (43.1)	a	a	Euramericana	46.5 (18.3)	a b	a	Alba	148.1 (58.3)	a b	a b
Alba	107.6 (42.4)	a b	a	Euramericana (Italian hybrid)	43.0 (17.0)	b	a	Jackii	134.2 (52.8)	a b c	a b
Euramericana (Italian hybrid)	103.1 (40.6)	b	a	Alba	23.5 (9.3)	c	b	Deltoides	126.8 (50.0)	a b c	a b
Grandidentata	95.1 (37.4)	b c	a b	Deltoides	23.0 (9.2)	c	b c	Euramericana	107.2 (42.2)	b c	b
Deltoides	90.6 (35.7)	c	a b	Grandidentata	15.2 (6.0)	d	c	Balsamifera	99.5 (39.2)	c	
Canescens	88.2 (34.7)	c	a b	Canescens	14.9 (5.9)	d e	c d				
(1-year growth)				Balsamifera (1-year growth)	10.9 (4.3)	e	d	(1-year growth, except Deltoides)			

Note: Classes with the same letter are non-significantly different from each other at the appropriate level.

3. On the basis of height growth of unrooted cuttings, the Jackii class so far appears to be most suitable for western Newfoundland, followed by Euramericana (including Italian hybrids) and possibly Alba.

4. Out of the six classes of clones planted as rooted cuttings in June, 1972, the classes Tremuloides, Alba, Jackii and Deltoides appear equally suitable for western Newfoundland. All of them except the class Tremuloides can be propagated from unrooted shoot cuttings, which are slower growing than rooted cuttings in the first year but equal the latter in the second and subsequent years. In view of the difficulty of obtaining large quantities of rooted cuttings from root sections of the Tremuloides class, Jackii, Euramericana (including Italian hybrids) and Alba remain most suitable for western Newfoundland. However, if shoot cuttings of Tremuloides can be induced to root, using root-forming hormones, these clones can also be used. Recent experiments conducted by me on the use of root-forming hormones have produced promising results.

These clones were outplanted at four locations in July 1975 in replicated experiments to assess their suitability to the different site conditions of Newfoundland.

STUDY NO. NFC 20-2. PROVENANCE EXPERIMENTS WITH SITKA SPRUCE

The nine provenance experiments planted in 1969 and 1970 were maintained. Height and root-collar diameter measurements were taken and trees were scored for mortality, winter desiccation and Armillaria mellea (Vahl. ex. Fr.) Kummer root rot in the fall of 1974. Appreciable frost damage from winter desiccation was not noticed. The results are being analysed and will be published soon.

STUDY NO. NFC-20-3. PROVENANCE EXPERIMENT WITH RED SPRUCE

The preliminary results included in the previous report have since been published (Khalil 1974). Further analyses of the data have been carried out and will be published shortly.

STUDY NO. NFC 20-4. A TEST OF THE SUSCEPTIBILITY OF CERTAIN SPECIES OF ABIES TO BALSAM WOOLLY APHID INJURY

Three replicated experiments were established in June, 1964 in balsam-fir (Abies balsamea (L.) Mill) cutovers, using six Asian species of Abies and one provenance of balsam fir from New Brunswick. Results to date (Hall et al. 1971) show that Abies veitchii (Lindl.) B. provenance from Nagano Prefecture, Usuda, Japan, had the best survival and growth, followed by Abies veitchii C. provenance (source not known) from Japan and balsam fir. As A. veitchii is also apparently resistant to balsam woolly aphid, it is potentially excellent for replacing balsam fir, particularly in areas with high hazard of woolly aphid damage. The species may not be particularly susceptible to Armillaria mellea root rot, though confirmation is awaited.

STUDY NO. NFC 20-5. ARBORETA TRIALS OF EXOTIC SPECIES

Three arboreta were established between 1967 and 1970 in eastern, east-central and western Newfoundland respectively for trial of 25 species belonging to the genera Betula, Cryptomeria, Larix, Robinia, Picea, Pinus and Pseudotsuga. Results of survival and five-year height growth have been reported by Hall (1973). They indicate the suitability of the following species for further trial:

Betula spp. Betula ermanii Cham. and B. verrucosa Ehrh. in eastern and B. maximoviczіana Regel. in western Newfoundland.

Larix spp. Larix decidua Mill., L. laricina (Du Roi) K. Koch and L. leptolepis Sieb. and Zucc. in eastern, central and western Newfoundland.

Picea spp. Black spruce (Picea mariana (Mill.) B.S.P.), Sitka spruce (P. sitchensis (Bong.) Carr), white spruce (P. glauca (Moench) Voss.), red spruce (P rubens Sarg.) for eastern, central and western Newfoundland and Engelmann spruce (P. engelmanni Parry) for central and western Newfoundland.

Pinus spp. Jack pine (Pinus banksiana (Lamb.), lodge-pole pine (P. contorta (Dougl.), and Scots pine (P sylvestris (L.) (Finnish and U.K. provenances) for eastern, central and western Newfoundland and Corsican pine (P. nigra (Arn.) var. Corsicana Loud), western white pine (P. monticola (Dougl.) and red pine (P. resinosa Ait.) for western Newfoundland.

STUDY NO. NFC 20-6. PLANTATION TRIALS OF EXOTIC SPECIES

A replicated experiment was established in 1966 in east-central Newfoundland with eight pine species. Survival and height growth after five years indicate that lodge-pole pine, jack pine and Scots pine are most suitable for Newfoundland, followed by red pine and Corsican pine (Hall 1972). Damage by root-collar weevil (Hylobius spp.) has not been noticed so far.

Two experiments with eight spruce species were established in October 1971 in eastern, central and western Newfoundland. Results of first year survival indicate that all species were successful except one provenance each of Norway spruce (Picea abies (L.) Karst.) (from Germany) and Hand. spruce (P. jezoensis (Sieb. and Zucc.) Carr.) (from Japan) which were inferior to the rest (Hall 1971).

Trials of exotic spruce and pine species started in 1967 in a nutrient-poor wind-swept ploughed bog on the Avalon Peninsula tentatively show that white spruce and Scots pine are the most suitable species. Serbian spruce (P. omorika (Pancic) Purk.), sitka spruce and black spruce are unsuitable and Norway spruce is doubtful. The experiments were fertilized in 1972 with urea (47 g/seedling) superphospate (60 g/seedling) and potassium sulphate (27 g/seedling). Survival and height growth data collected in 1973 and 1974 are being analyzed and will be published soon.

STUDY NO. NFC 20-7. AGE OF SEEDLINGS AND TIME OF PLANTING OF WHITE SPRUCE

A five-replicated experiment in split-plot design was established in the fall of 1972 at Bottom Brook in western Newfoundland. Nursery grown white spruce seedlings of one provenance of four different ages were used, with spring and fall planting. Data on survival and growth since establishment will be analysed and published soon.

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TREE BREEDING AT THE MARITIMES FOREST RESEARCH CENTRE, 1973 AND 1974

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INTRODUCTION

The objective of the tree breeding work at the Maritimes Forest Research Centre is to determine the amount of genetic improvement attainable within promising tree genera and to provide resource managers of the region with the information and breeding materials required to attain realistic genetic improvement of trees used in reforestation.

During 1973 and 1974 a number of personnel changes occurred which have had and will continue to have an influence on tree breeding in the Maritimes Region. In October, 1973, R. Hallett joined the Canadian Forestry Service staff as a consultant in reforestation and applied tree improvement thus increasing our capability to assist provincial and industrial organizations of the region to solve reforestation and tree improvement problems. In January 1975, S.A.M. Manley joined the staff of the Province of New Brunswick in the capacity of forest geneticist. Now, for the first time, a provincial government in the Maritimes Region has developed its own internal capability in forest genetics. J.M. Coles was recruited to fill the position vacated by Manley. Coles completed a masters degree at the University of New Brunswick in 1974 and is presently working on a Ph.D. degree at Oxford University. Coles masters work was carried out in close association with the C.F.S. and is summarized in this report.

D.P. Fowler was on a Professional Development Assignment to the University of California, Berkeley from August 1974 to June 1975.

The Canadian Forestry Service continued to assist the provincial governments of the region with the development of their tree improvement programs. In 1973, contracts with the Provinces of New Brunswick and Nova Scotia provided for the vegetative propagation of selected trees. In 1974 tree seeds were collected from selected trees and stands under a contract with the Province of Nova Scotia. During this same period S.A.M. Manley worked directly with the Province of Prince Edward Island toward the development of their tree improvement programs.

In 1974 the first seed orchard (black spruce) was field planted in the region by J.D. Irving Ltd. The trees for this orchard were selected, propagated, and the orchard designed with the assistance of the Canadian Forestry Service.

HYBRIDIZATION IN *PICEA* AND *LARIX*

D.P. Fowler

The objectives of this study are to produce and test inter- and intraspecific hybrids that may be of value in the Region, to develop methods of mass producing promising hybrids, and to provide information and breeding materials for the production of genetically improved trees to forest managers.

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

Picea

Work on inter- and intraspecific hybridization of *Picea* species was continued during 1973 and 1974. In 1973 most of the effort in controlled pollinations were concentrated on obtaining a better understanding of within stand population structure in white spruce. This work was carried out in conjunction with Mr. J.F. Coles and provided the basis for a Masters of Science degree in forestry at the University of New Brunswick. The work is summarized in the following abstract of Coles' thesis "Inbreeding Studies in *Picea glauca* (Moench) Voss":

> There is little information available on the relationship among trees in groups for the conifer species. In this study an attempt was made to elucidate the population structure of white spruce *Picea glauca* (Moench) Voss) in two stands in south central New Brunswick. Controlled pollinations produced information on the amount of inbreeding depression that occurs from self-pollen, crosses between parents of varying distances apart and long-distance, unrelated pollen. Wind pollinated material provided an estimate of the amount of natural selfing that occurs in white spruce.
>
> Percent sound seed and seedling height were found to be significantly affected by pollen parent and as such were analyzed for distance between parents. Traits such as seed weight, cotyledon number and germination percent were unaffected by pollen parent.
>
> The data indicate that relationships do exist between at least some trees within a 100-metre radius of a central tree. Relationship coefficients were found to be 0.37 and 0.17 for the two stands. Beyond 100 metres there appears to be little chance of the trees being related. Natural selfing was estimated to be between 14 and 18 percent. This amount of natural selfing is slightly higher than normally found and is probably due to the open grown nature of the two stands.
>
> The implications of the results for methods of selection of superior phenotypes and for breeding orchards are discussed.

In 1974 additional studies on population structure in white spruce were made to obtain information with which estimates of the amount of inbreeding occurring in natural stands of white spruce could be obtained. Four white spruce stands in the Fredericton area were chosen for the study. Five trees in each stand were crossed with pollen mixes from the other three stands. Open pollinated cones were also collected. It is anticipated that a comparison of seed and seedling characteristics of the "crossed" and "open" progenies will provide the desired information.

Flowering on spruce in 1973 was average and in 1974 it was exceptional in central New Brunswick. A sizable interspecific controlled pollination program was carried out with emphasis on the production of hybrids between *Picea glauca* and *Picea sitchensis*. The results of the 1973 and 1974 pollination are presented in Table I.

Larix

It is generally accepted that trees growing in close proximity have a higher probability of being related than trees separated by greater distances. It is also recognized that crosses between related trees results in inbreeding which in conifers is usually expressed by reduced full seed set, poorer germination and reduced growth. The relatedness of trees within stands has important implications to the choice of tree selection procedures and other aspects of population genetic theory. For example, if the relationship among trees within stands is high, the widely used, comparison tree selection technique is rather inefficient. Very little information on within stand, population structure is available of coniferous species and none is available for *Larix*.

1973 was an early and rather poor flowering year for all *Larix* species in the Fredericton, N.B. area. Only a few interspecific crosses between selected *L. leptolepis* and *L. decidua* were attempted. 1974 was an exceptionally good flowering year for *L. laricina*. Work on *Larix* in 1974 was aimed at obtaining a better understanding of within stand relationships in *L. laricina*. Four stands of *L. laricina*, located at the Acadia Forest Experiment Station were chosen for the work.

Controlled pollinations were made on each of five trees in each stand. The five trees were located within a 50 m circle in the central portion of each stand. The following pollens were used in each tree:

1. self
2. trees located within 50 m of pollinated tree (4 crosses)
3. trees located 50-100 m from pollinated tree (3 crosses)
4. trees located 100-200 m from pollinated tree (3 crosses)
5. pollen mix from one of the other stands.

Table 1. Results of controlled *Picea* pollinations 1973 and 1974

Female parent	Male Parent											
	P. abies	*P. asperata*	*P. bicolor*	*P. engelmannii*	*P. glauca*	*P. koreana*	*P. mariana*	*P. amorica*	*P. orientalis*	*P. rubens*	*P. sitchensis*	*P. smithiana*
P. abies	5* 5(34) 51(1741)	4 4(36) 4.7(168)	5 0(29) -	1 0(35) -				4 1(29) .10(3)	1 0(6) -		4 1(31) .23(7)	1 0(4) -
P. engel-mannii	1 0(27) -	1 1(25) .20(5)		1 1(27) 22(588)	1 1(23) 57(1321)		1 1(16) .25(4)	1 0(28) -			1 1(38) 26(999)	
P. glauca			9 2(274) .01(4)	7 7(1136) 9.2(10451)	8 8(550) 17(9097)	3 0(145) -		11 7(1826) .03(54)	9 3(255) .02(6)		27 27(4243) .66(2795)	9 2(310) .05(14)
P. mariana	3 0(420) -	3 2(311) .01(2)	22 2(400) .01(4)	3 2(403) .30(123)	7 2(241) .03(6)	3 1(153) .01(2)	10 10(680) 9.4(6390)	3 3(373) 2.4(896)	19 2(387) .01(3)		3 3(437) .44(191)	14 1(321) .01(3)
P. rubens	3 2(221) .01(3)	3 3(325) .03(10)	4 2(17) .47(8)	3 1(284) .01(2)			3 3(8) 26(204)	3 3(254) 1.4(350)	3 0(8) -	3 3(334) 18(5998)	3 2(321) .01(4)	

*5 No. trees pollinated
5(34) No. crosses yielding full seeds (no. cones)
51(1741) No. full seeds/cone (No. full seeds)

Note: Where no. full seeds/cone are very low, i.e. .10 or less, the authenticity of the cross is highly questionable.

Data from these crosses will be used to investigate the relationship between distance of separation and genetic relationships.

One of the most promising larch hybrids tested in the Region is (*L. laricina* x *L. leptolepis*) x *L. decidua*. Seed set from this cross has been fairly high and seedling growth has been exceptional. The phenology of flowering of the hybrid and of *L. decidua* are similar enough to produce the three-way hybrid in seed orchards. To this end a small 4 acre orchard was established in 1974 to mass produce the hybrid for further testing and use.

Pinus

In 1972 an attempt was made to cross *Pinus resinosa* and *P. tropicalis*. A total of 433 ovulate strobili on 9 red pines were pollinated with *P. tropicalis* pollen kindly provided by Dr. P.W. Garrett, U.S. Forest Service. Despite good conditions for pollination, as indicated by high yields of full seeds from the red pine control crosses, no hybrids were obtained.

PROVENANCE AND PROGENY STUDIES

H.G. MacGillivray

Picea

Experiment 60. All-range black spruce (*Picea mariana* (Mill.) B.S.P.)seed source study (1971 germination).

Sites for 9 out of 10 proposed replicated seed-source trials of black spruce were selected, pre-planting preparations completed and the experimental layouts established, chiefly during the summer 1974. This was done to allow more time for planting in the spring, 1975 and was accomplished with the cooperation of company and provincial foresters.

The tests include the faster growing provenances as indicated by the replicated nursery test at the Acadia Forest Experiment Station. The field test at Acadia includes all available provenances for future tree-breeding and demonstration purposes as well as for provenance research. The test on the Cape Breton Highlands contains several relatively slow growing northern and western provenances because these might be more adaptable to the harsh environment than some of the more vigorous provenances.

Average 4-year tree heights of the 102 provenances growing in the nursery test at Acadia were converted to percentages of the plantation average. These data indicate that:

(1). The area around the Great Lakes, with the possible exception of part of the north shore of Lake Superior, may eventually prove to be a valuable source of black-spruce tree-breeding materials for the Maritimes Provinces. Seed from most of this area produced trees that grew rapidly at Acadia: the area west of Thunder Bay, Ontario (110%), Minnesota (112% and 114%), southern Wisconsin (120%), North and South Michigan (114%, 116%, 118% and 119%) and Ontario, south of a line from Sault Ste. Marie to Petawawa (114%, 117%, 117%, 119% and 119%).

(2). Trees from other but smaller areas also produced rapid juvenile growth: southeastern Manitoba (115%) northeastward to Minaki, Ontario (113%); Peribonka, Quebec (114%); northwestern Maine (113%), western Maine (116%), New Hampshire (114%) and adjacent Quebec (113%; Prince Edward Island (107%, 114% and 120%); around Miramichi Bay (111%, 118% and 120%), the northwestern part of Canadian Forces Base Gagetown (111% and 119%), and near the McCormack Fire Tower (113%), New Brunswick; and the Chignecto Game Sanctuary (115%), Nova Scotia.

(3). All seed collected north of 50° N. latitide and west of 97° W. longitude with the exception of the provenance from Minaki, Ontario mentioned above, produced average or below average height growth at Acadia.

(4). Seed from the Maritimes, other than those areas mentioned above, produced trees of more or less average growth. Provenances from the Cape Breton Highlands were below average (87%, 89% and 94%). The relatively average-to-poor growth of some Maritime provenances may have been caused by self pollinations. The special collections for this study were made in 1968 and 1969 which were poor seed production years. The individual trees that produced cones may have been their own source of pollen. Five general Maritime collections which had been made at earlier dates during good seed years all produced relatively fast growing trees (107%, 111%, 114%, 115% and 120%).

In 1973 phenological measurements and observations were recorded on selected provenances growing in the nursery experiment but these data have not been processed.

Abies

Experiment 88. Foliage color of Newfoundland balsam fir (*Abies balsamea* (L.) Mill.) (1969 germination).

This seed-source study out-planted in the spring, 1973 was prompted by the observation, made by the New Brunswick Extension Service, cooperating in Experiment 10, "Balsam fir provenance planting (1956 germination)" that some trees from seed collected at Canada Bay, Newfoundland had blue-green foliage, a characteristic desirable in Christmas trees. A survey of foliage color of all the trees in all the Experiment 10, New Brunswick, plantations showed that seed from Hawkes Bay, Nfld. produced numerous trees with blue-green foliage and that seed from Canada Bay produced some trees with blue-green and dark-green foliage. For Experiment 88, good sized cone collections were made by cooperators at these and one other location in Newfoundland. Seed from Hawkes Bay and Canada Bay was placed in storage at Acadia. Seed from the three Newfoundland sources and three Maritime sources were sown in the spring 1969. The seedlings and transplants did not show significant differences in foliage color. In the spring 1973 material from these seed sources were out-planted at Acadia. The trees will be observed for the appearance of blue-green foliage. The blue-green foliage color was not noticed under Experiment 10 until the trees had been outplanted for about two years. Should the seed from Hawkes Bay and/or Canada Bay produce trees with the desirable blue-green foliage, then seedling seed orchards will be produced in the Maritimes.

Experiment 29. Selection and breeding balsam fir Christmas tree material for resistance to the balsam gall midge, *Dasineura balsamicola* (Lintner).

The arrangement in the outplanting established in 1973 was to plant paired clones (one from the apparently resistant tree and the other from the susceptible tree selected in the same area) in paired plots and within each plot to plant cuttings from the top 1/3 and those from the bottom 1/3 of the crown of the ortet in paired sub-plots. The cuttings were obtained from these parts of the crowns in this and other experiments to provide material for a demonstration of growth and flowering habits of rooted cuttings from different parts of the crown.

Experiment 75-A. Rooting balsam fir cuttings using different bottom heats.

These cuttings were the result of a greenhouse experiment to see if rooting of cuttings could be improved using bottom heat. This experiment showed that many cuttings in the control, with no additional bottom heat (temperature of rooting medium about 20°C) rooted well. No roots were produced on cuttings where the rooting medium was heated to about 26°C or to about 30°C. The cuttings were planted in single-tree paired plots, each plot containing a plant from either the top or bottom 1/3 of the crown.

Experiment 75-B. Rooting balsam fir cuttings collected at different times during the year.

The cuttings planted here were the result of a test designed to confirm observations made at the Acadia nursery that cuttings collected and treated in the late autumn and early winter rooted better than those collected in the late winter and spring. It was also designed to test Seradix 3 and I.A.A. (0.5 mg I.A.A. powder in 1 gram lanolin) as a basal treatment and 1 A.A. as a top treatment (changed at weekly intervals and protected by foil caps). The last treatment was an attempt to induce roots along the length of the plunged part of the stem rather than just at the base of the cutting. Twenty-four cuttings from each crown level (top 1/3 and bottom 1/3 of Crown) of each of 10 trees of "Christmas" tree size (about 10 feet tall and with crowns exposed on at least three sides) were collected on each date: 13 December, 7 February, 15 March and 20 July.

Analysis of variance showed that significant differences occurred between success of rooting by dates (F = 11.4**) and by treatments (F = 11.0**) but not by crown levels (F = 0.2 ns.). Cuttings collected in December rooted best, followed by those collected in July. The buds on these cuttings were slow to break dormancy after the cuttings were placed in the rooting chamber under intermittent mist. The shoots produced were generally weak. This allowed food stored in and manufactured by the cuttings to be used for callus and root formation. Buds on cuttings collected in February and March after being exposed to a cold-rest period on the trees broke dormancy soon after being placed in the rooting chamber and produced good shoots but this left little food reserve for callus and root production. The Seradix 3 treatment produced the best rooting followed by the control. IAA basal and IAA top treatments placed second last and last, respectively. No roots were produced other than at the base of any cutting.

Experiment 76. Rooting balsam fir with blue-green foliage.

The plants outplanted in 1974 were vegetatively propagated scions or cuttings from trees with bluish-green foliage. These will eventually be used in producing improved Christmas trees.

GENECOLOGY OF RED AND BLACK SPRUCE

S.A.M. Manley

The work on this study is presented in a Ph.D. thesis "Genecology of hybridization of red spruce (*Picea rubens* Darg.) and black spruce (*Picea mariana* (Mill.) BSP.)" submitted to Yale University in the spring of 1975. An abstract of this thesis follows:

Based on field studies of natural hybridization in red and black spruce, an hypothesis was established that red spruce and black spruce are separate integral species. Hybridization did not result in breakdown of species integrity, despite extensive natural backcrossing and the potential for gene exchange.

Using a hybrid index, red and black spruce were found to be phenotypically distinct throughout the Canadian Maritimes when occupying habitats considered typical for each species. Evidence of introgression could not be detected in parental populations. Hybrid colonies were unstable in the sense that their understories were regenerating to red spruce on most upland sites and black spruce at bog edges.

Partial incompatability, hybrid sterility, and hybrid inviability were found through controlled pollination of red spruce, black spruce, natural F_1 hybrids and backcrosses. Full seed set was reduced to less than two percent in the red x black spruce cross. A mean full seed set of 0.3 percent was obtained using a 50:50, red:black pollen mix to produce F_1 hybrids. Reduced full seed sets were also obtained through backcrossing and intercrossing F_1 hybrids and hybrid derivatives. Incompatability in terms of full seed set in the red x black spruce cross increased by 25 percent if abnormal germination, nanism and teratism were taken into account.

Under 10 growth chamber conditions, either red or black spruce grew larger in height and dry weight than the F_1 hybrids and hybrid derivatives. Red spruce grew larger at warm temperature (26°C), and low light intensity (100 ft-c) than black spruce and all hybrid progenies. Black spruce grew larger than red spruce and all hybrid progenies at high light intensity (1000 to 2000 ft-c) when test temperatures were both cold and warm (12° to 26°C). Black spruce was also largest at low light intensity (100 to 250 ft-c) and cold temperature (12°C).

CO_2-exchange rates of red spruce, black spruce, F_1 hybrids, and hybrid derivatives that were grown under controlled conditions provided a physiological explanation of hybrid inferiority. Hybrid weakness or partial hybrid inviability was related to reduced CO_2-exchange of hybrids relative to parental species. Negative heterosis was greatest in the F_1 hybrid and backcrosses. CO_2-measurements substantiated ecological divergence of parental species. Black spruce had the highest CO_2-exchange rates at high light intensities (3500 ft-c), fitting it for a pioneering role. Red spruce had the lowest light compensation point (110 ft-c) and is adapted to shaded environments. F_1 hybrids were not intermediate in light response but had higher light compensation points and lower CO_2-exchange rates at 3500 ft-c than either parental species.

Red and black spruce seed germinated and survived best in the corresponding red or black spruce habitat indicating that each species is adapted to different environments. Seedlings of F_1 hybrids and hybrid derivatives, transplanted to red and black spruce habitats had higher mortality and grew less in height than either red or black spruce.

The mean frequency of hybridization from natural seed collections was estimated at nine percent for black spruce and six percent for red spruce. A hybrid index and electrophoresis was used to identify hybrids. The natural frequency of hybrids in populations where seed was collected varied from less than two percent to 0, indicating that selective mortality of F_1 hybrids must occur.

The collective results provide evidence that species integrity is maintained by partial pre-mating isolation. Strong hybrid inferiority resulting from hybrid sterility, incompatability and adaptive inferiority may be initiating further selection to enforce pre-mating isolation.

TISSUE AND ORGAN CULTURE

J.M. Bonga

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

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

Haploid tissue cultures, and haploid plants regenerated from such cultures, are also useful in mutation research. Many recessive mutations, which would not show in diploid plants, because of the presence of their dominant counterpart alleles, would show readily in the haploid tissue or plant, and can thus be selected for.

These considerations have led to the following experiments:

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

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

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TREE IMPROVEMENT AT THE BERTHIERVILLE FOREST TREE NURSERY, P.Q.

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Keywords: Seed handling, seed production areas, provenances, progeny testing, seed orchards.

The provincial forest tree nursery at Berthierville, P.Q., is responsible for the processing of all seeds and cones collected throughout the province. A geneticist is also located there and is responsible for regional tree improvement and also for seed orchard establishment in the province. The research work in tree improvement is conducted by the Research Branch of the Department of Lands & Forests.

Following is a brief summary of the work done in seed collection and processing and tree improvement at the Berthierville nursery.

SEED COLLECTION AND PROCESSING

In 1973 and 1974, about the same amount of cones were collected (Table 1) in the 13 seed collection zones of the province.

Table 1. Quantity of cones collected per species in 1973 and 1974.

Species	Cones collected in:	
	1973	1974
	.... x 40 liters	....
Larix decidua	13.5	72.3
Larix laricina	7.0	89.0
Larix leptolepis	----	98.9
Picea abies	----	1579.0
Picea glauca	22.0	1610.0
Picea mariana	4480.0	0.5
Picea rubens	258.6	1119.1
Pinus banksiana	6594.0	6718.8
Pinus resinosa	567.0	67.2
Pinus strobus	179.9	721.0
Pinus sylvestris	44.3	22.7
Thuja occidentalis	5.0	9.5
Total	12171.3	12098.5

About 12 x 40 liters of various hardwood genera were also collected: Acer, Betula, Carya, Fraxinus, Juglans and Quercus.

The 3,000 kgs of seeds extracted from these cones along with those already in storage will be sufficient to meet the demand for planting stock production and direct seeding programs for most species except for Picea abies (L.), Pinus resinosa Ait. and P. strobus L.

A total of 302 samples were taken from these seeds in order to conduct humidity, germination and purity tests and to determine the number of viable seeds per kilogram.

Most of these seeds have been collected from quality stands either by climbing or following logging operations.

The identity of seeds by provenance is maintained through all the processing steps so that nursery stock or seeds may be returned to the place of origin whenever possible.

FOREST TREE IMPROVEMENT

Seed production areas

A seed production area of about 40.5 hectares has been established in a young P. banksiana Lamb. stand located in Houde-Provost Townships. Thinning is practiced in order to leave only the best phenotypes and increase crown exposure. This stand has been fertilized. Cones will be collected by felling a portion of the stand during a good seed year. Seedlings will be planted back in the same stand or area.

A P. resinosa seed production area has been established on 16 hectares in Chertsey Township. Thinning and fertilization have been done in the past and another thinning is planned for next year. No important crop has been produced in this seed production area since its establishment.

A 54-year old mixed plantation of P. resinosa, P. strobus, P. sylvestris and P. abies is being thinned in order to allow good phenotypes to yield higher quantity of cones. This plantation covers 18 hectares.

The above seed production areas have been established in the past 2-4 years in the administrative region 06-Montreal. Other S.P.A. have also been established throughout the province.

Seeds collected from a Picea rubens Sarg. seed production area have been sown at the Berthierville nursery last fall. Some of the seedlings, after culling, will be outplanted back in the area near the original stand in the Seigneurie Fossambault. Seedlings will be planted at close spacing in order to allow further phenotypic selection at thinning time.

Provenance testing

Seeds from 8 P. abies provenances from various outstanding plantations and plus-trees in New-England and 2 local provenances have been sown in the nursery. The seedlings are expected to be outplanted in various locations in Southern Quebec in the spring of 1976. These plantations are expected to be used as seedling seed orchards and the best provenances and individual within provenances will be vegetatively propagated and planted in clonal seed orchards.

Seedlings from six P. sylvestris clones from an orchard in Belgium have been outplanted in the spring of 1975 in Chertsey Township located in the Great-Lakes-St Lawrence Region (4a). In a second test, seeds from 9 European provenances have been sown in the nursery. Outplanting is expected for the spring of 1977 at the same location.

Ten (10) species and/or provenances of Larix spp. are being grown at the Trecesson and Paspébiac nurseries. Outplanting at two locations in the boreal forest will provide useful information as to their adaptability under these growing conditions.

Progeny testing

Picea glauca (Moench)Voss) seeds were collected from 5 individual trees in each of 26 locations throughout the range of the species in Quebec. Seedlings were outplanted this spring at two locations in the boreal forest region and two locations in the Great Lakes-St Lawrence region. These plantations will potentially serve as seedling seed orchard and the best families will be vegetatively propagated and planted in clonal seed orchards.

Seed orchards

Super-seedlings have been selected in the nurseries of the Province according to rigid specifications. They have been planted in the same seed zones where the seeds came from. This program will continue next year. Seedlings which maintain their superior growth will be vegetatively propagated in seed orchards for seed production.

Ten (10) seeds lots of Picea glauca from Beachburg area and five (5) others from Swastika area have been obtained from Dr A.H. Teich. The seedlings are now being nursed at Berthierville and will be outplanted at different locations in southeastern Quebec and in the Abitibi region. The best phenotypes will be tested for rooting ability and propagated for seed production in a clonal seed orchard.

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

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Québec, P.Q.

SAPIN DE DOUGLAS

J. Robert

Projet G 69-7. Test de provenance sur le sapin de Douglas (*Pseudotsuya menziesii* (Mirb.) Franco).

L'intérêt que représente le sapin de Douglas pour le reboisement est une chose reconnue depuis plusieurs années déjà, notamment en Europe. Son introduction pose toutefois le problème du choix des provenances à utiliser car sa variabilité infraspécifique est très grande du fait de l'étendue de son aire de distribution naturelle.

Un premier test sur 59 provenances de sapin de Douglas a été entrepris au Service de la recherche en 1969 dans le cadre d'un programme plus vaste d'introduction d'espèces exotiques actuellement en cours. Ce document expose brièvement les premiers résultats obtenus en pépinière, à partir des ensemencements de 1970.

Méthode

Les 59 provenances de sapin de Douglas utilisées dans ce test ont été obtenues par l'intermédiaire du "*Working group on Procurement of Seed for Provenance Research*" de l'I.U.F.R.O. (Récolte 1966/67). A celles-ci, nous avons comparé une provenance déjà installée au Québec (Rivière-du-Loup).

Les graines ont été semées à l'automne 1970 sans répétition à la pépinière expérimentale de la station forestière de Duchesnay, à 40 kilomètres au nord-ouest de la ville de Québec. Les sols de la pépinière sont des sables limoneux dérivés d'un dépôt fluvio-glaciaire avec un drainage de classe 2. Les semis ont été repiqués au printemps 1973, sans répétition.

Des mesures et observations ont été faites de 1971 à 1974 sur les plants pour estimer leur résistance au froid et leur croissance (dégâts de gel à l'automne, mortalité, aoûtement et lignification, forme et hauteur). Les analyses ont ensuite été faites à partir des valeurs moyennes par provenance de chaque caractère.

Résultats

Nous avons, lors de l'analyse statistique, cherché à regrouper les provenances en fonction de leur comportement face aux conditions écologiques du lieu de l'essai. Pour ce faire, nous avons procédé à un calcul des composantes principales.

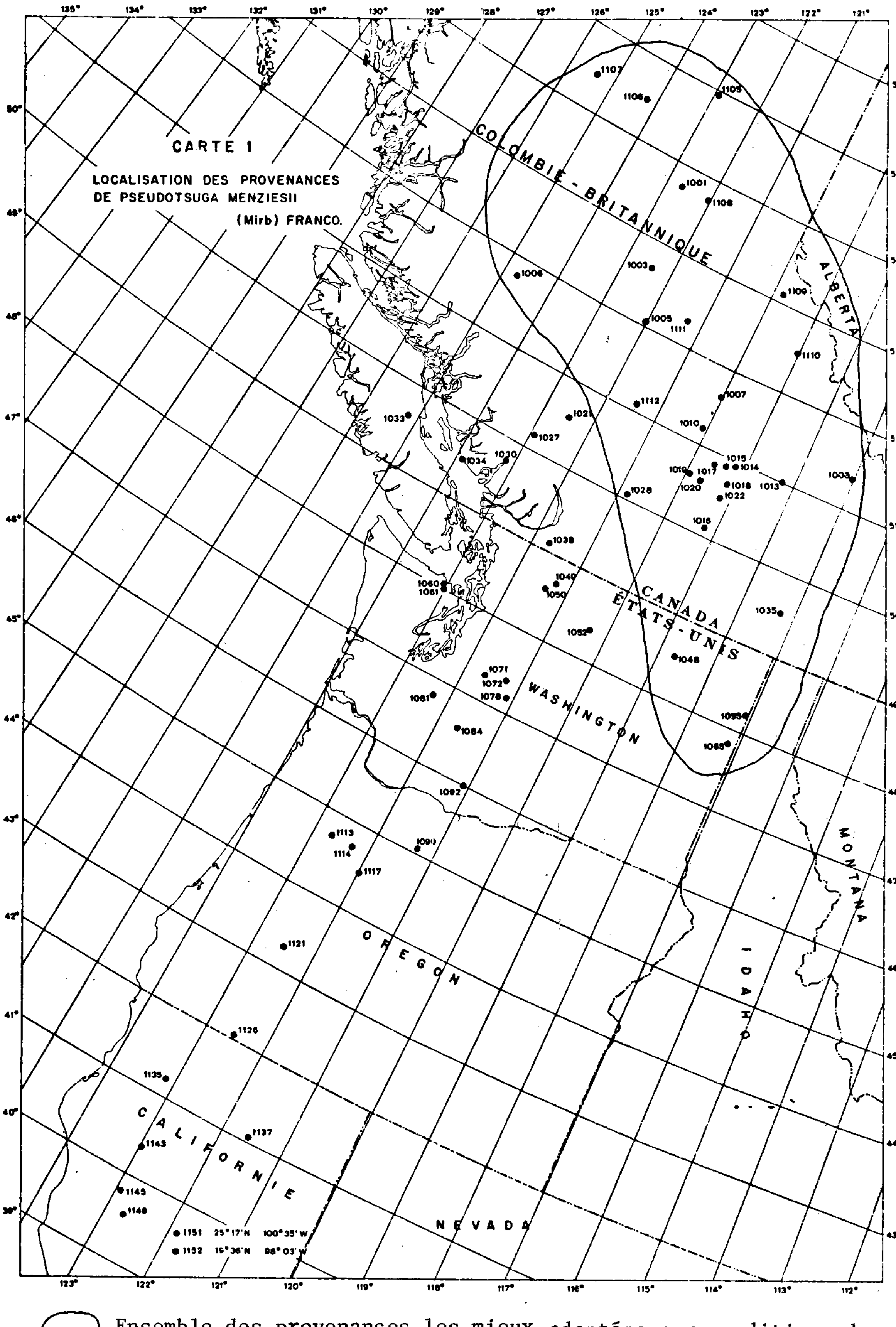
Ce calcul a permis de mettre en évidence deux comportements différents des provenances testées,par rapport à la résistance au froid. Ainsi, toutes les provenances originaires des zones montagneuses intérieures de la Comlombie britannique et le nord-est de l'Etat de Washington semblent peu affectées par le gel (notamment les gelées précoces de l'automne) et sont caractérisées par un fort pourcentage de plants bien aoûtés et lignifiés tôt dans la saison. Par contre, les provenances plus côtières de la Colombie britannique, de l'Etat de Washington, de l'Oregon et des Etats méridionaux sont très affectées par la longueur de la saison de végétation et la rigueur de l'hiver (les dégâts de gel sont sévères, les déformations nombreuses et la mortalité élevée). La carte 1 donne la localisation des provenances.

A l'intérieur du lot de provenances les mieux adaptées aux conditions du lieu de l'essai, les provenances originaires du district de Kamloops (Colombie britannique) et en particulier de la région du lac Shuswap ont démontré la meilleure croissance en pépinière. Une étude de la corrélation entre les caractères altitude d'origine et hauteur en pépinière menée sur les provenances comprises entre le 50^{e} et le 52^{e} degré de latitude nord s'est révélée significative (corrélation négative au seuil de 1%). Ainsi, les provenances de basse altitude ont une meilleure croissance que celles d'altitude plus élevée.

Conclusion

Ce premier test précoce en pépinière sur 59 provenances de sapin de Douglas, conduit au niveau des moyennes par provenance, a surtout permis de mettre en évidence une différence dans la résistance au froid des provenances selon leur origine. Ainsi, la zone intérieure du nord-ouest du continent nord américain semble fournir les lots de graines les mieux adaptés à nos conditions. Parmi ceux-ci se sont les provenances Barrière (1010)*, Revelstoke (1013), Eagle Bay (1014), Blind Bay (1015), White Lake (1016) et Squilax (1017) qui ont donné les meilleurs résultats sur le plan croissance, en tenant compte du fait qu'il n'y avait pas de répétition des lots dans la pépinière.

* Numéro de code de la provenance donnée par l'I.U.F.R.O.



Ensemble des provenances les mieux adaptées aux conditions du lieu de l'essai.

Toutefois, il convient de faire les réserves suivantes:

- Ces résultats concernent le comportement d'une collection de provenances élevées dans la région de la ville de Québec. Ils seraient peut-être différents si l'on était placé dans une autre région de la province.

- Les mesures et observations ont été effectuées sur un matériel très jeune (1 à 4 ans) qui séjourne encore sous la neige en hiver. Rien ne prouve que nous obtiendrons des résultats similaires lorsque les cîmes auront dépassé le niveau de la neige et seront alors exposées au dessèchement hivernal.

C'est pour ces raisons qu'il faudra attendre encore quelques années pour que les plantations comparatives installées ou en voie de l'être dans les différents arboretums de la province, puissent nous fournir un bilan plus définitif concernant l'introduction du sapin de Douglas au Québec.

MELEZE

A. Stipanicic

Projet G 70-3. Amélioration du melèze *(Larix sp.)*.

Les travaux sur l'amélioration du mélèze au Service de la recherche se sont poursuivis selon nos possibilités durant les deux dernières années avec comme objectif principal: élargir l'utilisation des espèces et des hybrides du genre *Larix* dans le reboisement actuel au Québec, en trouvant les clones et provenances les plus productifs et les mieux adaptés aux conditions des régions à reboiser.

Sélection des arbres

Jusqu'à présent nous avons sélectionné 43 arbres de *Larix decidua* (Miller), 4 de *Larix leptolepis* (Sieb. et Zucc.) et 230 de *Larix laricina* (du Roi) K.Koch.

Les mélèzes d'Europe et du Japon ont été sélectionnés dans des plantations (Drummondville, Berthierville) ou dans des parcs (Duchesnay, Orsainville). Les arbres de *Larix laricina* ont été sélectionnés dans les peuplements naturels surtout dans la partie sud du Québec et cette année, nous avons commencé la sélection sur la rive nord du Saint-Laurent. Soixante arbres ont été échantillonnés dans un peuplement du Comté de Portneuf pour une étude de structure génétique du mélèze laricin.

Les critères que nous avons suivis dans nos travaux de sélection sont les suivants:

- le fût de l'arbre doit être le plus droit possible,
- l'angle d'insertion des branches doit être droit ou presque,
- les dimensions dendrométriques de l'arbre choisi doivent être égales ou supérieures à la moyenne des autres arbres qui l'entourent,
- l'arbre choisi doit être exempt de maladies.

Propagation végétative

Sur les arbres sélectionnés, nous avons récolté des jeunes pousses qui nous ont servies, soit comme greffons, soit comme matériel pour nos expériences de bouturage. Nous avons utilisé deux techniques de greffage: la "greffe en fente" et la "greffe en placage". Les deux méthodes ont donné des résultats à peu près semblables. Toutefois, la "greffe en fente" semble plus avantageuse, parce qu'elle donne une meilleure forme au plant greffé et que la cicatrice du greffage est plus vite résorbée.

Le nombre de greffes que nous avons transplantées, au printemps 75, dans les deux parcs à clones est donné dans le tableau 1.

Tableau 1: Nombre de greffes transplantées au printemps 1975.

Espèce	Nombre de clones	Nombre total de greffes
Larix decidua	28	110
Larix leptolepis	1	1
Larix laricina	100	710
Larix laricina x L. leptolepis	1	9
Larix sibirica	1	1

Un parc à clones avec 131 clones a été installé dans l'arboretum de Duchesnay (Comté de Portneuf) et l'autre avec 96 clones, dans l'arboretum de Bonaventure (Comté de Bonaventure).

Au printemps 1975, nous avons greffé au total 132 clones, soit plus de 1 770 greffes. Parmi ce matériel, il y avait 47 clones reçus du

Petawawa Forest Experiment Station. Les résultats des travaux de cette année ne sont pas encore connus précisément, mais nous avons déjà remarqué un nombre assez élevé de greffes mortes. C'est vraisemblablement dû à la température élevée du mois de mai et aussi, dans le cas de *Larix laricina,* à la faible qualité des greffons. En effet, les arbres sélectionnés de mélèze laricin sont assez âgés et il est difficile de récolter de bons greffons.

Plusieurs essais de bouturage n'ont pas donné les résultats espérés. Nous possédons seulement 30 plants qui proviennent de bouturage, représentant 17 clones.

Les tests de provenances et de descendances.

A ce jour, 30 dispositifs du genre *Larix* ont été installés dans les arboretums à travers le Québec. Parmi ces dispositifs, 1 test de descendance de *Larix decidua,* 1 test de provenance et 1 test de descendance (PFES Exp No-376-D) de *Larix laricina* ont été installés aux arboretums de Lotbinière et de Bonaventure en 1974.

PEUPLIER
G. Vallée

Projet G 68-1. Sélection de clones et amélioration du peuplier.

Plantations comparatives

En 1973, une nouvelle série de tests clonaux a débuté pour comparer les meilleurs 180 clones sélectionnés d'après le comportement en pépinière en y incluant les clones actuellement utilisés en populiculture au Québec. Ainsi, 7 tests ont été installés en 1973 et 1974 dans les arboretums de Bonaventure, Lotbinière, Trécesson, à la ferme populicole de Cabano et au populetum de Matane. De plus, un test précoce comparant 540 clones de notre collection a été installé en 1974 à l'arboretum de Lotbinière.

Trois tests précoces de 25 descendances de *Populus deltoides* Marsh. ont été installés dont l'un à l'arboretum de Bonaventure et deux au populetum de Matane, en fonction des gradients écologiques.

Acquisitions

Des lots de graines ont été obtenus du "*Working Party on Provenance of Poplars*" de l'I.U.F.R.O., comprenant 63 lots de *P. trichocarpa* et 22 lots de *P. deltoides.* De plus, 3 lots de *P. nigra* ont été obtenus de la station d'amélioration des arbres forestiers du C.N.R.F., France et 3 lots de *P. deltoides* ont été récoltés dans la région du Lac Champlain au sud de Québec. Les plants originant de ces lots de graines sont actuellement élevés en pépinière pour la réalisation de plantations conservatoires.

Résultats préliminaires

La première série de tests clonaux commencée en 1969 a permis d'établir le comportement de différents hybrides et espèces dans la région de la Gaspésie et pour les domaines de la sapinière et de l'érablière à bouleau jaune. Les dispositifs à bloc complet étaient constitués de 4 ou 5 répétitions, distibuées au hasard, chaçune comprenant respectivement 5 ou 4 boutures plantées selon des parcelles linéaires, de sorte que chaque clone était représenté par 20 boutures. Ces dispositifs comprenaient de 18 à 36 clones, selon les disponibilités en bouture, sélectionnés surtout dans des régénérations naturelles de la région de Québec, en y incluant des clones standards comme base de comparaison. Les boutures ont été plantées verticalement sur des terrains fraîchement essouchés et dans des sols labourés superficiellement. Une fertilisation a été faite à la deuxième ou troisième année de la plantation.

Le tableau 2 donne la hauteur moyenne, le diamètre moyen des tiges à un mètre du sol, le pourcentage de plants encore vivants après 5 ans de croissance de 4 dispositifs situés au populetum de Matane. Ces dispositifs sont assis sur des terrasses alluviales fluvio-glaciaires de la rivière Matane, dont le fond de la Vallée peut être considéré comme un trou à gelée occupé généralement par la sapinière à bouleau jaune ou des peuplements de peupliers baumiers.

En général, la croissance est faible à cause d'une préparation sommaire des sols avant la plantation, de la faible fertilité des sols qui sont déficients pour le peuplier (en azote, potassium, phosphore, magnésium et calcium), et du déracinement des jeunes plants occassionné par le gel du sol lié à la plantation verticale des boutures.

Les 5 meilleurs clones sont du type *P.x Jackii* et ont une hauteur moyenne de 22% et 38% supérieure à la hauteur moyenne de l'ensemble des 15 clones et des 10 moins bons, respectivement. La différence de la hauteur moyenne des 5 meilleurs clones par rapport au 2 clones de type *P. balsamifera* (Q-14-Q et C-26-Q), sélectionnés dans la région de la ville de Québec tout comme les *P.x Jackii*, est de 46%. Les clones de *P.x Jackii* et ceux de *P. balsamifera* sont bien adaptés aux conditions du populetum de Matane où les clones de type *P.x euramericana* souffrent des gelées précoces et tardives. La longueur de la saison de végétation à cet endroit étant de l'ordre de 90 jours, il n'y a que les clones ayant un rythme de croissance adapté à ces conditions qui résistent. Ainsi, le clone Q-36-Q qui est un *P.x euramericana* sélectionné dans la région de Québec, semble mieux s'adapter aux conditions du populetum que les clones *P.cv. eugenei* et *P.cv. robusta* qui sont aussi des *P.x euramericana* en provenance de l'Europe occidentale. Quelques clones de *P.x deltoides* provenant de la région de Québec ont été essayés dans ces dispositifs et ont montré un comportement médiocre. Les hybrides baumiers comme *P.x interamericana*, *P. trichocarpa x P. tacamahaca* et *P.cv. roxbury* ont montré des croissances initiales très fortes mais se sont déclassés avec le temps, probablement par manque d'adaptation au climat.

Tableau 2. Classement des 15 meilleurs clones d'après les observations sur 4 dispositifs âgés de 5 ans au populetum de Matane.

N° clone	Espèce ou hybride	Hauteur m	Diamètre (1) cm	Plant vivant %	Sensibilité à la rouille (2)
C-24-Q	*P.x Jackii*	2.77	2.70	86.2	5
C-22-Q	*P.x Jackii*	2.77	2.56	91.2	5
Q-16-Q	*P.x Jackii*	2.77	2.86	96.2	4
Q- 2-Q	*P.x Jackii*	2.62	2.67	86.6	5
C-30-Q	*P.x Jackii*	2.34	2.36	77.5	4
B-208-B	*P. candicans*	2.22	2.48	80.0	4
B-201-B	*P.x interamericana (3)*	2.16	2.05	87.5	2
B-207-B	*P. trichocarpa x P. tacamahara*	2.16	1.75	87.5	4
Q-36-Q	*P.x euramericana*	2.07	1.70	67.5	3
Q-14-Q	*P. balsamifera*	1.82	1.65	76.6	4
B-206-B	*P.cv. roxbury*	1.92	1.33	77.5	2
C-26-Q	*P. balsamifera*	1.79	1.51	85.0	3
B-202-B	*P.cv. eugenei*	1.79	1.58	80.0	4
B-203-B	*P.cv. robusta*	1.76	1.60	71.2	4
Q-18-Q	*P.x Jackii*	1.49	1.14	78.3	4

(1) Diamètre à 1 mètre du sol.

(2) La sensibilité à la rouille des feuilles provient d'observations faites, à la fin d'août, à la pépinière de Duchesnay située à 40 kilomètres au nord-ouest de Québec. L'indice 1 correspond à une résistance bonne sans nécrose des feuilles et l'indice 6 à une senbilité très forte avec nécrose et perte de feuilles.

(3) *P.x interamericana: P. deltoides x P. trichocarpa.*

La sensibilité à la rouille des clones *P.x Jackii* ne présente pas d'inconvénient dans le cas d'une utilisation dans la péninsule gaspésienne où les rouilles apparaissent surtout après la mi-août, peu de temps avant la fin de la saison de végétation. Ainsi, leur impact sur la croissance ne peut être sérieux pour cette région.

La croissance obtenue dans ces dispositifs n'est pas représentative de ce que l'on peut obtenir par une meilleure culture des peupliers. Ainsi, dans un des tests clonaux installés en 1973 au populetum, sur un sol de même qualité mais mieux préparé et fertilisé, les clones Q-36-Q et C-22-Q avaient une hauteur de 1,43 mètre à l'âge de 2 ans. Dans ce cas les plants n'ont pas été déracinés par le gel du sol, les boutures étant plantées obliquement.

TREE IMPROVEMENT AT THE LAURENTIAN FOREST RESEARCH CENTRE, 1972-75

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Forest tree improvement programs are still in their initial phases in Quebec. Because of the large natural forests, the need for such work has taken a long time to be recognized. Also successive departures of the responsible geneticists did not help to accelerate the progress. However, genecological studies and provenance trials are continuously bringing interesting results on which will be based selective breeding during the next years. At the LFRC, four studies have as objectives the genetic improvement of softwood and hardwood species.

Additional details of the progress accomplished prior to the period under review were printed in previous reports to the Committee.

PROVENANCE RESEARCH ON SOFTWOOD SPECIES

Between 1955 and 1966 more than 200 provenances and geographic hybrids of white spruce (*Picea glauca* (Moench) Voss), red spruce (*Picea rubens* Sarg.), Norway spruce (*Picea abies* L. Karst), red pine (*Pinus resinosa* Ait.), jack pine (*Pinus banksiana* Lamb) and Scotch pine (*Pinus sylvestris* L.) were established in several experimental tests within different ecological regions of Quebec.

During the past few years, the emphasis has been placed mainly on white and Norway spruces and to a lesser extent on balsam fir (*Abies balsamea* (L.) Mill) and Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco). Seventy Norway spruce provenances from Roumania, White Russia, Lativian S.S.R., Germany, Poland, Czechoslovakia, Bulgaria and Jugoslavia were field planted at Valcartier Forest Experiment Station and at the Provincial Arboretum of Matapedia. Survival has been excellent and growth is very satisfactory for all provenances. It is however too early to make a definitive judgment on the value of particular provenances for the reforestation in Quebec. In addition, we have in nursery 40 provenances

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[1] The author received his Ph.D. degree from North Carolina State University in October 1974.

from White Russia and Finland that will be field planted next spring and 20 Polish provenances were sowed in 1974. Norway spruce is surely one of the most promising exotic species for the southern portion of the province and we hope to find one or several provenances that can outclass native species on comparable sites.

GENECOLOGY AND IMPROVEMENT OF BLACK SPRUCE

Black spruce (Picea mariana (Mill.) BSP.) genecological study initiated in 1968 has been continued during the period under review. Growth measurements were made on permanently marked seedlings after the first, the second and fourth growing season in nursery. The date of dormancy of each provenance was noted at the end of the second growing season.

A morphological study of black spruce female cones was started in 1971 and completed in the winter of the next year. The cones of some fifteen trees per provenance were used. Measurements taken were: cone weight, cone length, cone width, number of scales per cone and spirals maximum scale length and width and color intensity of the cone.

Three tests of 90 provenances were established in 1974 at Lac St-Ignace, forest region B.2, Chibougamau (B.1b) and Mont Laurier (L.4c). Last spring three additional tests were completed in Amos (B.4), Labrieville (B.1a) and Valcartier (L.3). At each location the design used was a lattice with 6 replications. In addition, to provide information about the geographically correlated genetic variation of black spruce, the tests will allow the selection of the more suitable provenances for the ecological regions sampled and the definition of seed movements criteria.

GENETIC IMPROVEMENT OF WHITE SPRUCE

Measurements taken in eight tests of white spruce provenances from the Great Lakes, St. Lawrence River and Ottawa Valley Region were analyzed and outstanding provenances were identified. The material was 15 to 20 years old at time of the last measurements. Procedures were taken to select, vegetatively propagate and to test elite trees within the superior provenances. A minimum of one hundred clones will be established in clonal seed orchards and clone banks during the next years to provide seeds for reforestation in meridional Quebec.

GENECOLOGY AND IMPROVEMENT OF YELLOW BIRCH

The yellow birch (*Betula alleghaniensis* Britton) genecological study has been initiated in 1968. Some 400 parent-trees representing 48 provenances were sampled and phenotypically described. Seeds from the trees were sowed in nursery and seedling growth and dormancy dates were noted. In the spring of 1972 three one parent progeny tests were established in the forest regions L.3 (Lotbinière) L.6 (Matapêdia) and L.4c (Fort Coulonge). Mechanical and chemical treatments of the sites were necessary to reduce the competition from the natural regeneration and to insure a good growth of the seedlings. After two growing seasons heights exceeding two meters were recorded. It is still too early to identify with certainty superior families. The tests will be later on transformed into seed production areas (seedling seed orchards) by practicing family and within family selections.

BOUTURAGE DES *PICEA*, STE-FOY, 1972-1975

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INTRODUCTION

Il y a nécessité de conserver dans des parcs à clones des phénotypes supérieurs d'épinettes pour fin d'amélioration. Bien que le greffage existe comme méthode de multiplication végétative, il introduit généralement dans le matériel les variations des porte-greffes issues de semis. L'incompatibilité entre porte-greffe et greffon peut être totale ou limitée, immédiate ou, dans certains cas, n'apparaître qu'après plusieurs années. Des clones multipliés par le bouturage permettraient l'obtention d'arbres sur leurs propres racines sans les complications causées par l'incompatibilité des greffes.

OBJECTIFS DE L'ETUDE

Développer des méthodes pour la production en masse de boutures de rameaux et établir des banques ou des parcs à clones et des vergers à graines en: 1. Mettant au point des techniques pour promouvoir et accélérer le racinement des boutures d'épinettes; 2. Etudiant les facteurs anatomiques et physiologiques qui influent sur le racinement des boutures; 3. Sélectionnant et multipliant des clones pour l'établissement de plantations comparatives (parcs à clones) et des vergers à graines.

PROGRES

Bouturage en serre

Pour déterminer de façon précise les variations saisonnières du racinement, des boutures furent prélevées périodiquement pendant deux ans sur de jeunes arbres d'une seule provenance de l'épinette de Norvège (*Picea abies* (L.) Karst.). Le bouturage s'est effectué en serre sous un brouillard artificiel intermittent. Les résultats ont indiqué que l'époque la plus favorable au prélèvement des boutures était au printemps, juste avant ou durant le débourrement. Une deuxième époque, moins bonne que la première, mais quand même recommandable, fut trouvée à la mi-automne. Le bouturage en serre fut compliqué, surtout durant l'été, par des moisissures grises sur les nouvelles pousses (Girouard 1975b).

Bouturage à l'extérieur avec arrosage manuel

Des couches froides recouvertes de fibre de verre furent construites en pépinière pour recevoir en fin de juillet 1970, 10,000 boutures semi-ligneuses. L'arrosage, qui s'est fait manuellement a coûté cher en main-d'oeuvre. L'expérience, terminée vers la fin d'août 1971, a révélé que seules les boutures d'épinette de Norvège avaient raciné en grand nombre. Le rendement des boutures simples était supérieur à celui des boutures à talon. Les traitements auxiniques n'ont augmenté ni le pourcentage de racinement, ni le taux de survivance des boutures (Girouard 1973).

Sélection et multiplication de clones d'épinette blanche

Nous avons analysé des données obtenues en 1969 par les membres de la section d'amélioration des arbres forestiers du CRFL, concernant la croissance en hauteur de jeunes arbres dans cinq plantations d'un test de provenances d'épinette blanche (*Picea glauca* (Moench) Voss) au Québec. La provenance 2438 (Peterborough, Ontario) est ressortie comme étant très supérieure à la moyenne dans chacune des cinq plantations. Au début de mai 1971, nous avons prélevé sur chacun des 50 plus grands arbres une moyenne de 30 boutures dans la moitié inférieure des tiges sans endommager les pousses terminales des branches. Après une étude en serre sous brouillard intermittent, on a trouvé que quatre des meilleurs clones pour le bouturage dépassaient de 46% la moyenne expérimentale, et que seule la moitié des clones se bouturaient assez bien. Les résultats nous ont montré en définitive qu'il faudrait augmenter le nombre d'arbres étudiés si on veut éventuellement choisir et multiplier au moins 50 clones qui sont faciles à bouturer pour l'établissement de vergers à graines (Girouard 1972).

Au printemps 1972, des boutures de 100 des meilleurs arbres pour croissance en hauteur de la provenance 2438 (Peterborough, Ontario) furent plantées en pépinière dans une couche à ciel ouvert avec panneaux latéraux et brouillard artificiel intermittent. Différents milieux de bouturage furent comparés et l'effet d'une chaleur de fond sur le pourcentage de racinement fut étudié. Les résultats de ces expériences seront publiés bientôt. Les boutures racinées furent repiquées au début du mois d'octobre dans une pépinière à Ste-Foy où le sol avait été transformé à l'été. Les dégels répétés du sol à l'automne ont soulevé de terre la moitié des plantes mal établies. Ces pertes nous ont fait comprendre que tous les repiquages en pleine terre doivent se faire avant la fin de l'été pour permettre un enracinement fort des jeunes plantes avant les gels et dégels automnaux du sol.

En 1973, le rendement en pépinière de la couche à ciel ouvert fut amélioré et on peut dire que la phase de l'étude appelée "perfectionnement d'une couche pour le bouturage des *Picea* en masse" fut à toute fin pratique terminée. Durant l'hiver 1973-1974, nous avons développé une méthode pour effectuer une sélection hâtive des clones sous conditions semi-contrôlées, et de comparer les clones sélectionnés d'une année à l'autre. Cette méthode sera décrite bientôt dans une publication.

Environ 5,000 boutures d'épinette blanche prélevées sur 100 clones de la provenance 2438 (Peterborough, Ontario) et racinées durant l'été 1974, nous ont permis de constater l'amélioration réelle de la couche de multiplication depuis trois ans. On a pu comparer le rendement des clones bouturés en 1974 avec celui de 1972. En 1975, une sélection hâtive des clones de la provenance 2438 s'est effectuée en serre. Les plants bouturés furent plantés en pépinière et serviront à l'établissement dans quatre ans soit d'une banque à clones, soit d'un verger à graines clonal près de Berthierville, Québec.

Parc à clones en forme de haies

Un parc à clones en forme de haies fut initié en 1972 pour l'épinette blanche à la Station forestière expérimentale de Valcartier. Le parc fut transformé en 1974. Les futures haies serviront à retarder le vieillissement physiologique des clones et à fournir des boutures dans cinq à six ans.

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PRELIMINARY STUDIES ON TOTAL GROWTH OF BLACK SPRUCE IN THE JAMES BAY AREA OF QUEBEC

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The study of annual rings in forest trees has occupied the attention of foresters, geographers, and biologists for many years (Macdougal 1938, Glock 1941, 1955, Gaertner 1954, Fritts 1975). Although the annual ring has provided much needed information in dendrochronology, the allocation of photosynthates not only to the annual ring but to the total tree, both its vegetative and reproductive parts, is of greater significance to a forester. Interpretation of such data can be especially useful in the study of changes in eco- and macro-climates, both natural and man-made. Budyko (1974) in the USSR and Bryson (1974) in the USA have forecast large-scale abrupt changes in world climate; these would become reflected in total tree growth. Another aspect of such analysis that offers practical application is the change in river flows as influenced by the James Bay Development Project with its allied James Bay Power Corporation.

The relative productivity per unit (needle, chlorophyll, dry weight) of photosynthetic tissue and the total growth form of the tree are of particular interest when selecting tree breeding material. Productivity in terms of a single needle was estimated by Macdougal (1938) for Monterey Pine (*Pinus radiata* D. Don.) and by Fraser *et al*. (1964, 1969) for white (*Picea glauca* (Moench) Voss) and black spruce (*Picea mariana* (Mill.) BSP.). The present study was undertaken to evaluate growth productivity of black spruce in northern Quebec as it relates to future development under unchanged environmental conditions. Black spruce was selected for the initial phase of the study because of its economic importance, its wide distribution and because growth patterns of this species have already been established at Chalk River, Ontario, where experimental trees growing on the Corry Lake and Loon Lake Physiology Areas continue to provide research material for parallel studies. The apical growth forecast from that attained by the fall of 1974 will later be compared with actual growth produced in future years after local environment is changed by hydroelectric developments and the water table is lowered (Opinaca River) or raised (Lac Low, La Grande).

Trees were collected in the following regions:

(1) The flood plain of the lower Opinaca River, which will have its waters partially diverted into the La Grande drainage area when the hydroelectric development is operational and where water tables will probably be lowered.

(2) The Lac Low Area, where the newly flooded areas will raise the general water table (Fig. 1).

(3) Other sample areas extended along the "Route d'Acces" highway extending from the Rupert River to Val d'Or, Quebec.

Selected trees were cut at ground level and placed in plastic netting to prevent damage to branches and needles during the transportation by air to Montreal, where they were stored at 4°C. The procedure of growth data analysis followed that developed for white spruce (Fraser et al 1964). While the concept of growth "Summation" was developed to designate the manner in which growth data are examined, a new diagram was later developed (Fraser and McGuire 1969) to facilitate the visualization of the added sums of growth (Fig. 2).

The Summations here presented were obtained through analysis of growth of a black spruce tree located on the flood plain on the north bank of the Opinaca River near Opinaca Headquarters site. It was growing in an open stand and was 12 years old at stump height. An abundance of blueberries (Vaccinium angustifolium Ait.) grew between the trees.

The Oblique Summation (Fig. 3) for this tree of the apical growth of branches in meters showed a uniform increase from a few cm in 1962 to a little over 8 meters in 1974. The progressive uniformity shown in this Summation indicates a minimum of environmental changes with no competition from adjacent vegetation. The forecast apical growth summation for 1975 and 1976 is indicated in broken lines and approximates 9 and 10 meters respectively. Several functions were investigated to assess their degree of fitness suitable for calculation of future growth characteristics. The power curve fit of $y = ax^b$ where a and b are arbitrary constants defined by the variables y and x which represent growth versus time, gave satisfactory results for progressive apical growth summations when applied to growth data following the initial establishment of the tree seedlings.

The Horizontal Summation accounts for all branch growth at each internode (Fig. 4). The total production for this Summation is primarily dependent on the number of branches per node. Usually vegetative growth is reduced during a good seed year. The Horizontal Summation for the analysed tree showed peaks for 1965 and 1967, years when there was a greater number of surviving branches per node and probably poor seed years. The data will be analysed at a later date when investigations of other trees are completed.

The Vertical Summation (Fig. 5) summarizes apical growth of the branch internodes in relation to their time of formation. Thus all the growth of branches during their first year, as represented by the extension

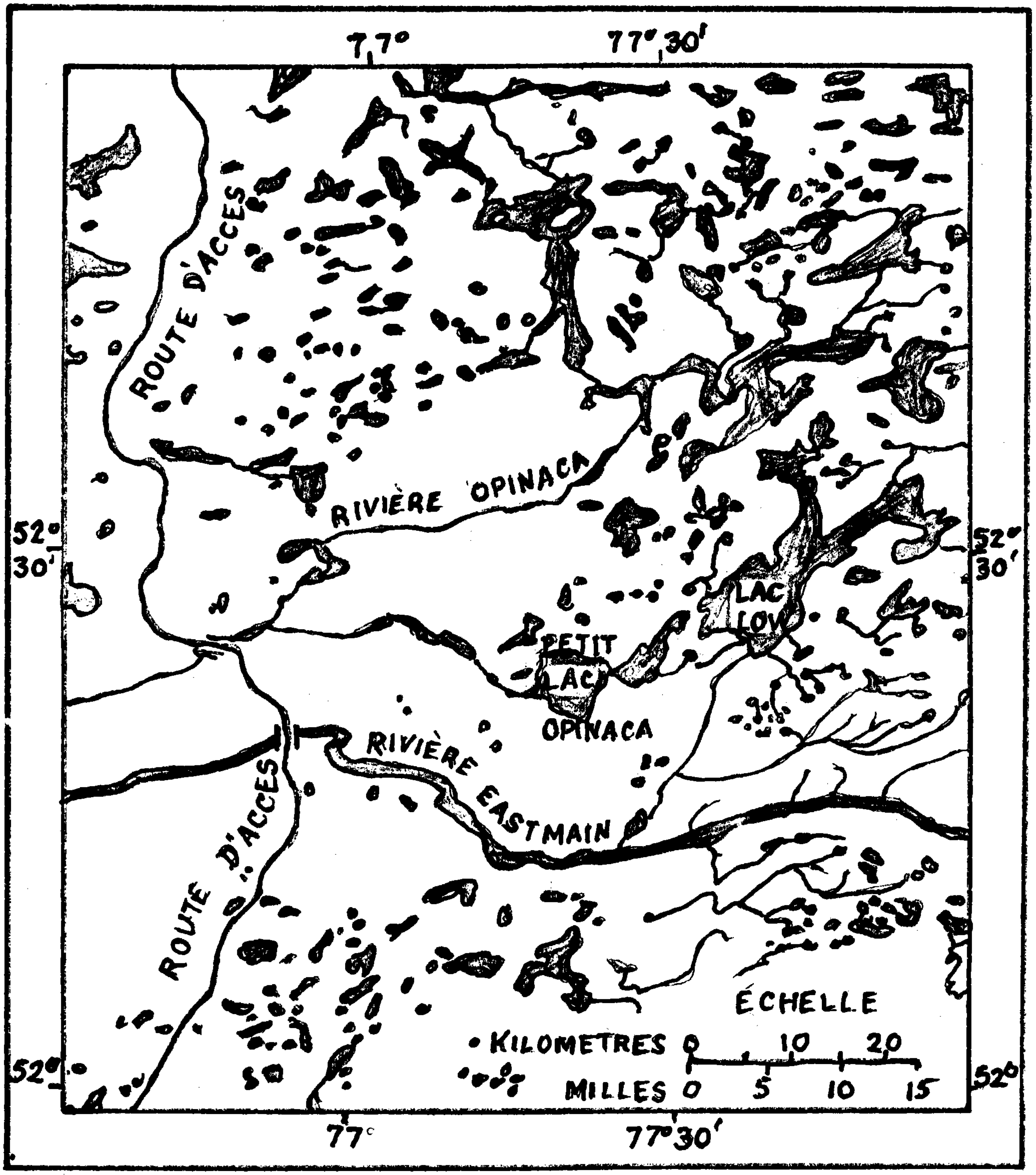

Fig. 1. Region of the James Bay Hydroelectric Development Area, Quebec, where sample trees of black spruce were collected, Sept. 1974.

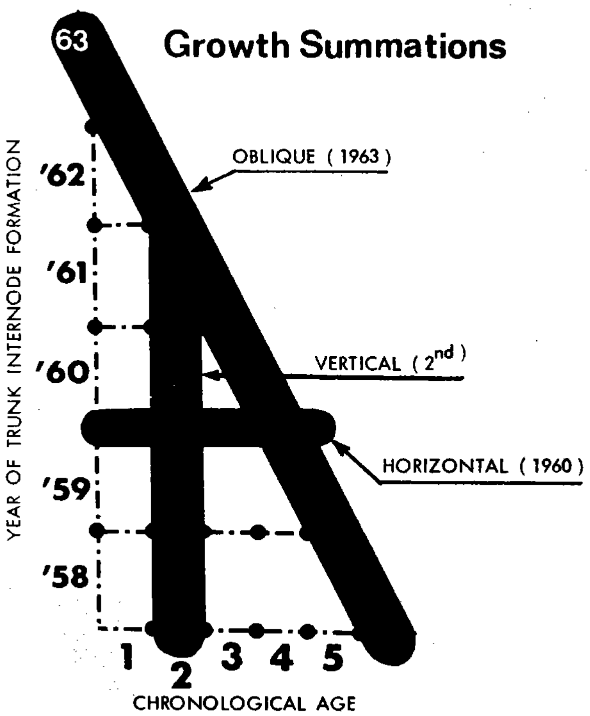

Fig. 2. Three types of Summations of apical growth of a 6-year old black spruce tree

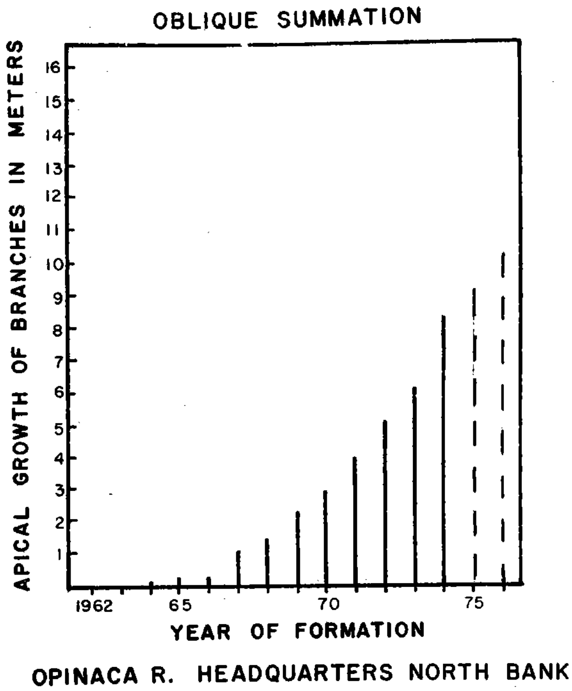

Fig.3. Oblique Summation of apical growth for black spruce for 1962-74 with projection for 1975 and 1976

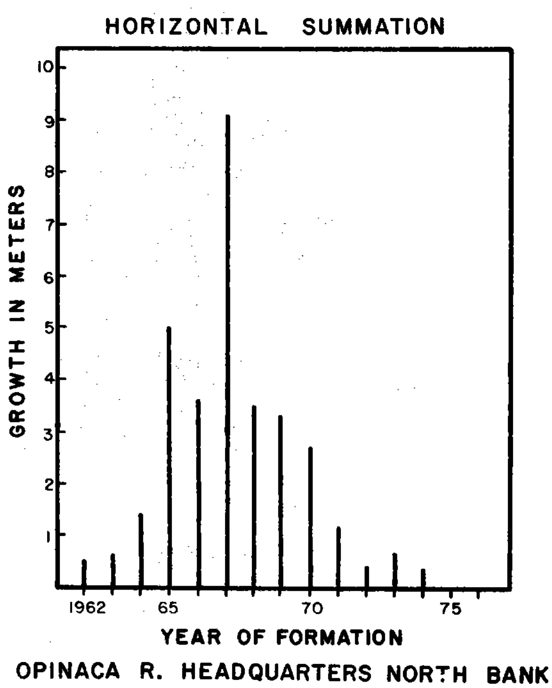

Fig. 4. Horizontal Summation of apical growth for a 12-year old black spruce tree

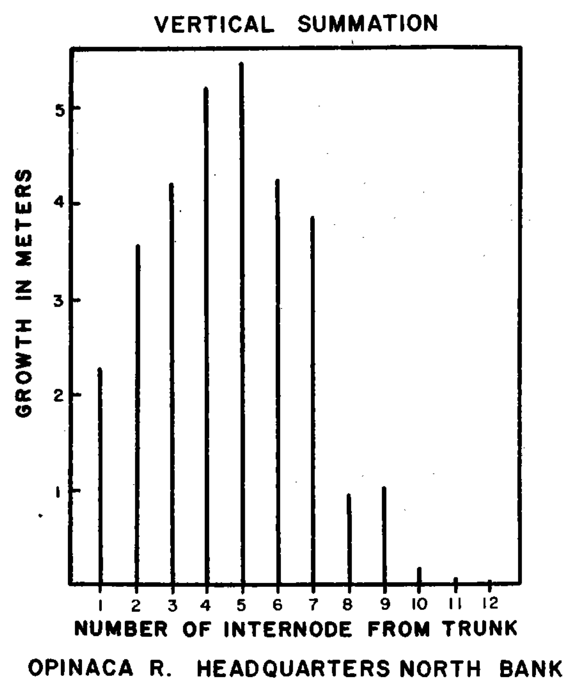

Fig. 5. Vertical Summation of apical growth for black spruce at 12 internodes of sample tree

of the first internode from the main axis (Chronological Age 1), amounted to only 2 1/2 meters. Branch growth of the second order of Chronological Age involves all apical growth separated from the trunk by one internode. This includes both primary branch growth and adventitious shoots formed during the second year on the branches of the first order. This amounted to 3 1/2 meters. The following orders increased similarly up to the fifth order when a maximum of 5 1/2 meters of apical growth was produced. A progressive decrease followed.

The application of data from this tree in northern Quebec indicates the procedure considered for other specimens grown both in northern Quebec and on the Corry Lake and Loon Lake Physiology Areas on the Petawawa Forest Experiment Station, Chalk River, Ontario. It will be necessary to collect data from a number of specimens before conclusions concerning growth reactions of black spruce in a north - south distribution range and to future man-made alterations of the environment can be derived.

ACKNOWLEDGEMENTS

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SEED ORCHARDS AND SEED PRODUCTION AREAS IN ONTARIO

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SEED ORCHARDS

In Aubrey Township, Dryden District, a new seed orchard site was selected to hold white and black spruce clonal stock from plus trees selected in Site Region 4S. Two blocks of each species were planted in the spring of 1975.

An additional orchard site was acquired in the winter of 1973. This area has 135 acres and is adjacent (north) to the existing one acquired in 1971. Situated in Tossorontio Township about 7 miles from Angus, the two areas together are known as the Glencairn seed orchard. In 1973, thirteen blocks of black spruce and nine blocks of white spruce were planted, and in 1974, four blocks of black spruce and twelve blocks of white spruce grafted trees were planted in the southern portion of the Glencairn orchard. In 1974, trees of smaller sizes were outplanted and a clump of grass was left surrounding each orchard tree throughout the summer. After one growing season these trees looked healthier in comparison with those in the previous blocks and survival was greatly improved. It seemed that the small trees required less moisture for transpiration, thus exerting minimum stress upon the newly planted roots, enabling them to establish. The clump of grass tended to reduce the drying effect of the prevailing wind in this particular orchard. In 1975, since most available stock was planted out, no new block was planted. Planting involved mainly refilling old blocks and the transfer of one block of black spruce from a former orchard site. However, other species such as Autumn Olive, Russian Olive, Dogwood, Silver Maple and Viburnum were planted in the Glencairn orchard for seed production and windbreak purposes. Also a clone bank was established to accommodate surplus stock from the nursery.

Since 1973, the task of plus tree selection was delegated to the district staff throughout the province. The change-over is aimed at selecting and preserving more superior specimens from a larger area within a shorter period of time. Accordingly, the number of grafts made from individual trees was reduced to propagate the increased number of plus trees. The grafting operation at Angus for the seasons of 1973-74 was as follows:

Species	Total Grafts	Clones Old*	New	Survival In Greenhouse
		1973 - 1974		
White Spruce	2,228	18	64	91%
Black Spruce	2,052	41	54	84%
White Pine	208		7	96%
		1974 - 1975		
White Spruce	2,572		108	53%
Black Spruce	2,639		102	69%
White Pine	569		47	94%

* Regrafting from previous clone in seed orchard

The lower survival rates in the greenhouse in the '74-'75 season was likely due to the increased number of new plus trees grafted, resulting in a greater variation in graftability among clones and diversity in scion quality. Also numerous understock trees were top burned due to intermittent unusual mild spells in the second winter.

PROGENY TESTING

Close co-operation was maintained with the Forest Genetics Group, Forest Research Branch, in the progeny testing work. Local staff assisted research staff in collecting pollen, isolating female flowers, control pollinating and harvesting cones. A total of 513 lots of white spruce and 182 lots of black spruce control-pollinated cones were picked. The cones were measured, seed extracted, and cleaned by local staff and delivered to the research staff. In addition, 56 lots of cones from black spruce plus trees were measured and extracted for one-parent progeny testing purposes.

FLOWER INDUCTION TRIAL

Research results by Dr. R.P. Pharis, University of Calgary, indicated that exogenous application of plant hormones significantly enhanced flowering in half-sib Douglas-fir seedlings, lodgepole pine seedlings and loblolly pine grafts. In May 1975, under the guidance of Dr. Pharis and in co-operation with the Forest Genetics Group, a trial was set up in the white spruce seed orchard at Midhurst Nursery. A total of 83 trees were selected. Some branches were girdled prior to chemical treatments while others were left intact as controls. At 10-day intervals GA 4/7 mixture in alcohol solution was applied to the treatment branches at two concentration levels. A total of 6 treatment intervals were used.

SEED PRODUCTION AREAS

No pickable crops were observed in the Oro Township red pine seed production area in the two crop years, 1973 and 1974. Ammonium nitrate was applied each spring around the first week of May at a rate of 2 lb. per tree.

A white spruce seed production area was established in a 20-acre plantation in Mutrie Township, Dryden District.

Four additional jack pine seed collection areas were established in Chapleau, Gogama, Algonquin Park and Wawa Districts.

GENECOLOGY AND RACIAL VARIATION IN PICEA

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The objectives of genecological studies in the spruce genus (Picea) are:

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

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

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

A manuscript on the taxonomic and genetic relationships of red and black spruce has gone forward to reviewers. This study was based on 1000 sample trees and covered the complete range of one species and a representative sample of the other.

Sampling of our spruce provenance plantations continues. These have been outplanted from the transplant stage for 8 to 16 years in several locations.

Flowering was heavy in 1974 and cone collections for variation studies were made and coded from all the provenances in one P. rubens and one P. mariana experiment. Heritability estimates should be possible from some of this material. A P. rubens plantation yielded several hectalitres of cones from local provenances for the tree seed program, Silviculture Section.

In 1973, Picea rubens was crossed with P. rubens, P. asperata, P. asperata var. notabilis, P. meyeri, P. purpurea, P. omorika, P. chihuahuana, P. pungens and P. mariana. Of these crosses, only the P. rubens x P. rubens, P. omorika and P. mariana were successful. The seed germination percentages of the P. rubens and P. omorika were approximately the same while that of the P. rubens x P. mariana varied from 0 to almost 4%.

Two P. omorika clones were crossed with P. omorika, P. rubens, P. asperata, P. asperata var. notabilis, P. meyeri, P. purpurea, P. koyamai. P. chihuahuana and P. pungens. These crosses all failed except P. omorika x P. omorika (51% germination), x P. rubens (27% germination) and x P. chihuahuana (0.47% germination). This last cross is the first successful crossing known for P. chihuahuana. There were 22 cones, 1274 seeds, 12 full seeds of which 6 were viable. Of these, 2 had reverse embryos. Four hybrid seedlings were produced. The number of full seed relative to those that were actually viable (% germination) provides an indication of the lack of suitability of this criterion in crossing studies.

In 1974, 14 intraspecific crosses involving 5 Picea species, and 49 interspecific crosses involving 16 species were made. P. rubens (1 to 8 clones) was crossed with P. rubens (2 provenances), P. abies, P. chihuahuana, P. orientalis, P. purpurea, P. polita, P. maximowiczii, P. koyamai, P. meyeri, P. asperata, P. asperata var. notabilis, P. schrenkiana, P. engelmannii and P. jezoensis. The crosses with P. rubens x P. rubens (0-48% germination), x P. orientalis (.01% germination), x P. chihuahuana (.008% germination), x P. orientalis (.02% germination), x P. polita (.57% germination), and x P. schrenkiana (.04% germination) were successful. The P. rubens x P. chihuahuana cross involved 8 clones, 292 cones, 25,129 total seeds of which only 2 were viable. One of these seedlings while not chlorotic, was pale and was subsequently killed by damping-off fungi. Of these crosses, those involving P. rubens x P. abies, P. polita and P. schrenkiana are questionable.

The P. rubens x P. abies cross is represented by one seedling out of 7790 seeds from 116 cones. That of the P. rubens x P. schrenkiana is represented by one seedling out of 2363 seeds from 24 cones. There are 19 seedlings of seed of the P. rubens x P. polita cross. None of the seedlings from these 3 crosses are confirmed and exhibit no hybrid characteristics as yet.

Two clones of P. omorika were crossed with P. abies, P. polita, P. chihuahuana, P. purpurea, P. maximowiczii, P. schrenkiana, P. asperata, P. asperata var.notabilis. Only the P. omorika x P. chihuahuana, a cross repeated from 1973, was successful (.4% germination). There were 2 clones, 6 cones, 498 seeds of which 5 were filled, but only 2 viable. The P. omorika x P. schrenkiana and x P. asperata var. notabilis produced single filled seeds which failed to germinate.

One clone of P. abies was crossed with P. mariana, P. rubens, P. polita, P. chihuahuana, P. koyamai, P. asperata, P. orientalis, all of which were failures except P. abies x P. rubens (.08% germination), x P. asperata (.2% germination) and P. abies x P. chihuahuana (.08% germination). The P. abies x P. rubens and x P. chihuahuana crosses are questionable. The former is represented by one seedling out of 1277 seeds and the latter by 1 out of 1162 seeds. Neither seedling is confirmed.

Crosses were made with 2 clones of P. glauca x P. orientalis, P. maximowiczii, P. sitchensis, P. asperata, P. asperata var. notabilis, P. chihuahuana, P. purpurea and P. meyeri. All of these were unsuccessful except P. glauca x P. sitchensis (.4% germination).

Crosses were made of 4 clones of P. mariana x P. koyamai, P. asperata, P. asperata var. notabilis, P. chihuahuana, P. schrenkiana, P. orientalis, P. purpurea, P. maximowiczii, P. abies, P. sitchensis and P. polita. All of these crosses were unsuccessful except P. mariana x P. asperata (.07% germination). This cross was made with 1 clone, 34 cones, 2574 seeds with only 2 viable. These seedlings are unconfirmed.

In 1975 crosses were made with two provenances of P. rubens P. mariana, P. omorika and P. chihuahuana. Results from these crosses will be reported later.

A fully reciprocal P. omorika x P. rubens experiment, previously reported, was outplanted in 1974. Heterosis (hybrid vigour) of the hybrids over both parents was still evident.

The relationships of genetic variation on the nutrition, growth and efficiency in spruce are being investigated by measurements and analysis of different provenances and species in the same and different sites. Several species and hybrids are being considered.

Most of the experimental seedlings, representing 28 species, 50 provenances, 14 forms and hybrids, have now been outplanted in experimental plantations called 'Piceta' covering a complete range of plant hardiness zones and site regions in Ontario (Boreal, North Temperate and southern Ontario conditions). The planting is still not complete in all the 'Piceta' since the various types, etc. have grown at different rates from germination. A very few of the more slowly developing lots as well as replacements are still being planted.

Initial height growth measurements have been made in one Picetum. There are of course, considerable differences in establishment and height growth between species, but some provenance differences appear quite interesting as well. Some follow after earlier ranking order in the nursery but others behave quite differently.

SWAMP, NECTAR AND EDIBLE NUT SILVICULTURAL RESEARCH

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Selection

Three Jackii poplar (Populus jackii) wildings of exceptionally fine quality were discovered in the Greenock and Burford swamps in 1973 and in 1974. They ranged from 10 to 30 years of age and from 30'to 90' in height. Cuttings were taken from these trees in 1974 for site-performance evaluation.

Two red ash (Fraxinus pennsylvanica) and one green ash (Fraxinus pennsylvanica var subintegerrima) timber phenotypes were located in the Burford swamp. They are being propagated by greenwood cuttings in the misting bed at Maple and will also be site-tested in some of the main swamps in southern Ontario. Mr. Shane Walshe, Botanist, reported finding 36" (90.2 cm) black ash (Fraxinus nigra) in the Atikokan District. Greenwood cuttings will be taken from the best of these trees in early July 1975 and planted in the misting bed at Maple. The rooted cuttings will be later site tested on the lowlands of southern Ontario for their timber potential.

Propagation

Forty-two percent (2125) of 5000 unrooted silver maple cuttings from 19 clones planted in the misting bed at Maple in 1972 were alive in November 1973. They will be out-planted in the spring of 1974 in two seed orchards and in four swamp sites in southern Ontario.

In July 1973, a grand total of 2700 silver maple cuttings were planted in a misting bed and a total of 49% were transplanted to the nursery in spring of 1974. A total of 1000 more cuttings in 1974 were planted in the misting bed at Maple. These were taken from 14 timber clones, 24 were from a wavy grained selection and 49 were from an exceptionally "sweet" heavy sap producing tree in the Beverly swamp. In addition 467 green ash and 100 red ash cuttings from an exceptionally high quality population were planted in the misting bed in early August, 1973 and in early July of 1974. These will be later planted in a seed orchard and in a number of swamps in southern Ontario.

Silver Maple Seed Orchards

There was almost 100 percent survival. Growth ranged from poor to excellent at the orchard at the Forest Tree Nursery, Orono. A second silver maple seed orchard of 14 selections was established in a nectar grove at Wingham and a third at Glen Cairn, near Angus.

Provenance Studies

Since 1971, 14 silver maple provenances have been collected from naturally-occurring stands scattered throughout southern and northern Ontario and planted in the nursery at Maple. They were outplanted in a randomized and replicated design in the Elderslie and Minising swamps in the spring of 1974.

The purpose of this project is to establish a gene bank for the preservation of as many genetical features of silver maple as possible which then can be incorporated into any future breeding program of this valuable species.

Establishment Studies

One and two year old rooted cuttings of 14 silver maple timber selections were planted on mounds in the Elderslie, Minising and Luther swamps as well as 800 Jackii progeny from controlled crosses of eastern cottonwood and balsam poplar timber types to determine their growth potential on such sites.

Silver maple progeny and eastern cottonwood and Jackii poplar clones which had been planted since 1970 in the Elderslie, Luther, Minising and Puslinch swamps appear to be established on all sites below 1000' (319 M) elevation and not at all on those sites at 1700' (520 M) elevation.

Mounding Plow

The Mark III mounding plow mounded 30 acres in the Elderlie and about 90 acres in the Minising Swamp complexes. Valuable suggestions were made by the field staff for improving the performance of this experimental machine. These were incorporated into the plow in 1974 and tests that year indicated greatly improved performance.

TULIP POPLAR HARDINESS TRIALS

Three tulip poplar strains from the mountains of West Virginia, Ohio Valley and from the Lake Erie District were planted in a replicated and randomized design in 13 locations stretching from Cambridge in the south (Latitude 43° 20') to North Bay (Latitude 46° 28'). Generally all strains grew well on all sites. Their winter hardiness features will be carefully recorded. The greatest height growth occurred in 1974 on those tulip near Powassan. Some trees grew five feet in height in 1974. Unfortunately this species is not programed for the spring, winter and fall conditions at this latitude and were killed back in the winter of 1975. The objectives of this study are to determine if the range of this valuable species can be moved further north than the shores of Lake Erie and at the same time to select and propagate any hardy trees within each strain.

NECTAR TREE RESEARCH

This program was greatly expanded in 1973 and in 1974 by locating and propagating by cuttings and roots 14 nectar-producing black locust (*Robinia pseudoacacia*); by budding 150 basswood (*Tilia americana*) grafting stock to two nectar producing selections of our native basswood and two nectar producing selections of European linden (*Tilia platyphyllas*). Preliminary arrangements were for the establishment of three nectar groves. One of the orchards near Clinton, has already been partly planted or sown too with Ohio buckeye (*Aesculus glabra*), black locust, silver maple (*Acer saccharinum*), American basswood, staghorn sumac (*Rhus typhina*), honey suckle (*Lonicera tatarica*) and Japanese lilac (*Syringa reticulata*).

EDIBLE NUTS AND WILD FRUIT RESEARCH

Very little effort has ever been made in Ontario to select superior strains of our native nut and wild fruit species for wildlife and human consumption. To-date, one black walnut, (*Juglans nigra*) and one beaked hazel (*Corylus cornuta*) and one red mulberry (*Morus rubra*) one high bush cranberry (*Viburnum trilobatum*) and one Saskatoon berry (*Amelanchier alnifolia*) and one elderberry (*Sambucus canadensis*) were discovered in southern Ontario. These will be propagated in the nursery by budding, cuttings or by bush division in the summer of 1974.

Special mention of the Burns black walnut must be recorded here. The nuts from this selection were given the cracking test by Dr. L.H. MacDaniels, Cornell University in 1973 who stated that the Burns walnut is a very superior nut in cracking qualities and should be propagated as soon as possible as it had definite commercial possibilities. The other nut and fruit selections mentioned here must be given further tests to determine their potential.

The Ministry also donated filbert and sweet chestnut cultivars to the Royal Botanical Gardens to be incorporated into their edible nut arboretum.

GENETIC IMPROVEMENT OF SPRUCE FOR ONTARIO, 1973-74

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During these two years, the emphasis of the genetic improvement programme has been on black (*Picea mariana* (Mill.) B.S.P.) and white spruce (*P. glauca* (Moench) Voss). Controlled pollinations in the seed orchards has continued. In addition, testing of other types of selected material has started. Vegetative propagation of cuttings has been quite successful and more effort is being directed towards this aspect of the programme. Interspecific hybridization work is being continued on a smaller scale.

SELECTION AND IMPROVEMENT OF BLACK AND WHITE SPRUCE

In 1972, the Forest Management Branch of our Ministry established target objectives for the artificial regeneration programme for the next 30 years. The anticipated requirements are for 425 million white and 625 million black spruce seed. This is a three-fold increase of present needs. The challenge in the tree improvement programme is to ensure that genetically improved seed is available to meet these targets.

In order to obtain sufficient quantities of improved seed and stock of white and black spruce, the work programme has developed along 4 lines. These are 1) testing of seed production areas, 2) preliminary testing of plus trees as they are selected, 3) testing of plus trees which are established in the seed orchards, and 4) rooting and testing of superior seedlings selected in nurseries throughout the Province.

Testing of the seed production areas will provide such information as the quality of the seed and the attainable gains in the various areas selected, within and between stand variation, and juvenile-mature correlations of individual trees for each stand. The testing of some areas has started and larger comparative tests will be established as the seed production area programme develops.

In recent years, when seed was available, it was collected from black spruce plus trees at the same time that the scions were collected. In the winter of 1975-76, much of this seed will be germinated and one-parent progeny tests started. As data is collected from these trials, some of the poor combiners will be eliminated before they are established in the seed orchard. Any trees eliminated at this stage will reduce the number of controlled pollinations required in the orchards.

Testing of the seed orchards started several years ago. Controlled pollinations using the bi-parental mating design described in the last report has continued in both the black and white spruce seed orchard for the northeastern area of Ontario. During the springs of 1973 and 1974, several thousand flowers were bagged and pollinated, and sufficient seed is available from some of the crosses to start replicated trials. Intensive testing will begin next in the north-central area of Ontario. Eventually, the bi-parental mating design will be used on this orchard and on all other orchards across the Province where spruce is economically important.

In the fourth area of endeavour, superior seedlings have been selected in six nurseries for the past three years. These selections, along with some average trees as controls, have been placed in a holding area on or near the nurseries. Now that the selected trees are large enough, vegetative propagation by means of rooting cuttings can start in August of 1975 or in the spring of 1976. The selections will be evaluated for their ability to root and the subsequent growth performance of the cuttings. The best clones will be propagated on a much larger scale.

VEGETATIVE PROPAGATION BY ROOTING OF CUTTINGS

Our original experiments at the Maple Station showed that rooting cuttings was a feasible means of reproducing large quantities of genetically improved stock. Thus a mist house was built at one of our southern nurseries for large-scale propagation. Although for the first two years some adverse conditions with temperature and humidity existed, many of the clones rooted quite well. Modifications have been made on the misting system and the interior conditions, so results should improve with the 1975 experiments.

During 1973 and 1974, material was collected from selected, young white and black spruce trees in seed production areas throughout Ontario. Several experiments were established with this material to determine the best techniques for rooting. Cuttings were taken with and without a heel of old wood. Coarse sand was compared to combinations of peat and sand. Cuttings were dipped in indolebutyric acid, captan, or a combination of indolebutyric acid and captan. Rooting in the open bed was compared to that in Japanese paper pots and the Ontario non-split plastic tube. Under the conditions which prevailed in the mist house, some of the best results were produced when cuttings were taken with a heel of old wood and planted in a mixture of 75% sand and 25% peat. Invariably the highest rooting percentage was obtained when no dip was used. Rooting percentages were best in the open beds, but the roots tended to wander and many were broken when lifted. The results using the Japanese paper pot were almost as good yet the roots were somewhat restricted by the pot. The main advantage of the paper pot is that the cuttings can be transplanted with minimum disturbance to the root system. Species and clonal variation was the most important factor in all of the experiments. Many of the white spruce clones had rooting averages of over 90%, but few of the black spruce rooted better that 25%. Some clones have been selected as good rooters and are being raised for outplanting tests to determine their growth performance in the field. Those that do well will be mass produced and entered into the artificial regeneration programme.

Table 1 Height growth for interspecific spruce hybrids.

Species	Population	Average total height (mm)	Weighted average height (mm)
Expt. 1 Three-year height growth of *P. glauca* and two hybrids.			
P. glauca x jezoensis	SP147	158	197
	SP150	191	
	SP155	219	
P. glauca	Bulk population	289	289
P. glauca x sitchensis	SP151	258	307
	SP156	291	
	SP153	322	
	SP148	342	
Expt. 2 Two-year height growth of *P. omorika*, *P. mariana* and their hybrid.			
P. omorika x omorika	SP277	75	84
	SP276	88	
	SP272	90	
P. mariana	Bulk population	103	103
P. omorika x mariana	SP279	116	120
	SP273	117	
	SP278	128	
Expt. 3 One-year height growth of *P. abies*, *P. koyamai* and their hybrid.			
P. abies open-pollinated	SP235	48	55
	SP107	61	
P. koyamai open-pollinated	SP104	74	79
	SP421	85	
P. abies x abies	SP241	73	77
	SP236	82	
P. abies x koyamai	SP244	90	100
	SP245	95	
	SP246	103	

INTERSPECIFIC HYBRIDIZATION

Although this aspect of the programme has received less emphasis in the last few years, several promising hybrids have been produced. The *P. glauca x sitchensis* (Bong.) Carr. hybrid performed very well in the nursery and was outplanted in three different locations in southern and central Ontario in the spring of 1974. Two areas were open and the third was under a light overstory of young poplar. The ability of this hybrid to overwinter in the field will be a determining factor in its usefulness and economic value in Ontario. Two other hybrids which show promise are *P. omorika* Purkyne x *mariana* and *P. abies* (L.) Karst x *koyamai* Shirasawa. The following table shows the average heights for these hybrids. The crosses which can maintain superiority in field plantings will be repeated on a larger scale.

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POPLAR AND PINE BREEDING IN 1973 AND 1974

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The aims and achievements of poplar and pine breeding at the Forest Research Branch, Maple, Ontario, were summarized in the report submitted to the 14th Meeting of the Canadian Tree Improvement Association (Zsuffa, 1975a). Here, the developments in 1973 and 1974 will be briefly discussed. The *poplar breeding*, selection and propagation continued for the following types of culture: (1) for good poplar sites in Southern Ontario, (2) for poor poplar sites in Southern Ontario, (3) for Northern Ontario, and (4) for poplar farming. The *white pine* work concentrated on breeding and testing of *Pinus griffithii* McClelland *x strobus* L. hybrids and on the vegetative propagation. In *hard pines* advancements were made in breeding and testing of hybrids, in identification of earlier produced red pine (*Pinus resinosa* Ait.) interspecific hybrids and in vegetative propagation of jack pine (*Pinus banksiana* Lamb).

POPLAR

On good poplar sites (such as fresh, well-aerated loams) in Southern Ontario, the best *P. x euramericana* (Dode) Guinier (*P. deltoides* Marsh x *P. nigra* L.) clones performed well (Table 1). The clonal variation was large. In many instances it amounted to more than 50% in height growth and 100% in diameter growth. Large variation was also observed in site tolerance, and frost and disease resistance of clones. The rank of the clones usually changed every year and stabilized only after the fourth or fifth year of growth. Although satisfactory clones were selected for large scale propagation on good poplar sites, the potential of *P. deltoides x nigra* hybrids on such sites was further explored by making new crosses between selected Eastern Cottonwood trees from Ontario and *P. nigra* from Czechoslovakia, Hungary and Yugoslavia.

On poor poplar sites, such as poorly drained, acid, heavy, shallow soils or poor sands, the *P. x euramericana* clones do not grow satisfactorily. Large areas of such unutilised land are available in Eastern and Central Ontario. Balsam poplar hybrids show promise in these conditions. Therefore, the breeding and clonal testing of *P. x Jackii* Sarg., *P. deltoides x jackii*, *P. balsamifera* L. *x deltoides* and *P. balsamifera x nigra* has expanded.

The breeding and testing of hybrid poplar for Northern Ontario has continued. Several thousand progenies of various poplar selections and crosses were outplanted in nurseries and observed for frost hardiness, disease resistance and growth performance. The ortets of silver poplar (*P. alba* L.) and aspen hybrids tested in these series were not frost-hardy. The clonal propagation of 42 promising frost-hardy ortets of *P. deltoides* var. *occidentalis*, Rydb. and *P. x Jackii* was initiated after four years of observations. New crosses were made between *P. balsamifera* from Northern Ontario and *P. deltoides* from Southern Ontario, and between *P. tremuloides* Michx. and *P. davidiana* Dode.

Table 1 The growth of the best *P. x euramericana* clones in trials in Southern Ontario *.

		Years after planting				
		1	2	3	4	5
AVERAGE HEIGHT GROWTH (m)	Annual	1.2	1.7	2.2	3.0	2.2
	Total	1.2	2.9	5.1	8.1	10.3
AVERAGE DIAMETER GROWTH (DBH) (cm)	Annual	0	2.0	4.6	4.6	3.7
	Total	0	2.0	6.6	11.2	14.9

* Unrooted, 30 cm long stem cuttings planted in prepared soil; the spacings varied from 3 x 3 m to 5 x 5 m.

The concept of producing large volumes of poplar biomass on intensively managed, densely-grown, one- or two-year-old coppices of hybrid poplar clones, in a system of farming was further tested and advanced by two studies. (1) One study was to determine the yield and wood quality of two-year-old coppices of 35 *P. x euramericana* clones (Anderson and Zsuffa, 1975a). The clonal variation was considerable in every aspect analysed. The clonal production rates varied from 26.7 m^3/ha to 161.4 m^3/ha in green volume, and from 9.9 tonnes/ha to 38.3 tonnes/ha for oven-dry biomass. The clonal values for average weighted specific gravity of bole xylem ranged from 0.234 to 0.341, and the fibre length from 0.60 to 0.87 mm, the highest clonal values (for juvenile, fast-grown xylem) approaching the specific gravity and fibre length of mature, slower grown poplar. (2) Another clonal study concentrated on the total above ground biomass (foliage, wood and bark) of one-year coppice growth and its protein content (Anderson and Zsuffa, 1975b). Four *P. x euramericana* clones and one *P. grandidentata* Michx. *x alba* clone were studied. The clonal variation in foliage-, wood- and bark-volume was more than three-fold (9 to 32 tonnes/ha of oven-dry total biomass at the end of the season). The foliage and coppice (wood and bark) contributed equally to the total mass. The clonal variation in foliage-coppice volume ratio was small (10% or less). The clonal variation in moisture content was larger in the wood and bark (up to 50%), than in the leaves (20% or less). The clonal variation in crude protein content was significant and larger in wood and bark (up to 100%) then in foliage (25% or less). The study gave positive indications that the yields and feeding values were comparable or superior to some agricultural food crops. The wide clonal variation in many of the yield characteristics in the two above studies shows that high selection potential exists among the clones examined.

WHITE PINE

Many of the *Pinus griffithii x P. strobus* hybrids are vigorous in growth and exhibit a practical level of resistance to blister rust (*Cronartium ribicola* J.C. Fisch ex Rabenh). The advanced generations of the hybrid seem to maintain these characteristics. In a replicated field trial, with eastern white pine (*P. strobus*) as control, at 6 years of age, a *P. (griffithii x strobus) x (griffithii x strobus)* progeny outgrew the control by 39% in height. More experimental plantations of this type have been established in Ontario to gather information on site tolerance.

Considerable variation exists between, as well as within, the progenies of *P. griffithii x strobus*. A study of 14-year-old grafted trees belonging to eight clones of a half-sib showed significant variation in all analysed traits (Zsuffa, 1975b). The variation amounted to 52% in tree height, 109% in diameter (DBH), 61% in branch length and 37% in branch angle. The broad sense heritabilities calculated for these traits pointed to the genetic gains which would be achieved in clonal propagation (Table 2).

Table 2 Means, broad sense heritabilities and predicted genetic gains in individual selection and clonal propagation of eight ortets of a *P. griffithii x strobus* half-sib.

Trait	Mean^x	h^2	Genetic gain (Δ G) in units	%
Tree height - (m)	3.1	0.62	0.33	11
Tree diameter (DBH) - (cm)	3.6	0.45	0.48	13
Branch length - (m)	1.2	0.76	0.18	15
Branch angle - (degrees)	50.0	0.71	5.60	11

^{x} for 5 grafted trees, 14 years of age

The clonal propagation of white pine can secure significant gains in growth. It can also preserve the genetic gain achieved in the selection of blister rust resistant trees. The rooting trials established with cuttings taken from such trees of *P. griffithii x strobus* and *P. strobus* gave a good indication of the ease of rooting and resulted in the selection of easily-rootable types (Zsuffa, 1973).

HARD PINE

The breeding and testing of the earlier reported (Zsuffa, 1975a) promising *Pinus rigida* Mill. *x taeda* L. and *P. densiflora* Sieb. et Zucc. *x nigra* Arnold *x sylvestris* L. hybrids has continued. In the spring of 1974 approximately 350 pollinations of the above types were made. Also, seedling stock was raised and several experimental plantations were established to collect information on site tolerance and field performance of these hybrids. These replicated trials have red pine planted as control. In the oldest plantings, the growth of hybrid hard pines (Table 3) confirmed earlier observations made on their vigour in arboreta.

In previous years, attempts were made to produce interspecific hybrids of red pine by using highly irradiated (200,000 R) recognition pollen of red pine. Few putative hybrids of *P. resinosa x nigra* and *P. resinosa x densiflora* resulted (Zufa 1971a, 1971b). The identity of these hybrids was verified by descending two-dimensional paper chromatography, run on polyphenol extracts prepared from needles of parent species and their hybrids, and after the chemical affinities to each parent were calculated. Another method of hybrid determination, using needle anatomy, especially with reference to thickness of hypodermal layers and position of resin canals, was evaluated. The *P. resinosa x nigra* hybrid was identified by this technique. However, the two-year-old needle material appeared to be too variable morphologically at such a young age to be consistently distinct. The work on the determination of hybrids was conducted by Mr. H. W. Anderson, in co-operation (Forest Research Branch, 1974).

Table 3 The height growth of *Pinus (densiflora x nigra) x (sylvestris)* and *P. densiflora x nigra* in test plantations in Southern Ontario, Huronia District (Barrie area).

Hybrid pine tested	Age[x] (yrs)	Mean tree height (m) Hybrid pine	Red pine (control)
P. densiflora x nigra	5	0.70	0.50
P. (densiflora x nigra) x sylvestris	6	1.65	1.05

[x] Physical age of trees. Plantations established on unprepared light sand, at 2 x 2 m spacing.

Jack pine trees in plantations show large variation in many traits, of which the growth rate, stem form and branching are very obvious, and at the same time silviculturally important. The vegetative propagation of jack pine, if feasible, would allow the tree breeder to capitalize on fast growing genotypes of good form. Clones would also be useful in the study of genetic traits, and the preservation and replication of selected genotypes in seed orchards and breeding arboreta. Little is known on the rooting ability of jack pine. We attempted to root cuttings taken from 6- and 10-year-old trees under intermittent mist, using the facilities and applying the conditions already established for rooting of white pine and spruce cuttings. A high percentage of the cuttings of all clones callused. However, a number of callused cuttings later died, possibly due to conditions in the propagation house. Some of the jack pine cuttings rooted and developed well-balanced root systems with many fine side roots (Zsuffa, 1974). The influence of several factors on rooting was studied. Clonal variation in rooting was observed. In general, 6- and 10-year-old ortets rooted similarly. The ortets with heavy, long branches rooted better than the ones with light, short branches. Cuttings taken from second-order shoots rooted and survived like those taken from third-order shoots.

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RESEARCH ON TREE GENETICS AND BREEDING AND TREE SEED AT PETAWAWA FOREST EXPERIMENT STATION 1973-75

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The purpose of this paper is to give an outline of research on tree improvement at Petawawa Forest Experiment Station for the period 1973-75. The report will deal with general strategy, trends, and highlights. Detailed reports on individual species are given in these Proceedings by E.K. Morgenstern, C.W. Yeatman, M.J. Holst, B.S.P. Wang, B.D. Haddon, D.F.W. Pollard and K.T. Logan.

PROGRAM DEVELOPMENT

Re-organization within the federal Department of Environment has resulted in the diversion of resources from existing programs, including those of Petawawa Forest Experiment Station. Consequently the labour force used in the nursery and experimental plantations has been considerably reduced. However, we have been able to maintain our professional manpower levels. Re-organization of programs within the Station has made it possible to create a new professional position for selection and breeding of hardwoods for operational and urban forestry. This position has not yet been filled.

Red pine, Scots pine, and Norway spruce

As a result of manpower restrictions it has been necessary to reduce the range of our activities. The research programs on red pine (*Pinus resinosa*), Scots pine (*P. sylvestris*) and Norway spruce (*Picea abies*) are in abeyance for the time being. Current trials of these species are on care and maintenance, and no new work on these species is planned in the near future.

Results so far indicate that red pine provenance selection can give increases of 10% in height growth and 20% in volume growth.

Larch

A surge of interest in larch (*Larix* spp) has occurred both in Ontario and Quebec. Interest is focussed on tamarack (*Larix laricina*) at the moment, but there is also interest in introduced larch species and their hybrids. Petawawa's research on introduced species will in future concentrate on larch. It has already been found that the hybrid *Larix decidua* x *leptolepis* grows well in the Acadian and Great Lakes--St. Lawrence Region.

White spruce

The program received a temporary set-back in 1974 when the scientist responsible for the white spruce (*Picea glauca*), Dr. A.H. Teich, transferred to the Canada Department of Agriculture research establishment at Harrow, where he is now breeding wheat. There have been some problems in refilling the position, and Dr. Morgenstern has acted as supervisor of the program for one year. We shall be replacing Dr. Teich in the near future.

During the period 1974-75, Dr. N. Dhir has worked on the Station as a post-doctoral fellow under the aegis of the National Research Council. His work is mainly concerned with the quantitative genetics of white spruce, particularly with respect to the populations of the Ottawa Valley. During his two-year stay he will also be reviewing the evidence of genetic variation of trees and shrubs in tolerance to air pollution by gases and heavy metals.

Seed collections are still being made for an all-range white spruce provenance experiment in cooperation with the provincial governments. Collections are being made on a single tree basis, and so far there are about 1000 seed lots. However, there is still a large gap in the collections from seed sources in north-western Canada.

The wide-ranging success of the white spruce from Beachburg and Douglas (Ont.) has led to a closer look being taken at the white spruce populations of this part of eastern Ontario to see whether or not these superior provenances are representatives of a much large superior seed source. The tested superior white spruce provenances are in great demand both in Canada and the USA, but the source stands are small and scattered and in some danger of being lost. Seed orchards of tested superior provenances have been established by the Canadian Forestry Service and by the Ontario Ministry of Natural Resources to protect the gene resource.

In the spring and early summer of 1975 many of the white spruce trials on and near the Station were severely attacked by spruce budworm (*Choristoneura fumiferana*) larvae. The plots were sprayed but the infestation is still a serious problem and we expect some losses of trees.

During 1974 there was a good white spruce cone crop and a great effort was made to collect seed. Seed quality was generally good, but in some locations many seeds were empty, with full seeds producing many albino plants.

Black spruce

The black spruce (*Picea mariana*) program has, over the past two years, been mainly concerned with reporting past trials and establishing an all-range provenance trial and progeny tests in liaison with the provincial governments and other cooperators. The sites have been selected and many trials have already been established.

It has become evident that refined methods must be used in selecting plus-trees of black spruce for growth performance. Results from a diallel cross have given us a deeper insight into genetic control of growth in black spruce.

The 10-11 year old black spruce provenance trial in Ontario was remeasured. Survival has been good but some problems have been encountered with *Armillarea mellea* infestations.

Jack pine

The results from the 1973 measurements of the 10 year old jack pine trials have been analyzed, and it is evident that at most locations local or nearby seed sources have height growth that is usually of high rank, although it may not always be the best. There are exceptions, where the local seed source produces trees with appreciably poorer growth than more distant seed sources. Differences in resistance to scleroderris (*Gremmeniella abietina*) attack among provenances have again been observed.

Progenies from open-pollinated trees were tested during the period covered by this report, and growth differences as high as 25% were observed at 10 years of age. Work was carried out on the possibility of selecting jack pine for stem and branch character, and on the effectiveness of mass selection. Some problems have been encountered in the grafting of this species, but these are likely to be overcome by better scion storage and treatment prior to grafting.

The research results so far have made it possible to advise both provincial forest services and the forest industry on the best ways of controlling and selecting seed and protecting gene pools under threat.

Growth acceleration

The growth acceleration system developed by Dr. D.F.W. Pollard and Mr. K.T. Logan reported in the last Proceedings, has been used with great success, and has greatly reduced the time and cost of some of the physiology and genetics research. The research was extended to determine, at the request of the Ontario Ministry of Natural Resources, the best regimes of photoperiod, humidity, temperature and CO_2 for tubeling jack pine (*Pinus banksiana*), white spruce (*Picea glauca*) and black spruce (*Picea mariana*); the results are now in use in large-scale programs in plastic greenhouses.

Screening of young trees for genetic variability, superior growth and hardiness

Attempts were made to assess the value of chemotaxonomic methods for rapid assessment of white spruce variability. Seedling terpene and isoenzyme contents were examined. In the case of terpenes, differences between collections were found but were difficult to interpret. Isoenzyme results are still being analysed, and will be used to examine the extent of the superior Beachburg--Douglas seed source in Ontario.

Development of early screening techniques for superior tree growth require an understanding of the physiological and morphological basis of differences in tree growth rate. During the period of the report the work in this field has concentrated on studies of bud morphogenesis and free growth in spruce, as related to growth differences. These features were examined in the IUFRO International Sitka Spruce Trial at the Station. As part of screening research a rapid test was developed for white spruce tolerance of low temperatures.

The Tree Seed Centre

The number and complexity of requests for information, seed, processing and testing greatly increased during the period of the report. The Centre's international involvement increased also, with requests being received from 20 countries.

The Centre has become the accredited Canadian member of the International Seed Testing Association, responsible for testing tree seed. A Forestry Officer, Mr. B.D. Haddon, joined Mr. Wang's team to assist with the increasing work load.

During 1974 the Seed Centre was heavily involved in the white spruce seed collections in eastern Ontario.

RESEARCH FACILITIES

During the review period, the old nursery buildings were removed and replaced by modern offices and an implement storage shed. In addition the old PDP-8 computer, which had given good service but was suffering from old age and obsolescence, was replaced by another unit, a PDP-11E of much greater power and flexibility. A fire proof vault has been built to store valuable experimental records, together with a cool room for plant and seed storage.

The Tree Seed Centre has had its bank of germination cabinets and cold store facilities considerably increased.

THE FUTURE

At present there is no sign of an improvement in the availability of resources for research and any future plans must of necessity take into account this constraint. The main handicap is the shortage of summer labour to plant, clean, spray and measure the plots.

Within our resource limits, the main goals are to:

1. Complete the reporting on existing long term trials.
2. Establish the all-range black spruce trial and associated progeny tests.
3. Complete white spruce seed collection for an all-range trial, examine in depth the variation and extent of the superior Beachburg--Douglas provenance, and move into the within provenance selection and breeding phase of the white spruce program.
4. Examine further the within and among provenance variation of jack pine, and initiate plus tree selections.
5. Increase research effort on larch selection and breeding, and decrease work on Scots pine, red pine and Norway spruce.
6. Initiate a program of selection and breeding of hardwoods for operational and urban forestry.
7. Pursue further the physiological basis of tree growth differences and develop early screening methods for tree growth and hardiness.
8. Consolidate the Tree Seed Centre's role as a national seed testing, information, and seed procurement body, and increase research on seed testing, storing and pre-treatment.

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THE INTRODUCTION AND SELECTION OF EXOTIC TREE SPECIES, PETAWAWA, 1973-74

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The emphasis of this project has been the study of Norway spruce (Picea abies (L.) Karst.), Scots pine (Pinus sylvestris (L.) and larch (Larix spp.).

NORWAY SPRUCE

The production of winterhardy, fast growing and white pine weevil (Pissodes strobi Peck.) resistant types continue to be the main objectives of breeding in Norway spruce at the Station.

Norway spruce has a very high potential in the Acadian Forest Region where it will outproduce the local spruce-fir mixture. For this Region it is only required to identify the fastest growing provenances without fear of winter frost damage. This is also true for the extreme eastern part of the Great Lakes - St. Lawrence Region where the precipitation is high and the winters are not so severe. However, in the middle and western part of the Great Lakes - St. Lawrence Region the climate becomes more and more continental and winter hardiness becomes more and more critical.

In the eastern and moister part of the Boreal Forest Region Norway spruce has not yet been adequately tested and some provenances could be found that are hardy and fast growing. In the middle and western part of the Boreal Forest Region the Norway spruce provenances tested so far are not as fast growing as local white spruce (Picea glauca (Moench) Voss) controls. In the Grassland Region the tested provenances have failed due to drought.

In the Maritimes the fast growing but frost tender provenances from Nagold and Thüringen in Germany showed higher yield than Westerhof, Germany and Istebna, Poland. In six test plantings located in Quebec, provenances from Istebna, Poland and Smith's Plantation, Que. had superior heights while Thüringen, Germany had the poorest height growth. At age 20 at the Petawawa Forest Experiment Station the Istebna, Poland provenance was about one meter higher (5.30 m) than Westerhof and Nagold in Germany (mean 4.29 m). Provenances with intermediate height included those from Germany via Ålvan, Sweden (3.56 m) and Monts du Velay, France (3.44 m). Provenances with poorest height were from Schwäbishen Alpen, Germany (3.23 m), Thüringen, Germany (3.05 m) and Villingen, Germany (2.90 m). Plus trees have been selected and propagated of the Istebna, Poland provenance.

Volumes have been calculated in the IUFRO Norway spruce provenance test of 1939, planted at the Petawawa Forest Experiment Station, when the test was 32 years old. The mean annual increment for local white spruce of site class 1 at age 32 years is 6.3 m^3 per ha. The following provenances had superior production: Hudson's Place, SN-24, P.F.E.S., Ont., Riga, Latvia, hardy trees from the Proulx Plantation, Que. and Burtnicki, Latvia (mean 9.3 m^3 M.A.I.). In the intermediate groups with a mean M.A.I. of 5.5 m^3, Poland (IUFRO No. 10) had the highest production of 6.2 m^3 M.A.I. while a general collection from Hudson's Place, P.F.E.S. produced only 5.6 m^3 M.A.I. In the poorest group with a mean of 3.0 m^3 M.A.I. we find the following provenances: Valea Bistrei, Rumania, Pförten, Poland, Wildberg, Germany, Pokljuka, Yugoslavia and Frienisberg, Switzerland.

This test, located in the continental climate at the Petawawa Forest Experiment Station, shows that over the long haul only those provenances which combine fast growth with winter hardiness will outproduce local white spruce. Such provenances have been found in Latvia and some in Canadian plantations where selections for winterhardiness have been made.

SCOTS PINE

In Scots pine we have the following objectives: testing of stands and provenances in terms of timber production; selection and breeding of Christmas trees; heritability studies of white pine weevil resistance; and production of a precocious rootstock that will induce early flowering.

The IUFRO Scots pine provenance tests of 1938 and 1939 located at the Petawawa Forest Experiment Station were measured in 1974 when most of the provenances were 35 years old from seed. Three provenances (Bolewice, Poland, Griva, Latvia and Mustekji, Ukraine, Russia) grew faster than the local Petawawa jack pine (*Pinus banksiana* Lamb.) control. Of these Bolewice, Poland and Griva, Latvia have outstanding stem form and can for this reason be highly recommended while Mustekji, Ukraine, Russia because of its poorer stem form cannot be recommended for timber production.

In the fall of 1974 our cooperative provenance experiment with Russian and Siberian Scots pine was measured. The provenances from Orel, Woronesh and Kiev are still the tallest in the test located in the Great Lakes - St. Lawrence Forest Region and in the Grassland Region. In these regions they are better than local jack pine. At Indian Head, Saskatchewan a grafted seed orchard has been established with these provenances and our Seed Bank has organized seed collections from similar Russian stands to be used in general reforestation. In the boreal forest of Ontario local jack pine has so far outgrown the Scots pine.

LARCH

The hybrid between European larch (*Larix decidua* Mill.) and Japanese larch (*L. leptolepis* (Sieb. x Zucc.) Gord.) can be grown with confidence in the Acadian Forest Region and in the Great Lakes - St. Lawrence

Forest Region. This hybrid definitely shows hybrid vigor. At the Petawawa Forest Experiment Station in a 43-year-old mixed plantation of the Dunkeld hybrid larch and Japanese larch, the Dunkeld hybrid larch outproduced the Japanese by 73% in volume. In another 13-year-old experiment the European x Japanese hybrid had 45% more volume than the European control.

Our long term objective is to expose both European and Japanese larch to selection in Canadian plantations and then cross the best types with each other. This work is in progress at Petawawa but we have not been able to cross types selected in Canada. In the meantime we have started a test with material from European seed orchards to determine which of the various types of European larch (Alps, Sudeten or Polish larch) gives the best progeny. This should indicate which of the European x Japanese larch hybrids we should concentrate on.

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THE GENETIC BASIS FOR IMPROVEMENT OF RED PINE, PETAWAWA, 1973-74

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Red pine (Pinus resinosa Ait.) is throughout its range a very uniform species. Red pine shows broad regional adaptation and broad regional differences. Stands within regions show a random occurrence of fast and slow growing provenances.

In most provenance tests a few provenances can be found which are about 10% taller than the mean and have about 20% higher volume production. These can be recommended for reforestation. However, it is also important that through provenance tests we identify the poor performers and warn against them.

In one of our cooperative tests (Exp. No. 96) the tests at Petawawa and Dorset, Ontario showed superior height growth for provenances from Cass Lake, Minn. and Petawawa F.E.S., Ont. while provenances from Stanley, N.S. and Grand Lake, N.B. had very poor height growth. In another of our cooperative tests (Exp. No. 216) provenances from Presque Isle Co., Mich. and Douglas, Ont. had high rating on acid sites in east-central Ontario, Quebec and the Maritimes, while they tended towards lowest rank on limey sands in southern Ontario and in Wisconsin. The provenances with consistently poor performance in this experiment were: Stanley, N.S., Thistledew Lake, Minn., Dryden, Ont., Fort Frances, Ont., Grand Lake, N.B. and Rawdon, Que.

A number of older red pine provenance experiments planted only on the Petawawa Forest Experiment Station were remeasured in 1972. One of these contains 16 and 25 provenances (Exp. No. 76-B and C). In the set with the 16 provenances the five tallest provenances were Trout Lake, Wis., Sault Ste. Marie, Ont, Griffith, Ont., Hyndford, Ont. and Petawawa F.E.S., while the five shortest provenances were Batchewana Bay, Ont., Red Lake, Minn., Geraldton, Ont., Mattawa, Ont., and Lebanon, Maine. In the set with the 25 provenances the seven tallest provenances were Trout Lake, Wis., Eagle River, Ont., Pembroke, Ont., Hyndford, Ont., Castleton, Ont., North Bay, Ont. and Griffith, Ont., while the seven shortest provenances were Lebanon, Maine, Regina Bay, Ont., Mattawa, Ont., Red Lake, Minn., Kawene, Ont., Thessalon, Ont. and Vermillion Bay, Ont. In a small test with only five provenances (Exp. No. 81) the three Quebec provenances from St. Charles de Mandeville, Grand'Mere and Berthierville were 5% taller than the two Ontario provenances from Petawawa F.E.S. and Thessalon.

The conclusion seems to be that the Trout Lake, Wis. provenance has been consistently superior when grown at Petawawa. Other provenances from areas to the south of Petawawa in Ontario and Quebec seem to have better height growth than the Petawawa control. Mattawa, Ont. which is only 80 miles northwest of

Petawawa along the Ottawa River had the second lowest rank while Lebanon, Maine which had a high ranking in the nursery test fell to the lowest rank when field planted. This is indeed an example of broad regional differences in red pine as other provenances from the Atlantic coast have grown poorly at Petawawa and show signs of frost damage. Other slow growing provenances come from northern and western Ontario (with the exception of one provenance from Eagle River which was fast growing, while the other Eagle River provenance was slow growing) and from Minnesota.

Our cooperative red pine provenance test (Exp. No. 96-B to K and 216-B to J) were scheduled to be measured in the fall of 1972. Most of this work was on schedule and the data have been compiled. The last field test will be measured in the spring of 1975, after which a full report will be given.

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WHITE SPRUCE GENETICS, PETAWAWA 1973-74

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Dr. A.H. Teich, who was responsible for white spruce (Picea glauca (Moench) Voss) genetics at Petawawa, resigned effective 31 July 1974 and joined the federal Department of Agriculture Research Station at Harrow, Ont. Since that time, work in this project was continued with less intensity. Dr. N.K. Dhir, a National Research Council post-doctorate fellow and recent graduate of the University of Minnesota, joined the genetics group in August 1974 and took on some of the assignments.

PROVENANCE STUDIES

Results from Experiments Established 1958-65

In the fall of 1973 11 Ontario experiments with trees 13 to 20 years old were measured in cooperation with Mr. D.A. Skeates of the Forest Research Branch, Ministry of Natural Resources. The first report was written from the viewpoint of applied silviculture. It indicated that within the broad ecoregions used as seed zones, there are areas where above-average provenances exist. Therefore exclusive reliance on bulk seed based on seed zones is not making the best use of genetic potential. All larger seed collections within seed zones and seedlings raised from them should be kept separate and labelled from collection to outplanting (Teich *et al.* 1975).

White Spruce Limestone Ecotypes

Two of the 11 experiments mentioned were suitable for testing a hypothesis of soil ecotypes. Although many attempts to demonstrate the existence of soil ecotypes have failed (partly because the role of competition among genotypes had been neglected - see Stern and Roche 1974), there was a distinct pattern in this case. Provenances from limestone areas grew better on the test site with limestone parent material and provenances from granitic areas on the granitic site. This finding again supported the need for separation of seedlots within seed zones (Teich and Holst 1974), and was in agreement with the laboratory results of Farrar and Nicholson (1967).

New Range-Wide Study

The previous report (Teich and Pollard 1975) described our attempts to broaden the exploration of the genetic resource. Members of the Canadian Tree Improvement Association including Dr. J.I. Klein, Edmonton, Alta; Mr. R.F. Calvert, Winnipeg, Man.; and M. Yves Lamontagne, Berthierville, Qué. have contributed seed. Collections undertaken annually since 1971 by Mr. D.A. Skeates, Maple, Ont. in cooperation with Petawawa have now accumulated 102 provenances in Ontario alone (Pickett 1974). Within one or two years seed for a comprehensive range-wide study will be available. Further seed exchange and joint planning of experiments is desirable to facilitate comparison of the results.

Physiological responses of selected seedlots from these new collections are under investigation by Mr. K.T. Logan and Dr. D.F.W. Pollard as described elsewhere in these Proceedings.

PROGENY TESTS

In plantations particularly, white spruce often suffers from spring frost injury, and phenotypes that flush late are less susceptible. If the timing of bud break in the spring is strongly inherited, selection of late flushing individuals is simple and can be incorporated easily into selection programs. An opportunity to study this problem arose at Petawawa after 5 trees in a natural stand had been crossed in several combinations and their progenies were raised in the nursery. Observations on the parent trees and their progenies in 1973 indicated very strong correlations (coefficient of determination, $r^2 = .91$) which point to a high heritability (Yeatman and Venkatesh 1974).

SEED SUPPLY AND GENE CONSERVATION

New Seed Orchards

The demand for seed from the fast growing provenances near Cobourg and in the Beachburg-Douglas area of southeastern Ontario continues to be high and very little seed is available. As indicated in the two previous reports (Morgenstern 1971, Teich and Pollard 1975), efforts are being made to develop seed orchards from these Ontario populations in Wisconsin by the North Central Forest Experiment Station and the University of Wisconsin; and in Ontario by the Ministry of Natural Resources and the Petawawa Forest Experiment Station. Recently scions for grafting and rooting were also sent to the Vermont Department of Forests and Parks. The material shipped to Vermont was cut from selected trees in the best four southeastern Ontario populations growing in provenance tests at Petawawa (Cobourg, Beachburg, Maynooth, Chalk River). Because of the small number of trees involved in each of the original collections (about 10), an orchard based on one provenance could lead to inbreeding.

Gene Conservation

Some of the superior races in southeastern Ontario are found in small stands on private land which is subject to changes in ownership, farming practice, clear cutting, etc. Attempts to develop seed orchards outside of the area of seed origin therefore assume an aspect of *ex situ* gene conservation. The method of gene conservation used here is of international interest and has been described in an FAO publication (Maini *et al*. 1975).

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RED AND BLACK SPRUCE GENETICS, PETAWAWA, 1973-74

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The program dealing with red spruce (Picea rubens Sarg.) and black spruce (Picea mariana (Mill.) B.S.P.) developed generally as planned. The types of studies and their objectives have been summarized in the previous report (Morgenstern 1975). Results achieved in 1973 and 1974 are discussed below.

BREEDING ALTERNATIVES

Program review

Experiments at Petawawa with these two species in the period 1950-73 were reviewed under the headings of "Natural variation and population parameters" and "Species and provenance hybridization". The implications of results were discussed and priorities established. It was concluded that the study of black spruce population parameters (genetic and environmental variances, correlations between characters) should have the highest priority. These parameters have broad applicability in the development of selection programs for one of our most important species (Morgenstern 1973a).

Selection methods

Geneticists are aware of the problems associated with phenotypic selection and recognize the need to apply efficient methods. Wherever management foresters are involved in selection programs, it is important that they understand why certain things are done. Using the method of rank correlations, it was demonstrated that substantially different black spruce populations could be selected on different sites and at different ages if the heritability of the character is low for which selection is made. Therefore, plus-tree selection for growth performance must be based upon very refined methods. Selection in replicated experiments, such as in progeny tests of families from open pollinated trees, will be a simple and efficient method (Morgenstern 1973b, Morgenstern 1974a, Morgenstern 1974b).

The first analysis of a black spruce diallel cross contributed some interesting results. It was found that additive variance prevails in the genetic control of growth while dominance variance is more important for germination and survival. These results agreed well with general theory (Morgenstern 1974c). The large additive variance for growth also supports selection of open pollinated families.

PROVENANCE EXPERIMENTS

Ontario

The Ontario black spruce provenance experiment sown in 1964 completed its eleventh growing season in 1974 and was remeasured at Chalk River and Kirkland Lake. The plantation at Chalk River was established in 1968 in a very careful manner and its survival in the first year was 98%. Subsequently there was some slight but persistent mortality which was traced to *Armillaria mellea* (Vahl ex Fr.) Kummer, a root disease, in the fall of 1974. Cumulative mortality in some plots exceeded 50%, and pathologists at the Great Lakes Forest Research Centre of the Canadian Forestry Service were consulted. In the spring of 1975 a decision will be made on the possibility of control by soil fumigation. Potential damage by *Armillaria mellea* must be considered in the design of experiments and will influence choice of sites, planting methods, and size of plot (Singh and Richardson 1973).

Range-wide

The Ontario component of the range-wide black spruce study was established in the fall of 1973 and spring of 1974 in cooperation with four districts of the Ministry of Natural Resources (Dryden, Thunder Bay, Geraldton, Chapleau) and at Chalk River. There were either 64 or 56 provenances in 3 replications, and 16 or 25 trees per plot. In the fall of 1974 the lowest overall survival per plantation was 76%.

The exchange of experience with other cooperators in the range-wide study continues. Dr. David Canavera of the University of Maine received some seed from the whole range and has recently joined the group of investigators in this study.

PROGENY TESTS

Working in cooperation with the Ontario Ministry of Natural Resources, plans have been made to conduct progeny tests of open-pollinated black spruce in those regions of Ontario where the annual planting program exceeds 3 million trees. This calls for tests in Region 3E (Lake Abitibi), 3W (Lake Nipigon), and 4S (Lake Wabigoon) (Hills 1961). There will be about 100 progenies on each of 6-8 test sites in each region. Because of the short spring season available for planting in continental climates, it was decided to distribute the planting of each regional series to fall and spring seasons. A beginning was made with Region 3E plantings by establishing the first four tests in the Cochrane, Kapuskasing and Hearst districts in August-September 1974. The remaining four tests in that region will be planted in 1975. In this way all tests should be planted by 1977. Other aspects of this program have been discussed elsewhere (Morgenstern 1972, Morgenstern 1974b).

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

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Key words: dormancy, bud morphogenesis, cold hardiness, photoperiod, provenance, Picea, Pinus.

INTRODUCTION

Genetic improvement of forest trees is impeded by the long duration of trials. Part of this problem lies with the slow initial growth displayed by seedlings. More serious is that desirable characters such as fast growth rate are often not revealed for many years. Understanding the physiological basis of such characters offers a solution to this problem.

A dual approach is employed in the study: on the one hand, growth of experimental phenotypes is accelerated by environmental manipulations, while on the other, improved genotypes are pursued through identification of key physiological characteristics.

The study has recently been extended following a request from the Ontario Ministry of Natural Resources to supply environmental prescriptions for accelerated growth of container-grown seedlings in plastic greenhouses.

In addition to answering specific and general practical problems, the study leads to an increase in basic knowledge of tree growth.

STUDY OBJECTIVES

1. To increase efficiency of tree improvement programs by reducing the period before establishment of trials.

2. To identify and exploit the physiological basis of important heritable traits, in particular fast growth rate.

3. To measure the range of physiological adaptation for assessing the potential of gene resources.

PROGRESS

APPLICATION OF GROWTH ACCELERATION

At the request of the Ontario Ministry of Natural Resources, experiments were initiated to determine which regimes of temperature, CO_2 enrichment, relative humidity and photoperiod would provide best growth of tubeling jack pine (*Pinus banksiana* Lamb.), white spruce (*Picea glauca* (Moench) Voss), and black spruce (*Picea mariana* (Mill.) B.S.P.). The temperature experiments have been completed (Logan and Pollard, 1974a,b) and the recommended regimes are as follows:

jack pine: 15-25°C by night and 25-35°C by day

white spruce and black spruce: 20°C by night and 25°C by day.

The initial experiments with CO_2 enrichment demonstrated a confounding effect of high relative humidity associated with the CO_2 treatment. The results showed the importance of holding humidity below 80% in high CO_2 level. Further experiments with CO_2 enrichment were postponed when OMNR nurserymen found it necessary to ventilate their greenhouses, thus making CO_2 enrichment impracticable.

Photoperiodic studies were conducted in two parts. First, as a demonstration, seedlings were grown in four high intensity photoperiods. The experiment was then repeated with low intensity extensions of a fixed high intensity photoperiod. In the first experiment, seedlings were grown for 8 weeks in 15, 18, 21 and 24h photoperiods respectively under a mixed source of fluorescent and incandescent lamps which provided 22,000 lux. All species grew faster under long photoperiods, with continuous light consistently yielding the heavier seedlings. Seedlings under continuous light were at least twice the weight of those grown under 15h. The response of height growth was slight in all species. Shoot weight increase was principally in foliage.

When photoperiod was extended with low intensity light, the results were quite different. In this study, photoperiods were composed of 14h of high intensity light with 0, 2, 6 and 10h of supplementary light of about 400 lux. After 10 weeks jack pine were somewhat taller but not heavier under the long photoperiods. White spruce showed a steady, though moderate, increase in height growth and shoot weight, while black spruce were unaffected.

In these two experiments, seedlings continued to grow even in the shortest photoperiod (14h). Thus extending the photoperiod with low intensity light yielded little additional photoperiodic response. However supplementary light of high intensity stimulated daily growth rate and marked increases in growth ensued.

INVESTIGATIONS RELATED TO SCREENING

Chemotaxonomic investigations of white spruce

A collection of white spruce seedlots representing five trees in each of two stands at seven locations in Yukon Territory, and several provenances in Ontario, were analysed for chemotaxonomic patterns. The purpose was to make gross comparisons with Ontario collections, to provide an estimate of genetic variability among the populations and to compare variability in the unglaciated (refugium) and glaciated parts of the range examined. In the first investigation, seedlots were compared by terpene content of 12-week old seedlings, based on quantitative analysis of 21 compounds. Stand differences emerged in several compounds, although individual tree progenies within stands were also quite variable. Marked differences occurred between Ontario and Yukon collections in some compounds, but the results were in general difficult to interpret.

Parallel comparisons were made through isozyme analyses of 100-seed samples of each seedlot. Formic dehydrogenase distinguished certain Yukon material from Ontario sources; no meaningful differences emerged from peroxidase, esterase or lactic dehydrogenase isozyme patterns. Assays for malic dehydrogenase and leucine aminopeptidase were found to be unreliable or quite negative. The results of both investigations are still under statistical study, and any significant results will be reported in the future. The isozyme work has been extended into a survey of geographic extent of the Beachburg provenance of white spruce.

Bud morphogenesis in white spruce

Differences in height growth occurring between provenances of white spruce are associated with variation in number of needle primordia formed in the dormant bud. The number is influenced by seasonal pattern of initiation. An experiment was designed to establish whether normal morphogenesis could proceed in a constant environment, and whether provenance variation would be expressed in the absence of seasonal changes (Pollard, 1974). Bud development was induced in 5 provenances of white spruce by subjecting first-year seedlings to short photoperiods. Developing buds were sampled at 3-week intervals over a period of 12 weeks. Throughout this time, photoperiod was maintained at 8 h, temperature was constant at 22.5°C (72.5°F). Observations revealed a morphogenetic pattern comparable to that of buds in older, field-grown trees. Needle initiation on the primordial shoot ceased 6 to 12 weeks after the inception of bud development. The inferred endogenous control of bud development and its effect on shoot growth was influenced genetically, with significant differences in needle initiation occurring among the provenances. Differences in bud development may allow early selection for fast growth and hardiness in this species. The results of this investigation identify the period immediately following shoot growth as critical for subsequent growth of nursery stock.

Free growth in black spruce

Two distinct phases of needle initiation contributed to the annual complement of needles of 4-year-old black spruce seedlings (Pollard and Logan, 1974). The first phase occurred during the development of the overwintering bud, and was expressed in predetermined growth. The second phase occurred in the same season as the overwintering bud was flushed, and was expressed in free growth. Ten black spruce provenances were flushed under conditions favorable or unfavorable for free growth. Variation in needle complements for overwintering buds was small and did not correlate with variation in height growth of provenances. Good correlation occurred between growth and needle complements when these included foliage initiated during any subsequent free growth. Fast growth of southern provenances grown at Chalk River, Ont. (46°00'N, 77°26'W), was interpreted as a result of less stringent requirements for free growth. Free growth potential was reduced or disappeared when the local photoperiod was shorter than that at the origin of the provenance. A supplementary experiment examined the capacity of northern provenances to enter free growth under suitable environmental conditions. Seedlings representing six of the above ten provenances were flushed in their second season in growth cabinets having 8, 12, 16 and 20h photoperiods. Both northern and southern provenances entered free growth in photoperiods as short as 12h when temperature was above 25°C.

A study of 12-year-old black spruce sought to establish whether free growth is a source of provenance variation in height growth of sapling spruce. Free growth was calculated as the difference between primordial count in the spring and needle complement at the end of summer. Of six provenances examined, only one showed significant free growth. This general lack of free growth supports the conclusion of Jablanczy (1971) that free growth disappears between the fifth and tenth years. In contrast to younger seedlings, variation in predetermined needle complements in the overwintering buds was correlated with variation in height growth of provenances.

The presence in northern conifers of two modes of growth, one affecting juvenile performance and the other affecting mature performance, has particular relevance to provenance trials. Changes in rank that are sometimes observed in provenance trials (e.g. Teich and Khalil, 1973) may in part result from provenance variations in the two modes of growth. In the nursery trial, rank will reflect a provenance's capacity for free growth and the effect of accumulated annual increments resulting from a free growth advantage may persist for many years beyond the nursery stage. If the more mature mode of predetermined growth in the provenance is not of the same rank as free growth, it will gradually lead to a new rank for that provenance. Because of the large differences in height growth that can occur from free growth over the first 5 to 10 years the effect of predetermined growth may take several decades to become fully manifest.

IUFRO International Sitka Spruce Provenance Trial

Growth and development of seedlings representing ten provenances of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) were compared in three investigations (Pollard, Teich and Logan, 1975). The provenances ranged from Oregon to south-east Alaska and were collected for the I.U.F.R.O. International Sitka Spruce Provenance Experiment. The potential for initial growth was examined by two analyses: the rate of shoot growth and the duration of shoot growth. Growth rate was rather uniform, being only slightly faster among northern provenances. The duration of shoot growth, measured under artificially declining photoperiods, was strongly influenced by latitude of origin. The critical photoperiods for sustained growth in southern provenances were up to four hours shorter than those necessary in northern provenances. In the third investigation development of the terminal bud was followed during the first eight weeks. Four weeks after induction of bud morphogenesis, recognizable buds had formed and roughly 100 needle primordia had accumulated on the primordial shoot. There was a strong latitudinal influence, with northern provenances accumulating up to 65% more primordia than southern provenances. At eight weeks, a strong but reversed relationship was evident, with southern provenances accumulating up to 35% more than northern provenances. These observations indicate that latitude-correlated variations will be a dominant feature of the I.U.F.R.O. Experiment, with southern provenances performing especially well in southern trials. The advantages of southern provenances will be protracted periods of shoot growth in young seedlings and protracted periods of development of the primordial shoot in overwintering buds. Where summer seasons are short, these advantages will not be realized; northern provenances will not only have higher survival but may also develop greater potentials for the spring flush.

The IUFRO Sitka spruce collection was also investigated for provenance variation in tolerance to moisture stress; availability of moisture is a major site factor in afforestation with this species. Two experiments were conducted under three regimes of moisture stress: the first examined morphogenesis of the primordial shoot in the developing bud. There was a marked decline in free growth under stress: mean height increment fell by 45% under medium tension (1-2 bars) and by 70% under high tension (5-9 bars). But considering the wide latitudinal range represented by this collection there was remarkably little variation in growth of seedlings. The variation that did occur was significantly correlated with latitude or origin under both medium stress ($r^2 = 0.64$) and high stress ($r^2 = 0.40$); there was no correlation in the control series ($r^2 = 0.03$). Abnormal bud development in many seedlings hindered provenance comparisons in the second investigation. But pooled data from normal buds indicated that stress effects were much weaker in bud morphogenesis than in free growth: primordia counts were down by 8% from the control under medium tension and by 16% under high tension. Neither investigation revealed opportunities for selecting provenances for dry sites.

Cold hardiness in white spruce

A rapid test for spring frost hardiness has been developed and tested in a recent experiment with white spruce (Logan and Pollard, 1975). Six provenances (2438, 2444, 2464, 2481, 2693, 2870) representing southern and northern locations in the Great Lakes - St. Lawrence Forest Region were tested, using 13-year-old trees on experiment 194-M (PFES Sugarbush Plantation). Frost resistance fell rapidly during April and May. Throughout this period, provenance 2444, from Beachburg, showed slightly poorer resistance; there were no distinct differences between the five other provenances. In all provenances some trees were usually more resistant and others less resistant than average. The existence of tree-to-tree variation in relative frost resistance and the development of this method of detection offer opportunities for selection of frost-resistant material from southern provenances whose growth is exceptionally fast but whose frost resistance is relatively poor.

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FOREST TREE SEED CENTRE, 1973-74

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Since the last progress report, the Tree Seed Unit at Petawawa Forest Experiment Station has been reorganized as the Canadian Forestry Service Tree Seed Centre. The forest tree seed project was subdivided into two separate studies: (1) provision of information, reproductive material and seed processing services; and (2) testing, treatment and storage of tree seed. The number and complexity of requests for information, seed, and seed processing services has increased, and as the Centre has recently become an accredited member laboratory of the International Seed Testing Association, the number of requests for testing services and the level of research in seed quality control and testing standards has also increased. A Forestry Officer was employed to help meet the increased workload.

PROVISION OF INFORMATION, REPRODUCTIVE MATERIAL AND SEED PROCESSING SERVICES

Information Service and Seed Distribution

With further development of the Centre's information file and worldwide network of contacts, services in procurement, distribution, and information on availability and other aspects of tree seed have been greatly improved. During the period 1973-74, a total of 119 requests for seed was received from within Canada and 20 other countries, in response to which 750 seedlots of 57 species were provided. A revised seed list was published (Wang and Haddon 1974).

In 1974 the Canadian Forestry Mission to China brought back a gift of seeds of Larix gmelini (Rupr.) Litvin., Pinus koraiensis Sieb. & Zucc. and Pinus sylvestris var. mongolica Litvin. After distribution to provincial governments, universities, C.F.S. Research Centres and botanical gardens in Canada, the remainder was deposited in the Seed Bank to meet future requests.

Seed Collection and Procurement

Additions to the Seed Bank are shown in Table 1. The year 1974 was a fair to good seed year for white spruce (Picea glauca (Moench) Voss) in eastern and northeastern Ontario, and much of that year's cone collection effort was directed toward this species. A total of 150 white spruce seedlots was collected from 9 areas of eastern Ontario in 1974. These seedlots were part of a province-wide cooperative collection by the Ontario Ministry of Natural Resources and the Petawawa Forest Experiment Station.

Seed Processing and Seed Yield

Along with the 370 new seedlots for the Seed Bank (Table 1), the seed extraction plant processed 462 seedlots during 1973-74 as a service to other

Table 1. 1973-1974 seed collection and procurement

Genus	Number of Species	Number of Seedlots	Number of Provenances	Genus	Number of Species	Number of Seedlots	Number of Provenances
Abies	5	35	25	Carya	2	6	4
Larix	1	13	13	Crataegus	1	3	1
Picea	3	186	28	Fraxinus	1	11	1
Pinus	7	48	31	Juglans	2	19	8
Pseudotsuga	1	4	4	Ostrya	1	1	1
Thuja	1	5	5	Populus	1	2	1
Tsuga	1	1	1	Prunus	1	1	1
Acer	5	16	8	Quercus	2	3	3
Betula	1	13	2	Ulmus	2	2	2
Carpinus	1	1	1				

Table 2. 1974 white spruce seed yield, Ontario collections

Origin	Total no. cones in sample	No. cones per hl	No. cones per bu	Yield of filled seed g/l	Yield of filled seed lb/bu	No. seeds[1] per cone	1000-seed[1] wt.(g) (average and range)
Chalk River	53,605	15,465	5,625	5.5	.44	16	2.30(1.94-3.78)
Douglas	27,122	15,498	5,650	6.7	.54	18	2.38(1.91-2.87)
Renfrew	20,618	17,927	6,525	7.2	.57	18	2.18(1.88-2.71)
Antrim	16,722	13,137	4,778	4.6	.37	14	2.54(1.93-3.46)
Bancroft	28,975	20,234	7,354	9.9	.79	22	2.22(1.77-3.22)
Apsley	19,655	13,511	4,914	9.1	.73	28	2.43(2.15-2.80)
Silver Lake	13,767	15,835	5,760	6.8	.55	18	2.42(2.06-3.02)
Whitney	59,965	20,611	7,496	16.7	1.3	36	2.23(1.46-2.97)
Foresters Falls	14,623	18,623	6,557	6.3	.50	14	2.42

[1] filled seed

forestry organizations. The largest component of the service work was white spruce.

Processing of most coniferous species is now standardized. Much has to be learned, however, about precuring and conditioning seeds of deciduous species. A report explaining how seeds for research use are collected, processed and stored by the Seed Centre was presented at the First International Symposium on Seed Processing in 1973 (Wang 1973a).

An analysis of the 1974 white spruce cone collection (Table 2) from eastern Ontario indicates that although cones appeared to be abundant on the trees, clean-seed yield from the 6 areas in the low-lying Ottawa Valley and Rideau Lakes systems that suffered severe spruce budworm attack during the last 4 to 5 years was very low (0.37 to 0.57 pound per bushel of cones) as compared to the 3 other areas from the Algonquin and Haliburton Highlands (0.73 to 1.3 lb./bu.) and the Ontario average (0.73 lb./bu.) (Ontario 1966). The low seed yield, with high percentages of empty seed is largely attributed to poor quality and low quantity of pollen produced by the attacked seed trees, and to some extent perhaps to poor cone development on weakened trees.

TESTING, TREATMENT AND STORAGE OF TREE SEED

Seed Storage

A study of the effect of prolonged storage on the germination vigor of white spruce, black spruce (*Picea mariana* (Mill.) B.S.P.), red spruce (*Picea rubens* Sarg.), jack pine (*Pinus banksiana* Lamb.), red pine (*Pinus resinosa* Ait.) and white pine (*Pinus strobus* L.) seed was made. Results of the study are given in Table 3. It is interesting to note that seeds of all the species studied are capable cf tolerating a wide range of moisture content in storage for many years with little deterioration in germinability. However, the germinability of two old lots of jack pine seed (491815 and 511813) dropped nearly 20% in the last three years as compared to an earlier study (Wang 1974a). Most of the seedlots that lost all or a great part of their geminability are those with high initial or subsequently increased moisture content (more than 8%). These findings suggest that seeds of the three spruces and jack pine can be effectively stored for more than 22 and 25 years respectively if their initial seed quality and storage conditions are properly controlled (Wang 1975c).

After 16 years of storage, the two lots of red pine seed still germinated with 90-91% and should be capable of retaining that germinability for many more years as red pine seed is known to possess considerable longevity (Eliason and Heit 1973, Wang 1974a).

Earlier, Roe (1948) had recommended that for long-term storage of white pine seed, the moisture content of seed should be reduced to at least 7%. This study has confirmed Roe's report, for the white pine seedlots that suffered severe reduction in germination were those with a moisture content of more than 7% (Table 3).

A paper on tree seed and pollen storage for genetic conservation was prepared for the FAO Bulletin on Methodology of Conservation of Forest Gene Resources (Wang 1975b).

Table 3. Germination results of stored seeds.

Species	Seedlot No.	Year of Collection	Moisture Content 1/ (%)	Germinability 2/
Picea glauca	493018	1949	11.8	0
	531001	1953	8.9	82
	552437	1955	7.3	59
	562692	1956	7.3	28
	663001	1966	7.3	87
	713056	1971	3.7	79
P. mariana	527066	1952	8.5	50
	532140	1953	4.8	97
	567080	1956	8.9	14
	597083	1959	10.0	41
	673065	1967	7.7	96
	677107	1967	7.0	78
	703150	1970	8.4	94
P. rubens	521050	1952	6.8	38
	521052	1952	7.6	57
	521053	1952	8.4	54
	531050	1953	8.2	87
	531051	1953	8.9	96
	564077	1956	6.5	93
	562001	1956	8.8	96
	601020	1960	8.6	90
	621021	1962	10.4	79
	631025	1963	9.4	95
	641020	1964	7.7	95
	681032	1968	7.3	0
Pinus banksiana	491815	1949	7.2	51
	511813	1951	7.7	66
	573223	1957	8.8	68
	573022	1957	11.0	60
	573234	1957	8.6	35
	586558	1958	10.8	50
	603113	1960	11.1	68
	673099	1967	9.1	82
	683008	1968	8.3	94
	703035	1970	4.4	94
P. resinosa	593084	1959	8.0	91
	593085	1959	8.3	90
P. strobus	593124	1959	8.5	45
	597612	1959	9.3	0
	597613	1959	8.8	1
	600097	1960	9.9	10
	600971	1960	8.7	44
	663022	1966	7.0	90

1/ Moisture content was measured on the fresh weight basis in 1974-75 in conjunction with germination tests.

2/ Germinability was based on percent of seeds germinated with cotyledons partially visible at 20-30°C with 8 hour photoperiod after 14 days for Picea mariana, Pinus banksiana and Pinus resinosa, 21 days for Picea glauca, and 28 days for Picea rubens and Pinus strobus seeds.

Seed Testing and Research

Since March 1974 the Seed Centre has become an accredited laboratory for official testing of tree and shrub seed in Canada under the auspices of the International Seed Testing Association. From November 1974, 47 separate tests of germination and moisture content of western Canadian and southern pine seeds for export were made. This marked the first time that the Canadian Forestry Service has performed official duties of this nature.

Routine testing of stored seeds is still lagging behind, but germination tests of most of the 1972-74 collections of white spruce and white and jack pine seeds have been completed. The Centre participated in several international referee tests of white and Scots pine (*Pinus sylvestris* L.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seeds with a view to find optimum prechilling requirements for germination and standards for evaluation of normal and abnormal seedlings. In 1974 the international rules for testing seed (International Seed Testing Association 1966) were revised, but the new prescriptions will not become effective until July 1, 1976 in the northern hemisphere and January 1, 1977 in the southern hemisphere.

In testing germinability, seeds that germinate and develop into albino (or white) seedlings are considered abnormal because albinism is lethal. While conducting germination tests for 1974 white spruce seed collections from eastern Ontario, it was observed that one seedlot of a single tree from Silver Lake (near Perth) showed 10.5% albino germinants, an unusually high frequency for this species. These germinants first appeared as pink or white radicles and then developed to pink or white hypocotyls with yellow cotyledons. One of the possible causes for albinism is self-fertilization. Tests of a possible genetic linkage between dormancy control mechanism and pigment production in white spruce seeds, as reported in Douglas-fir seed by Sorensen (1971), are in progress.

A cooperative testing of the effect of Arasan coating on white spruce seed germination was conducted with the Provincial Forest Tree Nursery, Berthierville, Quebec, and a joint report will be prepared.

In research, many years' germination results of white spruce seed from a wide range of geographic sources were reported at an international seed meeting. The findings clearly point out that dormancy in white spruce seed was the least in British Columbia, Alberta and the Maritime provinces, moderate in Quebec and Yukon Territory, and the greatest in the Ottawa Valley area of Ontario. The dormant white spruce seed requires 21 day prechilling at 3 to 5°C before standard laboratory testing and spring field sowing (Wang 1974c).

Laboratory germination criteria developed for testing seed vigor and field germinability of red pine (Wang 1973b) were successfully applied to white spruce seeds. A report is being prepared for publication. A technique for transfer of seeds from X-ray film to germination medium in radiographic analysis of seeds was devised and tested (Wang 1974b).

At the request of the editor of the Advances in Research and Technology of Seed, a literature review was made of selected 1970-72 articles covering subject areas in seed zones, cone collection and seed processing, factors affecting seed germination, seed dormancy, rapid seed testing and seed storage of 46 tree and shrub species of Asia, Europe and North America (Wang 1975a).

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JACK PINE GENETICS
PETAWAWA FOREST EXPERIMENT STATION
1974-75

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Jack pine (Pinus banksiana Lamb.) is second only to black spruce (Picea mariana (Mill.) B.S.P.) in volume harvested east of the Rocky Mountains and is used for pulpwood, lumber and as round timber. Large volumes of seed are required annually by provincial forest services for direct seeding and production of nursery stock. Success in reforestation depends on the identification and use of the best sources of seed currently available. Methods for genetic improvement need to be developed and applied. In combination with sound silvicultural practice, future wood yield can be substantially increased through selection, breeding and mass production of improved seed. The objectives of the Petawawa program in jack pine genetics include:

1. Providing guidelines for seed collection and distribution in relation to climate and site,
2. Developing and testing efficient breeding methods for creating more productive strains,
3. Creating practical demonstrations of genetic effects and applied tree improvement,
4. Cooperating with provincial forest services and forest industries in regional improvement programs.

During the past two years valuable information has been gained from range-wide seed source trials, local progeny tests and in grafting jack pine. New studies have been initiated in plus tree selection and testing and the application of mass selection in young jack pine regeneration.

PROVENANCE

Field tests of range-wide jack pine provenances were planted in 1966 at 13 locations distributed from western Ontario to New Brunswick. Observations of winter injury and disease incidence in the northern Ontario and western Quebec trials were reported earlier (Yeatman 1975a).

All 12 tests in Ontario, Quebec and New Brunswick were measured at 10 years of age in 1973 when severe scleroderris (Gremmeniella abietina (Lagerb.)

Morelet) infection and winter damage were also found at the high elevation site in New Brunswick. Very severe infection was observed in a test established on alluvial silt near Quebec City by Prof. L. Parrot, Laval University. Genetic adaptation to site and climate is clearly a major element in determining resistance to this canker under severe conditions of low temperature or marginal site. Differences of up to 30% infection among provenances from the same climatic region indicate an important potential for gain by source selection.

First analyses of 1973 (10-year) height measurements demonstrate that local and near-local provenances rank at or near the top in height growth at most test locations which range from the New Brunswick lowlands to northwestern Ontario. The exception is at Caramat, north of Lake Superior, where sources from well to the east or west of the test site are superior to the local by as much as 20 percent in height and are quite hardy and free from disease. Climatic adaptation continues to dominate the general response patterns, although geographically related sources frequently exhibit real differences in growth potential. The effects of winter injury and scleroderris canker are increasingly evident with time and as tree crowns extend above snow level.

PROGENY

Measurements and observations of open pollinated progenies of trees of natural origin and growing in plantations at Petawawa demonstrated significant differences in mean height at 10 years of the order of 25 percent. Progenies from trees of northern origin were slow growing, reflecting the maternal parental response to a southern environment. Preliminary correlations between parents and progenies were significant for cone shape and cone angle (themselves correlated characters) but not for cone opening, branch angle or stem form. It was probably too early to assess cone serotiny since young trees tend to have open cones and the data for branch angle and stem form require more complete analysis.

Analysis of 6-year height of 100 progenies of Ottawa Valley jack pine grown at three sites indicate that the individual tree is the primary source of genetic variation in stands spanning some 80 miles along the Valley (Yeatman 1975c). Plantations differed in average tree height but genotype x environment interaction was negligible, as were components of variation for areas and stands in areas. This implies the existence of a single population based over a relatively large area. Jack pine in the Ottawa Valley can be assumed to have originated along a common path of migration following deglaciation. Subpopulations have not subsequently differentiated in spite of the partial separation of the stands and present discontinuity of distribution of jack pine in this area. This finding is relevant to specifications for population sampling and testing, seed production and distribution, tree improvement and maintenance of gene pools of jack pine in other geo-climatic areas. A calculated heritability of 14% for 6-year height led to realistic gain estimates exceeding 10 percent for multi-stage mass selection and progeny testing. Initial selections could be made throughout the region studied and any area of good site quality for jack pine within the region would be suitable for breeding operations (progeny tests, clone banks, seedling seed orchards).

SELECTION

Stem and branch characters are highly variable in natural jack pine populations and offer great potential for improvement of wood yield and quality if suitable selection and breeding systems can be devised (Yeatman 1974b, 1975b). In 1972 a range of phenotypes was selected, grafted and seed was collected for progeny testing. By fall 1973 marked differences in height and foliage colour were evident among the families growing in the nursery, reflecting in at least one paired comparison the extremes in vigor of the seed parents. The top ranking progenies in seedling height in 1974 were from trees planted in 1945, themselves originating from Petawawa jack pine selected for form and vigor by Dr. Heimburger over 30 years ago. It is unclear whether the apparent superiority of vigor results from selection or from outbreeding relative to the progenies from trees in natural stands. The latter families may be expected to suffer a degree of inbreeding depression due to pollination among adjacent relatives.

In the winter of 1972-73, 64 trees were selected for vegetative propagation and progeny testing. Four plus trees and four minus trees were chosen on the basis of vigor and form in each of eight stands in the area of the Ottawa, Petawawa and Madawaska Valleys. Detailed measurements were made of the seed trees and each was photographed. The grafts are currently in the nursery and the open pollinated progenies were planted in field tests in the spring of 1975.

In January 1975 one hundred predominant jack pine were systematically selected, together with 100 control trees, from 11-year-old postburn regeneration for a test of the effectiveness of simple mass selection. Man hours were recorded for each operation. Twenty-five acres of well stocked regeneration were divided into 100 blocks 100 x 100 ft. The tallest tree and a nearby 'average' tree were selected in each block. Scions were collected and grafted for establishment of clone tests and breeding stock. There were few cones on the trees this winter, but to judge from the many conelets present it is expected that it will be possible to collect seed from most trees in the fall. Seed will be used to create seedling seed orchards and related progeny tests of both plus and average (control) trees.

BREEDING

Provenance hybrids growing for 10 years at Petawawa and elsewhere in Ontario, Quebec and New Brunswick have grown well, but not consistently better than the best parental provenance (Yeatman 1964a, 1975a). Most of the seed for these tests was collected from young trees at Petawawa following open pollination when the few male flowers of the introduced provenances were removed before pollen release. To obtain greater precision in results, reciprocal control-pollinations among selected and widely distributed provenances were started in 1971 in cooperation with the U.S. Forest Service and Michigan State University. Pollinations were repeated as necessary in subsequent years and supplementary pollinations were made, concluding in the spring of 1974. By fall of 1975 we should have accumulated sufficient seed for exchange with cooperators and for sowing the progenies.

In the spring of 1974 a start was made on a diallel crossing scheme among seven jack pine of local origin. Control pollinations will continue until sufficient seed of all combinations is assured.

GRAFTING

The grafting of trees selected in 1972 met with mixed success but the cause of failure of many graft unions was not clear. The following year a test was made of winter-grafting technique, when it was determined that scions are best stored in plastic bags in the frozen state (0°F, -18°C), but they must be thawed slowly (24 hrs) in a cold room (34°F, 1°C) before being grafted in a greenhouse.

EXTENSION

Consultations concerning jack pine seed control and improvement have been held with the Ontario and Quebec Provincial forest services and with officers of the Canadian International Paper Co. (C.I.P.), Maniwaki Division. On the basis of research results to date, attention has been drawn particularly to the immediate advantages to be gained by selecting plus stands for seed production and protecting the gene pools of these populations by ensuring adequate regeneration with seed of local origin. The matter is of some urgency in areas of heavy clear felling of mature forests followed by extensive seeding or planting. A policy of establishment of seed collection areas for jack pine has been adopted by the Ontario Ministry of Natural Resources and suitable stands have been designated in eastern, northcentral and northwestern Ontario. In western Quebec, C.I.P., with support from the Provincial and Federal governments, have established and improved a large seed production area to the west of Baskatong Lake. This seed source is in first rank in the range-wide test planted on the east shore of Baskatong Lake.

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THE MOLECULAR BASIS OF CHROMOSOMAL HEREDITY IN CONIFERS

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SUMMARY

The chromosomes of jack pine have been fractionated into discrete macromolecular components. The information now accumulated, when coupled with cytochemical observations provides a molecular basis for the selection of desirable traits in trees responsive to silvicultural practice. The responsiveness requires that specific gene products such as nucleic acids found both in the cytoplasm and nucleus be synthesized through gene amplification. Control of the reiteration of these genes seems to determine the extent of protein synthesis, hence the utilization of amino acids derived from nutrients in the air and soil eg. CO_2, water, N,P,K.

INTRODUCTION

For tree improvement, many breeders have relied heavily on provenance work and on the selection of superior specimens ie. "plus" trees. In short, they have diverted their attention from chromosomal heredity because of the difficulties in evaluating crosses and problems arising from the long life cycle of most trees. In the approach to selection there has been little direct concern for the molecular basis of chromosomal heredity resident in DNA that determines the desired genotypic traits.

For higher organism, alternatives to classical genetics have already emerged. While the collection and mapping of mutants remains laborious or impossible with current resources, gene analysis is possible by the chemical isolation of genes (Brown and Stern 1974). While new developments have related to proto- and eukaryotic organisms largely exclusive of the plant kingdom, methods are available for workers in forestry that permit the cytochemical localization of genetic material (eg. Durzan et al. 1971. Mitsche 1968, Vanden Born 1963, Mia and Durzan 1974), the isolation of purified, native DNA, even radioactively labelled in a specific form (Pitel and Durzan 1975), the characterization and estimation of several chemical and physical properties of DNA including base composition and the melting and reassociation of double helical strands (Miksche and Hotta 1974, Pitel and Durzan 1975) and the determination of DNA sequences that hybridize artificially with other nucleic acids from the same or diverse species (Hotta and Miksche 1974). Through the efforts largely of Miksche's Laboratory, the potential for mapping chromosomes of conifers to pinpoint loci responsible for specific phenotype traits now seems possible.

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Conifer chromosomes have been isolated and taken apart chemically. This report deals with our efforts with jack pine (Pinus banksiana Lamb.) and examines the molecular components chromosomes (n = 12).

OBSERVATIONS AND DISCUSSION

It is now well-established that jack pine chromosomes are composed of fibers containing DNA, histones (Figure 1), nonhistonechromosomal proteins (NHCP) (Figure 2), and possibly other materials. We have however, no good evidence that substances other than DNA and proteins constitute the chromosomes.

Native DNA strands from jack pine can be isolated and wound on a glass rod. DNA forms the essential backbone of the chromosomal fiber. The chromosomal proteins, eg. histones, NHCP, differ in their electrophoretic properties and can also be distinguished from proteins found in the nuclear sap (Figure 3) and in the cytoplasm (Figure 4). The base composition of conifer DNA is shown in Table 1.

Histones are the basic proteins bound ionically to the DNA in chromosomes. It has proven useful that histones from most organisms are sufficiently similar so that they can be distinguished from the arginine-rich seed reserves so often found in conifers. These reserves contaminate histone fractions and must be removed before histones are examined. Histones can be recognized by their chemical properties such as amino acid composition and sequence and by electrophoretic mobility of purified fractions on polyacrylamide gels (Figure 1).

Isolation of histones is facilitated by extraction from nuclei separated by ultracentrifugation to remove other subcellular organelles. With these and other precautions, conifers have been found by Pitel and Durzan (1974) to be no different than in other organisms containing the 5 major histone classes.

Heterogeniety of molecular species exists within each class due to minor variations in amino acid sequence and side chain modifications. So far we have not found modifications due to N-methylation or arginine and lysine residues.

The 5 types of histones are distributed in many coniferous tissue in roughly equimolar fashion. This raises the possibility that the structure of chromosome fibers are composed of repeated units. It is generally agreed that histones maintain the structure of chromosome fibers.

None-histone chromosomal proteins (NHCP) are proteins associated with the chromosomal material that cannot be characterized as histone. Unlike the histones they form a variable proportion of the total chromosomal mass (Figure 2). The function of the NHCP remains unknown although recent work with other organisms suggests NHCP are involved in gene expression.

Table 1. MOLAR PERCENTAGES OF PURINE AND PYRIMIDINE BASES IN PERCHLORIC ACID HYDROYSATES OF CONIFER SEED DNA

Species	Molar Percentage in DNA						
	A	G	T	C	5-MeC	G+G	Tm[1],[2](calculated)
Pinus banksiana							
dry seed	26.8	18.5	33.1	16.9	4.8	40.2	85.8
24h (imbibition)	26.3	18.7	31.9	19.7	3.6	41.9	86.5
48h (imbibition)	26.7	18.3	31.6	17.6	5.9	41.8	86.4
96h (germination)	26.7	18.7	33.6	17.7	4.5	40.8	86.0
168h (seedling)	26.7	22.3	28.7	19.0	2.7	44.0	87.3
Pinus resinosa	29.2	18.2	34.4	13.1	5.2	36.5	84.3
Picea abies	30.1	19.3	31.6	15.0	4.1	38.4	85.0
Escherichia coli	23.3	16.3	29.7	30.8	-	47.1	88.6
Pinus sibirica[3]	29.2	20.8	30.5	14.6	4.9	40.3	85.8
Pinus silvestris[3]	30.1	19.3	30.5	16.5	3.6	39.4	85.4
Picea excelsa[3]	30.7	19.5	30.2	19.6	-	39.1	85.3

[1] Calculated by mole % of G + G = (Tm-69.3)2.44 *cf.* J. Marmur and P. Doty, J. Mol. Biol. 5,109(1962)

[2] Observed values given in Table 1.

[3] Values from Handbook of Biochemistry Chemical Rubber Co. p. H30 (1968)

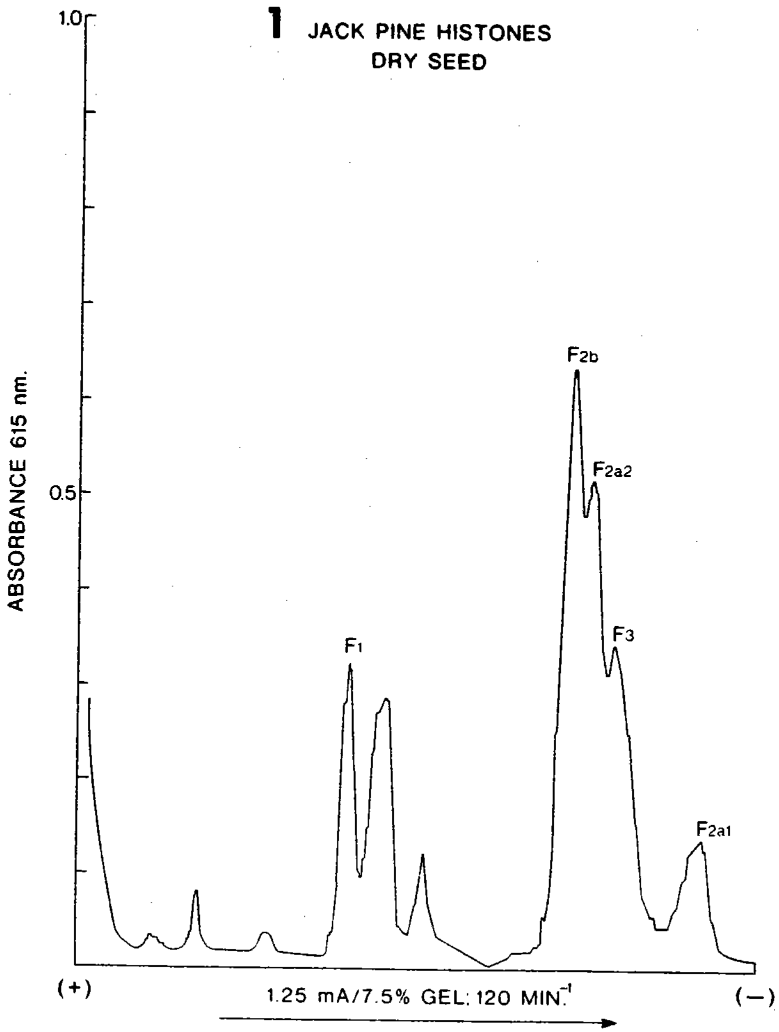

Figure 1. Histones identified in dry seed of jack pine.

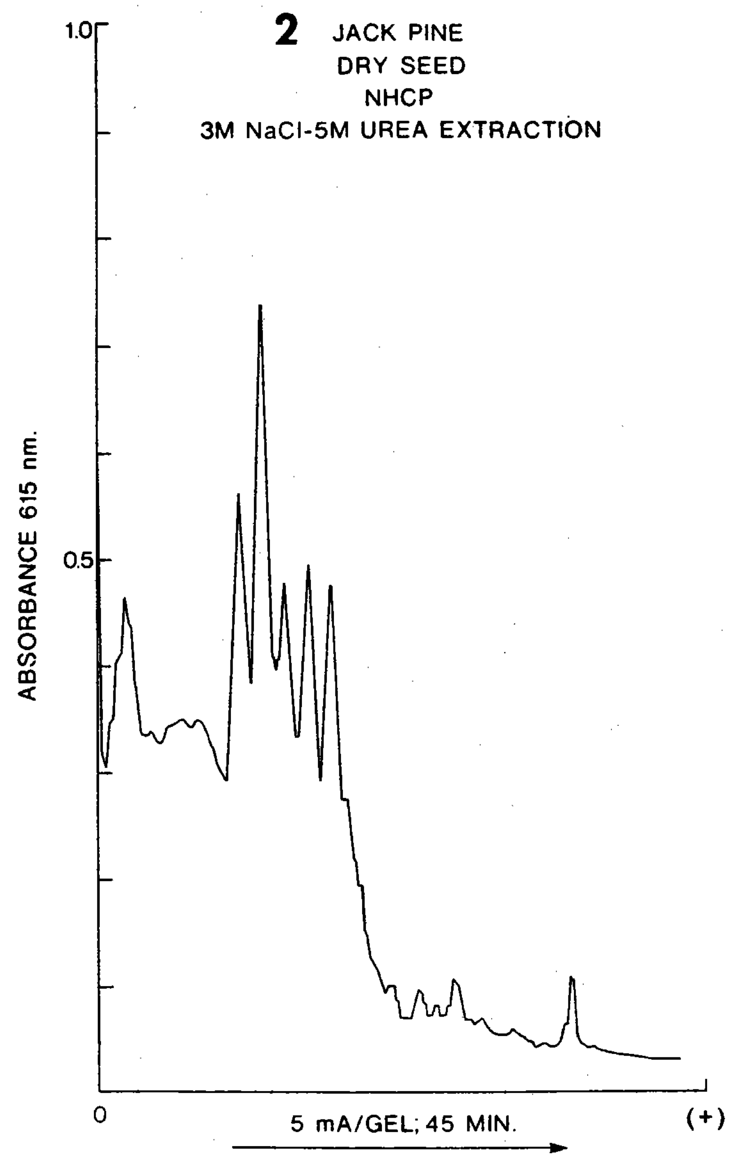

Figure 2. Non-histone chromosomal proteins (NHCP) identified in dry seed of jack pine (3M NaCl-5M urea extraction)

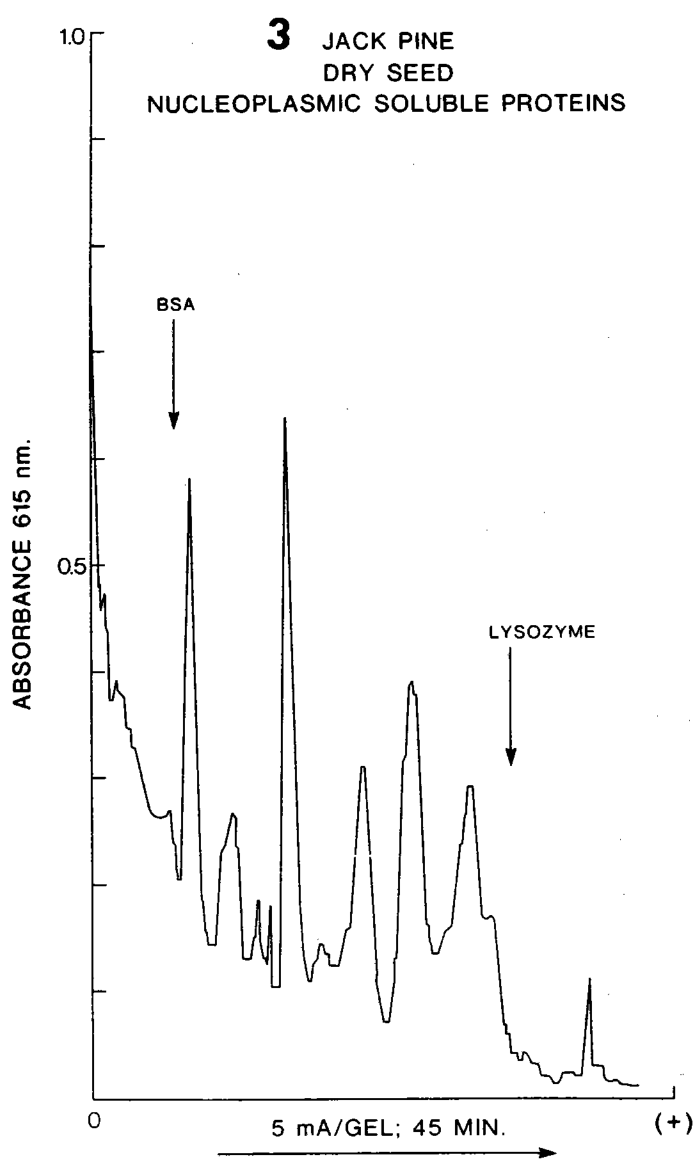

Figure 3. Nucleoplasmic soluble proteins identified in dry seed of jack pine.

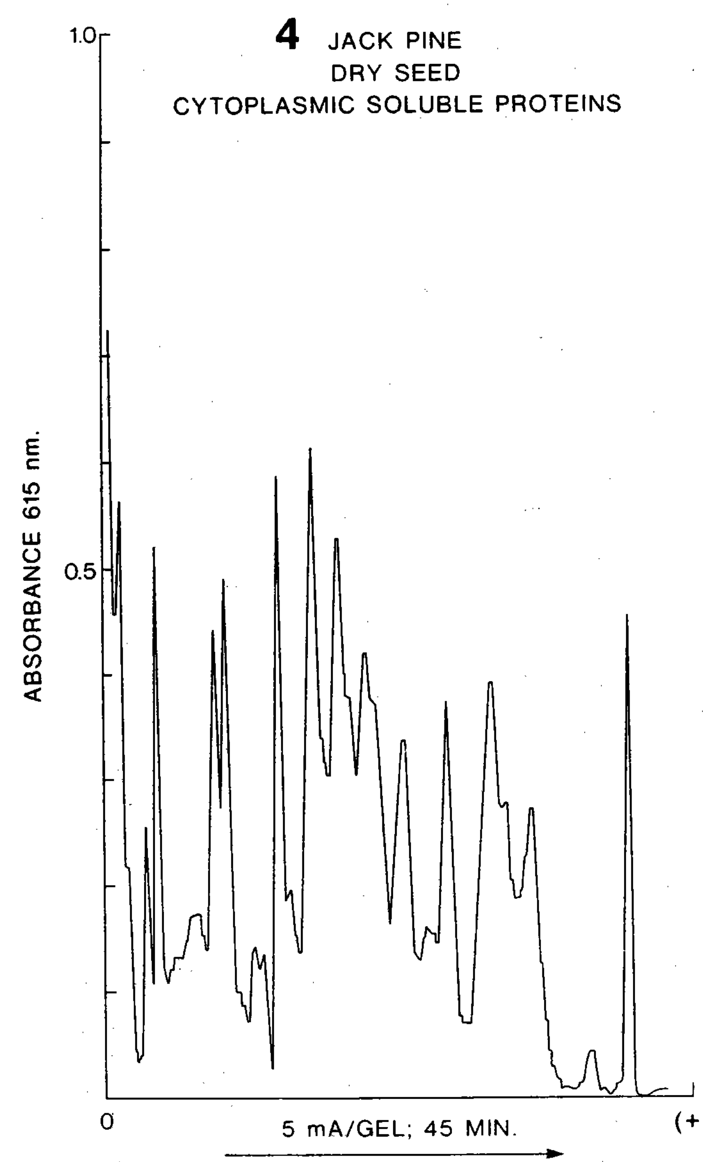

Figure 4. Cytoplasmic soluble proteins identified in dry seed of jack pine.

We have not found good evidence for the occurrence of other chromosomal components, such as ribonucleic acid (RNA) lipids or polysacchardies, as structural units. In cytological studies with jack pine embryos and seedlings (Durzan et al. 1971, Mia and Durzan 1974), proteins staining at pH 2.2 with fast green are detected in the nucleoli. The staining is probably due to ribosomal proteins associated with the biosynthesis of ribosomes and polysomes that move eventually to the cytoplasm and participate in the biosynthesis of new proteins eg. adaptive enzymes such as urease (Durzan 1973).

In conifers, the mechanisms for gene expression run largely by analogy with microbial and animal studies although considerable information on the peculiarities of plant systems is now accumulating. The fact that arginine is a main component of histones in regions that repress genetic information through ionic binding with the phosphate backbone of DNA raises interesting problems for the occurrence of monosubstituted guanidines (MSG) in conifers (Durzan 1968, 1969, Durzan and Steward 1967).

The prospect remains that low molecular guanidines can compete with arginyl residues for sites on DNA and repress or depress the availability of template information. The fact that certain MSG in pine and spruce accumulate in response to nutrition and stress concomitant with the fall of the relative growth rate, requires that the concept of genetic expression be investigated from diverse viewpoints.

Another important expression of chromosomal heredity particularly in conifers, involves the amplification of ribosomal genes (Hotta and Miksche 1974). In germinating jack pine seeds,amplification results in the net synthesis of ribosomal proteins and ribosomal RNA (rRNA) (Durzan et al. 1971, 1972, 1973). The bases in rRNA can be readily derived from salvage mechanisms involving the direct incorporation of purines and pyrimidines as well as from the de novo biosynthesis of bases via amino acids (Durzan 1973, Pitel and Durzan 1975).

The increased number or the amplification of genes seems to arise from the initial prodigous demands controlled by cellular differentiation for a particular gene product. This leads ultimately to increases in the number of templates for protein synthesis. It seems that the greater the reiteration of these genes within the haploid set, not only will the protein synthesis be greater but also the use of nitrogen and other nutrients eg. P and K, for phenotypic expression.

As we have already demonstrated, the carbon of urea and undoubtedly the associated nitrogen have been recovered from rRNA, DNA and newly synthesized proteins (Durzan 1973ab).

We can conclude, first, that selection for trees with specified abilities to amplify genes provides a new approach to the molecular basis for the selection of certain traits in coniferous trees. Gene amplification seems particularly important in juvenile specimens responsive to fertilizers and silvicultural practice. Second, more attention needs to be paid to the molecular basis for inherited and amplified changes in trees induced by the environment. Third, for the first time the chromosomes of conifers have been fractionated into discrete categories of macromolecules. The molecular approach opens the door to the modern era of tree breeding.

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VEGETATIVE PROPAGATION OF NATIVE CANADIAN FOREST TREES BY CELL AND TISSUE CULTURE METHODS

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SUMMARY

Native Canadian tree species have been propagated by chemically defined cell and tissue culture methods. Elm plantlets have been produced from cell suspension cultures. White spruce and jack pine cell suspension cultures are now well-established and are amenable to morphogenetic control. Recently, white spruce plantlets have been produced from hypocotyl segments. So far these have been the main temperate woody perennials propagated by cell and tissue culture methods.

INTRODUCTION

Cell and tissue culture methods are of special interest for forestry in the areas of clonal propagation and tree improvement (Durzan and Campbell 1974a,b). While commercial feasibility is yet to be demonstrated, tissue culture methods have found applications in horticulture (Murashige et al. 1974). Recently, the dramatic successes leading to the propagation of woody perennials by our and other laboratories have culminated in the funding in the U.S.A. of a substantial research effort in cell and tissue culture methods (Anon. 1975).

This article summarizes our efforts to propagate native Canadian tree species. The main constraint to progress continues to rest solely upon the lack of adequate funding in this area.

BACKGROUND

The first cell suspension cultures of conifers were established in 1967 at Cornell University in the laboratory of Prof. F. C. Steward FRS. This achievement was a cooperative venture between the Canadian Forestry Service (DJ Durzan, Petawawa Forest Expt. Sta.) and encouraged by J. S. Rowe and the late G. Allen. Progress was rapid and dramatic, indeed after several weeks of culture, cells of white spruce and jack pine produced proembryo-like structures (Durzan and Steward 1968, 1970). From this work appeared a nationally publicized advertisement in 10 trade journals that clonally produced

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forests could eventually be obtained from a flask. During this time, interest in container planting was intense and many foresters never really appreciated the fact that the plantlets raised by cell and tissue culture methods could be used in container planting. From 1968 onwards, the first cell suspension cultures of Canadian conifers (Picea and Pinus sp.) were established in the Biochemistry Unit at Petawawa. Dr. V. Chalupa was added to the staff but returned in 1970 to Czechoslovakia. In 1971 the Biochemistry Unit's transfer to Ottawa required the reestablishment of cultures.

The following observations were established. Coniferous cells could be maintained indefinitely on chemically defined media. Buds of 5 species collected in November could be induced to produce shoots *in vitro* with very little callus. The biochemical changes were eventually shown to be similar to those buds breaking in spring under field conditions (Chalupa and Durzan 1973). Proembryoids could be formed from cells in suspension. Cells occasionally produce unusual substances that may have commercial potential provided that cells could be maintained like microorganisms in large culture vessels.

The second phase involved a detailed examination of the growth parameters in jack pine cell suspensions with special references to quantitative differences in overall growth rates (Durzan *et al*. 1975, Chalupa *et al*. 1975). The ways nitrogenous compounds vary inside and outside of cells were described and correlated to a model of weighted formation (Durzan *et al*. 1975a,b, Durzan and Chalupa 1975). Pine cells in suspension eventually produced roots but only in low frequency ie. $\leq$1% (unpublished).

Cell suspensions of white spruce proved to be more amenable to morphogenetic control. Our laboratory was the first to demonstrate environmental control over the fate of developing cell clumps (Durzan *et al*. 1973). Cells would either grow into vascular clumps or remain as suspensions and produce elevated levels of tannins (Chafe and Durzan 1973). A low percentage of the vascularized clumps of the spruce suspensions formed elementary roots (unpublished).

In order to meet the priorities in the Forestry Service, our lab attempted to grow the American elm (*Ulmus americana* L.) and complement efforts in the Dutch Elm disease program. After one and a half years, plantlets were produced from cell suspension cultures. This work represents the first woody perennial produced from cell suspension cultures and provides further incentive to extend Winton's (1970) pioneering work with aspen to other species. Clearly wide variations in methodology can be used to grow tree tissues (Durzan and Lopushanski 1975a,b).

In 1972 the arrival of Dr. Campbell as a postdoctoral fellow in our laboratory enabled us to return to the problems of control of the development of conifers in vitro. Within a reasonable time period of 2 years Dr. Campbell increased the frequency of bud formation on hypocotyl segments of spruce and pine. The induced buds were separated and grown on agar plates into shoots followed in a few cases by roots (Campbell and Durzan 1975a, b). This work has continually been jeoparidized by shortage of funds. If it were not for several desperate attempts and considerable personal sacrifices, the results with spruce would not have passed the bud induction stage.

Collaborative work with Dr. Chalupa in Czechoslovakia has continued. This too, yielded valuable results on the rooting of shoots developed from buds of Picea abies (Chalupa and Durzan 1974). Chalupa diversed his attention successfully to european hardwood species (Chalupa 1974).

Throughout this difficult period the support of Prof. F. C. Steward FRS and Dr. M. Prebble must be acknowledged. Indeed, without their encouragement many of these achievements would not have reached fruition.

OBSERVATIONS

A. Control of the formation of cell patterns from cells in callus and organized tissue.

i. Embryogenesis: The reports of Durzan and Steward (1968, 1970) indicate that given the appropriate but complex nutrient conditions, eg. coconut milk, white spruce and jack pine cells in liquid suspension culture can grow and organize into proembryo-like structures. The proembryoids revealed polarity, bilateral symmetry and a pattern of cell division whereby daughter cells adhered tightly to the mother cell. This basic pattern (Durzan 1971) contains an apical clump of cells and a basal set of filamentous cells that eventually produced a cylindrical structure. The pattern of development was not unique to all cells in the suspension. Many cells continued to grow and produce callus in the same suspension.

A third variation was observed. The callus in the suspension produced cells that extruded in a manner similar to the early embryogenesis of pine and spruce. Later studies (Durzan et al. 1973) indicate that cell clumps can develop into organized tissues in suspensions. The more recent studies have the advantage that both the nutrient and environmental factors are well-defined.

ii. Organ induction: The importance of an auxin and cytokinin balance for the induction of organs, eg. buds or vascular tissues in white spruce, is now well-established (Campbell and Durzan 1975a,b). The induction is somewhat direct in the exposure of tissues to a specified range of levels of growth regulators in the medium.

Given a level of growth regulators, the environmental fluctuations can also determine the future growth patterns of cell suspensions (Durzan *et al.* 1973, Chafe and Durzan 1973).

In elm callus, derived from cell suspensions, the maintenance of high levels of auxin leads to root formation. By contrast, removal of auxin and other factors eg. myoinositol, thiamine, did not yield roots but numerous shoots (Durzan and Lopushanski 1975a,b).

iii. Plantlet formation: In other laboratories, several species have been propagated from callus or organ culture eg. aspen, birch. So far, only the American elm has been produced from cell suspensions cultures (Durzan and Lopushanski 1975a,b) although proembryoids of spruce have been observed.

White spruce (Campbell and Durzan 1975a,b unpublished), and pine (Sommers and Brown 1975) have been propagated from organized tissues eg. hypocotyl segments, cotyledons, respectively. In our laboratory the production of spruce was attained mainly by altering the auxin-cytokinin balance, whereas with pine, Sommers and Brown (1975) varied the auxin-cytokinin balance and gave a sequential nutrient treatment to their cotyledons.

B. Tree improvement through genetic changes *in vitro*

Combination of cells in suspension have yielded chimeras of spruce and pine callus. Although further development could not be elicited from the combination there is no doubt that if such combinations were to be given serious attention certain most interesting patterns of tissue development could arise.

Other genetic changes eg. mutations, require methods for their detection. This constitutes a major challenge. Screening is especially problematic when the cloning of plants is inconsistent and when understanding of the biochemical or molecular basis of the traits to be selected for are lacking.

CONCLUSIONS

Since the reviews by Durzan and Campbell (1974a,b) the number of successes for cloning temperate woody perennials has taken a significant upswing. There is no longer any doubt that cells of trees are as totipotent as carrots and tobacco. The right combinations of growth regulators, environmental conditions and nutrients in most cases are different for each species.

Many of the developmental events leading to organ formation can be induced or by-passed eg. vascularization of spruce without root or shoots and formation of elm plantlets without the intermediate steps of cotyledon production.

Since a factor limiting the growth of trees under Canadian conditions is availability of nitrogen we have turned our attention to the nitrogen metabolism of cells and tissue in vitro. There again is no doubt that once the molecular basis for understanding how trees use their N effectively is known, cells that do this effectively can be used to clone superior trees for a given and specified set of conditions (eg. Durzan 1975).

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FOREST GENETICS AT THE SCHOOL OF FORESTRY LAKEHEAD UNIVERSITY

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The academic and research programs in forest genetics and tree improvement at Lakehead University are at an early stage in their development. Initial efforts have been directed towards reaching the objective that the graduating forester should be fully aware of the potential for genetic improvement in our forests, and should understand the principal methods by which this improvement can be achieved. All undergraduate students in forestry receive instruction in the area of tree improvement during courses in silviculture. During the 1974-1975 academic year, cooperation with the Ontario Ministry of Natural Resources made it possible for students to study a seed orchard and provenance plots in the field. A course in forest genetics is available to senior year students who wish to study the subject in greater depth.

Research in progress involves nursery bed selection and vegetative propagation of exceptionally large seedlings of black spruce (*Picea mariana* (Mill.) B.S.P.). An objective of this work is comparison of rates of photosynthesis and respiration in propagules of these extra large seedlings and those from standard size nursery stock. Construction and testing of the necessary apparatus is in progress, and should be complete by the end of the 1975-1976 academic year.

A NEW TREE IMPROVEMENT UNIT IN ONTARIO

R.J. Hilton

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In December, 1970, the Governors of the University of Guelph accepted Master Plan documents presented for a new Ontario arboretum (Anon.,1974). It now occupies 134 ha. of the east portion of the university campus, about 40 ha. of which is naturally wooded. In the arboretum nursery, or sited elsewhere, are nearly 2000 Taxa of woody plants, and the wide diversity of the area in soil classifications and topography suits well the variations in water table, reservoir needs, slope and exposure that are required for an arboretum.

More than 50 graduate and undergraduate courses will make major or minor use of the arboretum as a field laboratory or "living plant library". To accomplish this effectively 30 collections involving woody plants in systematic or use categories, are being set out according to the Master Plan. Guelph is in Canada Plant Hardiness Zone 6a (Ouellet and Sherk, 1967), which places it midway between the climates of the Central Experimental Farm Arboretum in Ottawa and the Royal Botanical Gardens in Hamilton. Plant Hardiness Zone 6 is of particular importance because about 1/5 of the Canadian population now lives in this zone. Thus the call for up-to-date information on plant hardiness, and plant soil and climatic adaptation in general, is greater in Zone 6 than for any other part of Canada.

SOME TREE IMPROVEMENT OBJECTIVES

The arboretum at Guelph has been planned with a broad range of woody-plant interests in mind. First, the Synoptic Collection eventually will consist of one or more living plants of every woody species that will grow at Guelph. Additional taxonomic values, particularly for academic purposes, will accrue from large collections of certain important families, notably *Aceraceae*, *Betulaceae*, *Caprifoliaceae*, *Ericaceae*, *Fagaceae*, *Pinaceae*, *Rosaceae* and *Tiliaceae*. These are supplemented by collections that are oriented towards utility, such as windbreaks, hedges, fall colour, shade, tree forms, flower and fruit characteristics, and the use of plants to define spaces.

Two large areas have been set aside for Forestry Research and Economic Trees, and a space of 5 ha. is considered to be permanently and irrevocably allocated for use as a Gene Bank. In this space will be maintained forest tree individuals that have potential or proved value as parents, and with these will be promising hybrids and species judged to be endangered insofar as regionally adapted ecotypes are concerned.

Other collections of interest to tree improvement include a special collection of lines of *Robinia pseudoacacia* L., native Canadian trees and special group of Southern Ontario trees. Also, there is a "reconstructed" forest planting on the topographically variable acreage surrounding the headquarters building. The building itself was provided by alumni and friends of the Ontario Agriculture College, to mark the centennial of that institution in 1974.

RESEARCH POTENTIAL

In terms of more or less direct relationship to tree improvement in Canada, the following features at the University of Guelph Arboretum have most research relevance.

1. *Salicaceae* Collection. The decision to establish as complete as possible a collection of willows and poplars came with the recognition that heavily populated areas must retain swamps, bogs and other wetlands as reservoirs for much needed ground water supply. At the same time, we must anticipate as much economic productivity as possible from all our land areas. Resource productivity from wetlands is most likely to be in the growth of hydrophytes such as many species of willow and poplar. We have had excellent cooperation from federal plant introduction authorities and exotic willow species are being flown from abroad, as cuttings, directly to the Canadian Post-Entry Quarantine Station on Vancouver Island. There they are tested for two years and if certified free of watermark disease, cuttings are sent from the Quarantine Station to Guelph. At present about 75 willow species or cultivars are under test, along with 47 poplar taxa and a lonely plant of *Chosenia arbutifolia* Skvortz.

2. Special Purpose Collection. Here the plan is to study regional adaptation of certain woody plant groups such as nut-bearing species and hybrids. Of interest, too, are species (particularly in *Aceraceae* and *Rosaceae*, for example) that may have value as rootstocks. Another primary objective here, is the investigation of management practices to improve establishment rates of plants of certain species such as *Juglans nigra* L., *Picea glauca* Voss, *Pinus sylvestris* L., *Robinia pseudoacacia* L., and certain *Acer* selections.

3. Oldfield Studies. Several areas are available for ecological investigation under typical South-Central Ontario oldfield environments. In one instance, a population of more than 1,000 wildings of *Pyrus communis* L. has originated from three 70 year-old parent trees and these are competing strongly and successfully with the mixed population of *Crataegus* spp., *Thuja occidentalis* L., *Populus tremuloides* Michx., *Tsuga canadensis* Carr. and species of *Rhamnus*, *Amelanchier* and *Acer* that normally supply woody plant stature in such an old pasture clearing.

4. Shelterbelt Trials. Certain hybrids of fast-growing species, notably of *Populus*, should be tested for the time required to establish effective wind and snow breaks. With modern herbicides and information on nutritional balance, shelterbelts may have a role to play in afforestation practices, as well as for food crop production and as protection for exposed home sites.

5. Forestry Research. Among the projects in forestry that will receive early attention are those that bear on the interdependence among tree species for most rapid growth. Most of the Forestry Research sites are now producing forage grasses and it will be possible to use precision in establishing community plots of varying make-up, and to include herbaceous as well as woody plants. By so doing, needed information can be obtained on the synergistic effects of species upon other species.

6. *Robinia* Collection. The Black Locust is a very important tree in most of Central Europe and in Italy. It grows very quickly, is extremely durable, enriches infertile and gravelly cutbanks and pits, is an outstanding honey producer ... and can be a very attractive landscape plant. Unfortunately, the Locust Borer is a very serious deterrent to the uses of this tree in Southern Ontario. By testing many strains, both vegetatively and seminally propagated, we hope to observe some that are borer-resistant. Ideally, we could select one or more parent trees that would produce seedlings carrying such resistance.

7. The Guelph Rhizotron. The University of Guelph Department of Horticultural Science has, with co-operation from the National Research Council of Canada, established North America's first rhizotron for root observation studies. The trench itself is 30m.x 2m.x2m. and has 80 growing compartments outside the glass-sided trench. In these compartments may be placed soil monoliths, reconstituted soil types, or such other medium as the researcher may wish to provide for the plant roots. Each side of the trench has removable plate glass panes from soil surface to 1.25m. depth, the glass being 6.25mm. thick. Effects on root growth of soil compaction, soil surface restriction, winter heating of soil and the circadian rhythms of growth of several species and at various seasons are among studies now in progress.

NEEDS OF URBAN FORESTRY

The University of Guelph Arboretum is located in the area of Canada's most rapid population growth. It also has the advantage of direct association with an unusually significant bio-research programme operated by the numerically strong faculty in agriculture and veterinary medicine, and in wildlife, environmental and marine biologies. Modern socioeconomic trends lead to increased leisure time and the probability of reduced ability to acquire energy for travel. This results in a strongly increased application of certain forest practices in urban and suburban settings; in fact, this is Arboriculture. Therefore, arboreta and botanical gardens, as test areas for the kinds of plants of greatest recreational interest, are important resources.

Our affluent economy, while it still is affluent, has a characteristic generally correlated positively with the trend toward increased leisure; that is, the marked increase in most forms of environmental pollution. Hence, we observe depressingly deleterious effects on the very environment we now have more time to enjoy! The arboretum at Guelph, located in a town heavily oriented towards manufacturing industries, is in a good position to maintain close observation of the reaction of more than 2000 woody plant species, to such soil or atmospheric pollution as may from time to time exist in that area.

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URBAN FORESTRY STUDIES AT TORONTO UNIVERSITY 1975

John W. Andresen

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Faculty of Forestry, University of Toronto

1. The Faculty of Forestry is organizing a Centre or Group for Urban Forestry studies which will include tree improvement programs.

2. In November 1975 I'll attend the symposium "Better Trees for Metropolitan Landscapes" to be held in Washington, D.C. I will present a paper entitled "Selection of Trees for Endurance of High Temperature and Artificial Lights in Urban Areas".

3. Organization of the IUFRO P1.05 Project Group on Arboriculture and Urban Forestry is progressing on schedule. Meetings in Vancouver and Oslo, Norway in June of 1976 will feature some 20 to 30 papers, 5 of which will relate to the international aspects of tree improvement on the urban scene. P1.05 is coordinating with a number of other sections and groups within IUFRO so in Oslo we will determine whether we should remain as an independent entity or combine with another unit.

JACK PINE FAMILY TESTS AND PROVENANCE EXPERIMENTS WITH CONIFER SPECIES IN THE PRAIRIE PROVINCES, 1973-75

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The jack pine (Pinus banksiana Lamb.) breeding program initiated in 1967 continues to account for most of the resources allocated to the Northern Forest Research Centre tree improvement project. The second of three breeding district family tests was planted in 1974, and the first test was measured after the second growing season from planting. Six provenance experiments, of which five are components of cooperative studies organized by Petawawa Forest Experiment Station, account for nearly all of the balance of the project. Provenance experiment plantations of red pine (Pinus resinosa Ait.), Norway spruce (Picea abies (L) Karst.), and Scots pine (Pinus sylvestris L.) were measured during the review period, but results are not ready for reporting. Nursery measurements and preparation for field planting were carried out for the black spruce (Picea mariana (Mill.) B.S.P.) provenance study. Other major activities during the past two years were acquisition of a planting area fairly close to Edmonton, drafting of a file report summarizing progress on all phases of the project, and drafting of a work plan for the first experiment of a white spruce seed source selection program to be conducted by the Alberta Forest Service.

JACK PINE BREEDING PROGRAM

The western breeding district family test, planted in spring of 1974, contains 214 open-pollinated progenies of parent trees selected in central Saskatchewan to eastern Alberta, plus two stand progenies for controls. There are four plantations in the test, each with three replicates and four-tree row plots. Two plantations are on medium-textured till in western Saskatchewan, and two are on coarse-textured glacio-fluvial deposits 250 km to the east. Planting stock was reared in fold-up plastic containers having cavities 50 x 50 x 200 mm. The seedlings were sown in May and June of 1973, chilled outdoors from late summer to early winter, then given their second growing season in a greenhouse. Seedling height, ranging from 5 to 15 cm for all but a few seedlings, was measured after the second growth period. In March, the greenhouse temperature was set as low as possible, then at the end of the month the heating system was drained and all vents were left open. Informal inspection of the plantations during the summer of 1974 indicated good survival and growth.

Although we had good results with the rearing regime for the western district test, it was expensive of labor. Moreover, plugs of that size proved cumbersome to transport and plant. For the central breeding district family test, the third and last planned for the study, we are using containers of the same type, but only 40 x 40 x 120 mm in size. The seedlings will be grown in a greenhouse during summer, then moved to a lath house in fall. They may be left there for the winter, or moved to a cold room if that is judged to offer greater security.

The eastern breeding district family test, planted in May 1972, was measured in fall of 1973 and April 1974. Analysis of variance detected height differences among families and among locations, but not among replicates, and there was no family by location interaction. For what it is worth, 23 of 209 eastern district families had mean heights at least 15 percent above the test mean, with a maximum family superiority of 27 per cent. Analysis of this measurement will be carried further when time permits, which may be before the next measurement.

PROVENANCE EXPERIMENTS

Range-wide Black Spruce Study

Preparations for planting of the range-wide black spruce provenance study were largely completed by fall of 1974. Planting sites were prepared in western Manitoba (52.7^{o}N, 101.4^{o}W, elevation 760 m), central Saskatchewan (54.2^{o}N, 104.4^{o}W, elevation 640 m), and near Peace River, Alberta (56.0^{o}N, 116.6^{o}W, elevation 750 m). The Saskatchewan plantation will have 49 populations of virtually range-wide provenance, the Manitoba plantation 49 with few from north of 55^{o}, and the Alberta plantation 30 with few from south of 50^{o}.

Some problems were encountered in the rearing of planting stock. Consequently, some populations had to be omitted from plantations where their performance would have been of real interest. Seedlings of several populations were grown in containers during the past year, alleviating but not eliminating the shortages. Seedlings grown at the Provincial Tree Nursery near Edmonton were lifted in November 1974. After lifting, plot bundles were drawn from the selected populations, bound, labelled, packed according to the planting design, and placed in cold storage at -7^{o}C.

Nursery observations on flushing, and periodic measurements of terminals or dominant lateral shoots were taken on 47 populations during the 1974 growing season. The time-of-flushing observations show little or no discrimination among populations. Shoot extension terminated for most populations around the beginning of August, apparently due to moisture stress partly induced by root pruning. Some phenological response information may be accessible by calculating the proportion of total extension achieved at a standard measurement date.

All-range Jack Pine Provenance Experiment

The two jack pine provenance experiment plantations planted in spring of 1972 were examined during the 1973 growing season. In the plantation in southeastern Manitoba, 82 percent of the planting positions were stocked with a growing tree. Five of the 81 populations had one unstocked plot. The plantation is in lattice square design with five replicates and four-tree row plots. The plantation in central Saskatchewan sustained excessive mortality and has been written off. Cause of the mortality is unknown.

OTHER ACTIVITIES

Following a summer-long search, a half-section of Crown land was reserved for research planting on behalf of the Canadian Forestry Service. Location of the parcel is about 120 km west of Edmonton, at 53.5°N, 115.5°W, elevation 870 m. It is intended to serve as the location for plantations requiring accessibility more than a specific environment. Demonstration plantations and collections of breeding material, such as clone banks, will be planted there. The area may also be used for some test plantations, such as phenology studies or screening of exotic populations. Climate is typical of the productive boreal forest area of the prairie provinces, with 1100 growing degree-days above 6°C, a 90-day frost-free season, annual precipitation of 500 mm, and growing season precipitation of 350 mm (Government of Alberta and University of Alberta, 1969). Soil parent materials and texture profile are somewhat unusual, but probably provide regimes of moisture and nutrients similar to those of widespread medium-textured soils in the Region. Stone-free silt loam of uncertain origin is underlain at roughly 25 cm by a relatively shallow deposit of stony, fine-textured till over porous weathered bedrock. Soil profiles are predominantly orthic grey wooded to bisequa grey wooded. A mature stand of aspen (*Populus tremuloides* Michx.), white spruce (*Picea glauca* (Moench) Voss), and lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) presently covers the area.

The Alberta Forest Service requested advice for a research program intended to improve results from direct sowing of white spruce by selection of seed source. A plan submitted in December 1973 was accepted, and could be put into action in the near future. The initial study would investigate interaction of seed source with latitude and moisture regime of the sowing environment. Simple performance trials of many seed sources would be initiated subsequently. Before the fact, I would expect the direct sowing context to increase the difficulty of genetics research, but direct sowing is the primary mode of artificial regeneration of white spruce in Alberta.

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FOREST GENETICS RESEARCH AT THE UNIVERSITY OF ALBERTA

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The first year of activities in forest genetics research at the University of Alberta has concentrated on two projects. The first, a three year project funded by the National Research Council, involves a genecological study of the paper birch complex in western Canada. I hope to clarify the identity and relationships among the various reported taxa within the Betula papyrifera complex (B. papyrifera Marsh., B. resinifera Britt., and B. neoalanskana Sarg.) in Alberta and to relate the variability in the complex to environmental differences of the sites upon which the birches grow. In 1975 we located 20 populations for sampling, collected pollen from 8 of the populations, and collected leaves and fruits from all of them. Seed from these populations will be sown in two controlled environments simulating dry and wet site conditions and in the greenhouse for later outplanting in common gardens. Morphological measurements of the parental leaves, fruits, and pollen have been made; these data will be compared using various univariate and multivariate techniques and any relationships with site differences determined.

The second project, funded by the Alberta Forest Development Research Trust Fund, involved studies of natural genetic variation of the forest trees of Alberta. White spruce (Picea glauca (Moench) Voss) was the first species selected for investigation. With master's student Mr. Glen Dunsworth using part of the study for his thesis project, we have chosen bulked seed from 27 selected populations in the Alberta Forest Service seed bank and are comparing the growth and development among these populations in a nursery and in two controlled environments. Seed is also being collected from 10 trees in each of approximately 30 populations systematically selected to represent a wide range of climatic and site conditions in Alberta. At each site, soil and moisture conditions have been recorded, along with stand age, elevation, aspect, and associated plant species. The objectives of this project are: 1) to delineate the present genetic resources of this major tree species in Alberta, 2) to provide a basis for selection of seed from present seed lots and areas best suited for various planting sites, 3) to provide a detailed seed collection zone map for white spruce in Alberta, 4) to determine if populations from different sites differ genetically, and 5) to identify populations that have high potential for future selection and breeding programs. While making the spruce collections, we have also been noting populations of other tree species that will be investigated later.

A BREEDING PROGRAM IN COASTAL DOUGLAS FIR (P. MENZIESSI MIRB. (FRANCO))

J.C. Heaman

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Plus tree selection in a program for improvement in Coastal Douglas fir was started for the B.C. Forest Service in 1957 by Dr. Alan Orr-Ewing and was continued until 1966 by which time a workable breeding population had been collected. Help was provided by the forest companies and the University of B.C. The selected trees were grafted into first level seed orchards and into the breeding clone bank at the Cowichan Lake Experiment Station. As male and female strobili appear it is possible to move into the more advanced phases of the program.

Although some buds appeared in 1966 and 1968 at Cowichan it was not until 1971 that enough clones produced strobili to make a start on the more applied side of the program. Some crosses were made in that year but following consultation with Dr. Gene Namkoong in 1972 when the options available for a long term program were discussed, a double-pronged approach has been adopted.

RECURRENT SELECTION PROGRAM

First priority has been given to a recurrent selection program in a population of selected trees from Coastal British Columbia and Northern Washington. Eventually about 350 trees will be involved and the project is designed to provide material and information from which future, reconstituted seed orchards may be developed. Its chief impact will be on the lower to middle elevation zones. In an attempt to meet the three objectives of (a) breed production for second generation selection, (b) estimation of genetic parameters which will guide future breeding strategies and (c) the testing of selected genotypes, a partial diallel mating design is being used. The disconnected modified diallel mating design seems most appropriate and five crosses per parent should provide adequate information and yet still be within our resources. Each cross will be represented in the field tests by two hundred seedlings distributed over coastal B.C. and while looking for general adaptability, the importance of genotype environment interactions will also be studied.

Each modified diallel comprises six parent trees taken in theory at random from the population and as reciprocal effects are being ignored for the present, the allocation of parents will depend on the available numbers of reproductive buds. In this way a completed diallel will contain 15 crosses. Groups of 8-12 of these diallels will be used in a single year of field testing and overlapping crosses will provide some control between years of planting.

By the end of 1974, ten diallels had been completed and most crosses in a further eight had been made. In the spring of 1975 these ten units were sown in the greenhouse at Cowichan Lake and the progenies will be ready for planting as long-season, one year old Styro-8 plugs by the fall. Eleven test sites have been selected from Harrison Lake to Gold River and are being laid out this summer. The crosses will be planted in nine tree row plots with two replicates at each test site. Crosses were made to complete the remaining diallels in 1975 and six new ones started. There are now therefore 144 selected trees being used in the program. Emphasis is being given to the maintenance of balanced mating and plantation designs. The trees are spaced at 3 m x 3 m and they will be evaluated before severe competition takes place. Long term competition will only be studied subjectively.

As a subsidiary project, reciprocal effects are being examined and 25 reciprocal combinations are being included in the first field test.

RECIPROCAL RECURRENT SELECTION PROGRAM

The second approach has been loosely termed Reciprocal Recurrent Selection and is designed to follow up some of the encouraging results of Dr. Orr-Ewing's interracial crossing studies reported elsewhere. Here an incomplete factorial mating design is being used with two populations designated "Local" and "Exotic"; five crosses will be made with each parent brought into the program. The parents for the local population have been taken from Lower Coastal B.C. and Northern Washington as in the recurrent selection program while the "exotic" population is being drawn from some trees from the Northern British Columbia Coast (e.g. Bella Coola) and trees from Southern Washington, Oregon and Coastal California.

As first priority has been given to the recurrent selection program, the first pollinations for the factorial design were made in 1975 and the program will be discussed in more detail in future.

A PROGENY TEST OF COASTAL DOUGLAS FIR

Before the long term program was drawn up, a balanced factorial progeny test involving four tester males and 26 selected plus trees was in process of establishment. A change of priorities led to a reduction in the effort that could be put into this project and the trees were only planted out in two test sites near Victoria and Cowichan. The trees were planted in fall 1973 and spring 1974 and are now established. Information on a research basis will be forthcoming and useful experience has been given to handling small plots and plug stock.

PROVENANCE RESEARCH BY THE BRITISH COLUMBIA FOREST SERVICE, 1973-75

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STAFF CHANGES Since the 14th Meeting of the Canadian Tree Breeding Improvement Association, personnel changes within the genetics section of the B.C. Forest Service, Research Division have occasioned organizational shifts in the overall program.

Mr. R. L. Schmidt, formerly studying Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) provenances, has moved into administration; K. Rieche, studying variation in Sitka spruce (*Picea sitchensis* Bong. Carr.), has left the Division. Responsibility for these and all other provenance studies has been transferred to K. Illingworth.

Mr. N. Wheeler joined the Division in April, 1975, and will be responsible for lodgepole pine (*Pinus contorta* Dougl.) breed production and testing.

A quantitative geneticist, Dr. F. Yeh, came to the Division in November, 1974. In addition to conducting enzyme research, he will provide counselling and analytic assistance on all aspects of the Division's genetics program.

PROVENANCE RESEARCH Reforestation in British Columbia depends entirely upon indigenous conifers, and it is fortunate that the gene populations which they represent are rich in variety and relatively undisturbed by man. Studies of geographic variation consequently occupy a prominent and appropriate part of the research program of the B.C. Forest Service, both as adjunct to reforestation and as a basis for tree improvement.

Since 1968, provenance trials totalling some 255 hectares have been established at 125 locations throughout the province. They represent a substantial work load in terms of routine maintenance, scheduled assessments and data processing. For this reason the program to date mainly comprises studies of coastal Douglas fir, Sitka spruce and lodgepole pine. However, the pressing need to include other major species, such as the interior spruces and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), is recognized. To facilitate present and future work, procedures for the implementation of field trials, records, data collection and processing have, wherever possible, recently been standardised.

In general, the period 1973-75 was marked by the implementation of several new trials. A noteworthy trend emerging from assessments in older experiments is the substantial variation in vigour and, sometimes, survival among provenances from within the same seed zone. Currently, seed zones in British Columbia are crude derivations of bio-geo-climatic zones, but this trend questions and may well force a revision of present seed zone concepts.

An outline of individual studies and progress made in them during the past two years follows:-

Douglas fir In the period 1969-74 some 80 hectares of trials were planted at 38 locations throughout the coastal Douglas fir zone. Their general purpose is to permit the formulation of seed transfer rules. There are four related field experiments.

Part 1. To screen a wide range of seed sources - as many as seventy seven provenances are being grown in six contrasting climatic zones;

Part 2. To assess the importance of seed transfer over large altitudinal intervals - a high elevation and a low elevation seedlot from each of five localities are being tested at or near each seed source;

Part 3. To define provenance zone boundaries - a seedlot of local origin plus five from contrasting climatic zones are being tested in many climatic and geographic situations;

Part 4. To test and compare select coastal and interior provenances at three high elevation test sites.

The design of the older trials is randomised complete block incorporating four replications of 35 tree line plots at each site. More recent plantations now comprise 9 tree square plots in fourteen complete blocks per location. Bare-root 2 year old transplants are used.

The establishment phase of this programme is essentially complete. Sixth year measures were made at three sites in 1974. Survival and height at Port Renfrew (altitude 229m), Sooke (122m) and Lookout Mountain (1067m) were 97.2, 90.2 and 94.4 percent; 2.8, 1.7 and 1.1 metres, respectively. Provenances differed markedly in their ranking for mean height and also, apparently, in their genotypic stability. Darrington (Wash.), Shelton (Wash.), Kelsey Bay (B.C.) and Alberni (B.C.) exemplify consistently vigorous provenances. Significant variation in height growth was observed between provenances from the same seed zone. Thus, although one or more provenances from the local seed zone (1010 - west coast Vancouver Island) were included in the top range of non-significance at each location, Kennedy Lake and Gold River ranked consistently below Alberni, Kaouk River and San Juan River - the selection of any one of which current seed zone rules would have favoured for reforestation purposes.

Sitka spruce Studies of variation in Sitka spruce incorporate seedlots collected by the International Union of Forest Research Organization (I.U.F.R.O.). Since these studies have not previously been reported, a brief review follows:

The first sowings were made in 1971. Thirty-nine provenances consisting of 554 wind-pollinated families were grown in containers at the B.C. Forest Service nursery in Surrey, where they were the subject of intensive genecological study by E. Falkenhagen from the University of British Columbia. Subsequently the trees were used in field trials in the Queen Charlotte Islands and Vancouver Island. The first of these was planted in October, 1973. Intended as a guide to the selection of geographic seed sources suitable for transfer into the Queen Charlottes, it comprises 38 provenances planted in 22 replications of 9 tree plots. The replications are dispersed among five locations on Graham and Moresby Islands.

The four year old trees were measured in September, 1974. Despite slight but significantly consistent variation in mortality among the provenances, overall survival is 99.5 percent. Tree heights still reflect the pattern established in the nursery and are strongly correlated with latitude and altitude of the seed sources. However, current leader growth already permits a rough geographic grouping of the provenances; those from the middle Skeena (Shames to Kitwanga) and Nass valleys show substantially the greatest vigour, conceivably reflecting the effects of introgression with white spruce in the upper Skeena.

To permit estimates of genetic parameters at the half-sib level, plots of 75 wind-pollinated families (15 provenances x 5 families) were also planted at two of the Queen Charlotte Island test sites.

A third experiment utilizes the remainder of the Surrey trees (some 38 provenances and up to 15 families). In spring, 1974, they were set out in a 13 acre plantation on a Vancouver Island site infested by the white pine weevil (*Pissodes strobi* (Peck), which is the principal deterrent to Sitka spruce reforestation throughout much of the Pacific Northwest. The plantation is intended to afford a very crude screening of families or individuals for putative resistance to this pest.

In spring, 1975, the I.U.F.R.O., International Ten Provenance Experiment was established at seven locations on the northwest coast. At each location there are nine randomised complete blocks with 9 tree line - plots. Fourteen countries are participating in this study, and the B.C. plantations will provide an invaluable link with much of the European research on variation and genotypic stability in this species.

Lodgepole pine In spring, 1974, sets of sixty lodgepole pine provenances, selected from a range-wide collection of one hundred and fifty, were planted at sixty locations east of the Cascade - Coast Ranges. Provenance sets include ten standard provenances common to all test locations. Sites were selected so as to sample a range of topography and soils within twelve broad bio-geo-climatic regions. Despite epidemics of black army cutworm (*Actebia fennica*) at four locations and the loss of one plantation by fire, end-of-season survival was 98.6 percent. These and overwinter losses, mainly by rodents, were replaced in June 1975.

Shore pine provenances are being tested on problem sites in coastal environments. In the spring of 1973, two-year seedlings of six provenances (representing a north and a south transect from outer to inner coast) were planted on a frost-prone site on Vancouver Island and in the Kitimat valley. To study spacing effects, a modified Nelder variable spacing design is being used. At the Kitimat site, northern provenances are exhibiting a pronounced gradient of cold resistance, increasing from outer to inner coast. Southern provenances are suffering most and differences among them are relatively minor.

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

Gyula Kiss

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Prince George, British Columbia

The objective of this project is the production of genetically improved seed of white - and - Engelmann spruces (Picea glauca (Moench) Voss and P. engelmannii Parry respectively).

Since the previous report in the Proceedings of the 14th meeting of the CFTBC further progeny trial plantations were established. The 32 planting sites reported in 1973 to be prepared for planting have been planted along with the plantation near Red Rock. A total of about 54,000 2+1 seedlings representing 134 selected families were used in this trial. Initial height of each seedling was recorded. Survival after the first growing season was about 94 per cent.

The East Kootenay selection unit progeny trials were planted during the spring of 1975. The trials consist of 33 replications in 14 areas within the East Kootenay selection unit and seven replications at our Red Rock test site. The latter is well out of the seed zone. All but six of the 110 selected trees, from which we were able to collect cones, are represented by at least 300 seedlings. In each replication a row of 10 seedlings, distributed at random, represent a family. Following planting each seedling's height was measured and recorded.

The clone banks at Red Rock continue to grow well. Some of the ramets exceed 2.5 meters. Clones from the East Kootenay selection unit continue to grow faster than those of local origin. The tallest Prince George ramet is 216 cm while the tallest East Kootenay graft measures 254 cm yet the latter is 1 year younger (7 and 6 years since grafting, respectively). Several ramets averaged 60 cm's in the last three years. Only a few strobili, mostly male, appeared so far on the clones.

The climate in the Prince George area is not very conducive to fructification. Since we are planning to make a large number of controlled crosses it was decided to move our tree breeding centre to the northern Okanagan Valley in British Columbia. Here the climate is hot and dry during the summer and cone crops are much more frequent. The full-sib seedlings will then be tested at sites for which they are intended in the future. Many of the grafts to be moved to this new centre have already been made and are still in containers awaiting their transfer.

In anticipation of an inter-racial crossing program we have obtained white spruce scion material from many parts of Canada and the United States. Grafts thus obtained are doing well.

Both the Chilliwack and the Red Rock Piceta are doing well. Some species at Chilliwack are over 250 cm tall.

* Previously reported in: Proceedings of 12th, 13th and 14th meeting of CFTBC.

SUMMARY OF SEED-PRODUCTION PROGRAM OF REFORESTATION DIVISION, BRITISH COLUMBIA FOREST SERVICE, 1973-75

J. Konishi,
M. Meagher &
C.A. Hewson

Reforestation Division
British Columbia Forest Service
Victoria, British Columbia

Activities since the last report have been mainly preparatory to expanding our seed orchard program. This has entailed obtaining initial predictions of long-term seed needs for the Vancouver Forest District, and reconnoitering for land suitable for seed orchards throughout the province. Consultation and cooperation with Company foresters is ongoing to assure that public money spent on seed production will produce the greatest amount of suitable seed.

An 18-acre orchard based on 108 families, but including 73 other clones for early pollen production, was planted in 1975 to produce Douglas-fir seed for the Coast-Interior transition zone. After 15 years, this should provide seed for replanting 3000 acres a year. Stock for another Vancouver Island west coast Douglas-fir orchard (to be planted 1977 - '78 in a good flowering zone) is being reared now. Selection of western hemlock parent trees on the lower Coast will begin this fall for propagation by rooting.

In the Interior, a 10 acre lodgepole pine orchard (plus trees were selected by U.B.C.) was planted in 1974 in the breeding arboretum, near Red Rock. Mass selection of spruce trees from an area northwest of Prince George was done during the winters of 1973-1975. A total of 250 parent trees were selected and have been grafted, producing 10,000 ramets. These will be moved to clone banks and a 25-acre orchard near Salmon Arm, 4 degrees south of the Prince George source, in 1976. Further Central Interior spruce selections will be taken from the Smithers - Burns Lake area in 1975. Part of the East Kootenay area has been previously sampled by G. Kiss of the Research Division, B. C. Forest Service. These will be screened for suitability, using progeny test information wherever possible before placement in seed orchards. Mass selection will be employed in establishing other orchards in the Southern Interior of the province. A small orchard of the Beachburg (Ontario) provenance of white spruce will be planted at several locations in the province to permit comparison of growth and seed production capability to the native spruces.

In areas of poor access and deep snow, the collection of spruce scions has been simplified by collecting directly from a helicopter. In addition to being cheaper, this method facilitates the assessment of candidate trees.

The professional and technical staff involved in seed production has increased to 10, with the hiring of an additional forester and four technicians in the past two years. Wherever possible, field work will include District staff to increase coverage of suitable stands and strengthen liaison with District personnel.

BREEDING PSEUDOTSUGA IN COASTAL BRITISH COLUMBIA

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B.C. Forest Service
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Intraspecific Crosses with Douglas Fir

The 28 test sites planted from 1966 to 1971 are being maintained on a regular basis, the main work being the early removal of natural regeneration particularly that of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco). Data on the measurements made subsequent to those reported in Research Note 55 are now being analysed. These include diameters at one third total height once the crosses are six years of age. The results already indicate that there are highly significant contrasts in volume between different crosses on the same test site. This is evident even when the crosses are half-sibs, the 1963 crosses, for example, all had a common female parent yet on good sites the volumes produced by the best are almost three times those of the poorest cross. Such differences are most encouraging for future breeding.

Attempts were again made to hybridize some of the Asiatic Pseudotsuga species growing in the Arboretum at Lake Cowichan which were described in the 1964 and 1971 Research Reviews. These trees were planted in 1960 and have produced regular cone crops but sparse pollen. Attempts were made to hybridize them with Douglas fir in 1968 and 1970 but no viable seed was produced. It was considered at that time that the cause for this failure was the difference in the number of chromosomes. In 1974 with the cooperation of the U.S. Forest Service fresh pollen was obtained from three Pseudotsuga macrocarpa trees in California. This species, popularly known as Big-cone Douglas fir has the same basic chromosome number of 12 as the Asiatic species of Pseudotsuga. Pollinations were made on three trees of P. sinensis from China and two trees of P. japonica from Japan. One hundred and three cones were collected but all of the 954 seeds produced were empty. A cytological investigation for the cause of this incompatibility would be of great interest. Attempts will be made to cross the Chinese and Japanese Pseudotsuga once sufficient pollen has been produced.

Inbreeding Studies with Douglas Fir

The results from inbreeding studies with Douglas fir which were initiated in 1952 have recently been summarized (Orr-Ewing, 1974). In brief, inbreeding studies to the S_1 generation in Douglas fir have shown that some dwarfing occurred in every selfed family. The percentage of viable seed obtained from inbreeding to the S_2 generation varied greatly with different S_1 inbreds and even with the same tree self-pollinated in different years. The yields were considerably lower than those obtained from backcrossing and full-sib matings on the same tree. Full-sib matings in particular gave normal yields of viable seed and there seems to be no incompatibility system as in self-pollination, to prevent it. The incidence of dwarfing was considerably higher in the S_2 generation and several different forms have been found. There was considerable variation in their distribution with the normal or tall forms both between and within selfed families. The tall seedlings in the S_2 generation developed into normal looking trees and some pollinations to the S_3 generation have been made. The dwarfs grow slowly and appear to be sterile, this has prevented further investigation into their mode of inheritance. A cytological study of the root tips of both dwarf and tall seedlings showed considerable instability in number of chromosomes. The implications of dwarfing in relation to seed production areas, seed orchards and nurseries requires serious consideration.

The Douglas Fir Arboretum at Cowichan Lake, Vancouver Island

It is generally recognised that the genus Pseudotsuga is divided into two families, the Asiaticae and the Americanae. The former are represented by four species, P. forrestii Craib. and P. wilsoniana Hayata from Formosa in addition to P. sinensis and P. japonica referred to previously. The Americanae are represented by two species, P. macrocarpa (Torr.) Mayr and P. menziesii (Mirb.) Franco. The latter species is by far the most important for a breeding program in this province owing to its wide distribution over very different conditions of climate and site. The objective of establishing this arboretum therefore, has been to provide as wide a gene pool as possible for racial crossing which appears a promising breeding method for Douglas fir. The first and last provenances established for this purpose were planted in 1958 and 1973 respectively and at the present time the arboretum contains some 216 provenances and 121 clones (Orr-Ewing 1973). These have been collected throughout the distribution of Douglas fir ranging in elevation from 100 to 10,850 feet, in latitude from 19°40 to 55°05 and in longitude from 98°07 to 125°40. The remaining five species of Pseudotsuga have also been established in the arboretum mainly from interest as some of them are extremely rare. They all have a different chromosome number to the Douglas fir, and the only successful cross to date has been made with P. macrocarpa. The yield of viable seed is so low however that the prospects of an interspecific breeding program are mot promising. It is probable that further additions will be made to the main arboretum in future years particularly with an expansion of the clonal collections from the U.S.A.

Publications

Orr-Ewing, A.L. 1973. The Douglas Fir Arboretum at Cowichan Lake Vancouver Island. Res. Note 57 B.C. For. Serv. 47 p.

Orr-Ewing, A.L. 1974. The Incidence of Dwarfing in Inbred Douglas Fir. Res. Note 64. B.C. Forest Serv. 26 p.

TREE IMPROVEMENT AT THE PACIFIC FOREST RESEARCH CENTRE, 1973-74

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The major tree improvement effort at the Pacific Forest Research Centre concerns western hemlock (Tsuga heterophylla (Raf.) Sarg.). Early emphasis is being directed toward the testing, over a range of environments, of selected hemlock populations from coastal British Columbia. Being studied concurrently are the performances of half-sib and full-sib families, the propagation and subsequent use of rooted cuttings, and the development of breeding methods and technology.

Certification of forest tree seed under the O.E.C.D. (Organization for Economic Cooperation and Development) scheme is another important part of the P.F.R.C. program. The P.F.R.C., as certifying agency for seed collected in British Columbia and the Yukon Territory, implemented the scheme in B.C. in 1970, and has since, annually, certified source-identified tree seed intended for export under the O.E.C.D. scheme.

Several related studies, conducted both in-house and through grants and contract research, support tree improvement in general. These studies include research into cone and seed insects, rooting of cuttings from mature trees, pollen storage and testing, phenology of vegetative and reproductive bud development, and the induction of precocious flowering. Under an advice and services study, seeds and pollen from B.C. species are collected and distributed to meet researchers' needs, within and outside British Columbia.

WESTERN HEMLOCK TREE IMPROVEMENT

Population study plantations

On most sites, seedlings surviving 4 years after planting are generally well established. There has been little change in survival rates since the second year following outplanting, with survival averages of about 75% on the better sites, and 45-50% on the drier, more exposed sites. Height differences among populations became evident after the second year, but since the results were highly variable within and between blocks due to the variable degrees of establishment among seedlings, no formal analyses were conducted. Third and fourth year heights are being assessed this year and the increment and total height will be analyzed. After four growing seasons in the field, many seedlings exceed 2 m in height, some approaching or exceeding 3 m. Since natural regeneration has been generally abundant in these plantations, considerable effort was given this year to preserving the identities of planted stock and eradicating the wild stock.

Family test and clonal plantations

Seedlings of 18 full-sib progenies produced from controlled crosses on 1-year-old rooted cuttings in 1970 were outplanted in early 1973, and subsequent growth and survival have been good. Seeds resulting from the 1973 partial-diallel intra-specific matings, carried out in part on rooted cuttings in the clone bank at Cobble Hill, were germinated in early 1974. Seedlings subsequently produced were grown in the shadehouse for one growing season, and then outplanted in the fall. The study was comprised of 39 crosses, including seven selfed families. The half-sib plantation established during 1970-72 has been severely decimated due to heavy grass competition and droughty conditions. No further half-sib field studies have been undertaken.

The growth and survival of outplanted rooted cuttings (now 5 years old) continues to be good. Most plants average 1 m, with some as tall as 2-3 m. In 1974, the cuttings produced a moderate crop of seed cones, but no pollen cones. However, in 1975, several clones produced pollen cones in addition to a good crop of seed cones. These cones were used in the breeding studies discussed below.

Breeding studies

The objectives of these studies have been twofold: 1) to develop and improve techniques for controlled-pollinations in western hemlock, and 2) to produce full-sib progenies for subsequent testing and breeding.

Since potential contamination problems with the terylene pollination bag have become apparent, different isolation systems, including rigid acetate tubes with foam plugs, were tested this year. *In vivo* tests were also undertaken with stored pollen and with fresh pollen collected on different dates and forced in the growth room. In addition, a feasibility study using detached branchlets for controlled-pollinations in the growth room was undertaken.

Because of the highly variable numbers of seed cones per clone and the general inadequate production of pollen, no formal breeding design has been followed. Priority has been given to producing as many selfed families as possible, along with outcrossed counterparts. Small-scale full-diallel crossing designs (3-6 parents) have also been attempted.

A cooperative chemosystematic study of the leaf oils of western hemlock was undertaken with Dr. E. von Rudloff of the N.R.C. Prairie Regional Laboratory. Initial emphasis has been on testing ramet differences to determine the degree of variability that can be expected among ramets of the same clone.

An attempt is being made to obtain seeds of all *Tsuga* species for future inclusion in a breeding arboretum. Of the 10 species occurring world-wide, seeds from five have been acquired.

An establishment report, covering the tree improvement study from its inception to the plantation establishment phase, has been published (Piesch 1974).

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

Over the past 2 years, Certificates of Provenance for source-identified forest tree seeds from B.C. and the Yukon have been issued for an additional 15 seedlots, bringing to 117 the total number of certificates issued since the scheme was implemented in 1970. The relatively small number of certificates issued recently reflects the poor cone crops during the past 2 years, particularly with respect to seed requirements for the export trade.

The national publication covering O.E.C.D. seed certification for Canada was revised in 1974 to reflect changes brought about in 1973-74 in the international O.E.C.D. regulations. The publication is currently in press (Anon. 1975).

RELATED SUPPORT STUDIES

A preliminary assessment was conducted by A. Hedlin on the nature, extent of damage, and species involved, of graft-mining *Dioryctria* in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seed orchards. Clonal effects on damage caused by seed and cone insects were also studied. A handbook, covering the important cone and seed insect pests in British Columbia, was published (Hedlin 1974).

Studies on the rooting of cuttings from mature trees have continued under the direction of H. Brix. Two reports on the rooting of Douglas-fir cuttings were published (Brix and Barker 1973, Brix 1974) and a report on the rooting of western hemlock is in preparation.

Through contract research, studies on pollen storage and testing have been conducted, resulting in two publications (Binder *et al*. 1974, Binder and Ballantyne 1975). The phenology of vegetative and reproductive bud development for western hemlock and Sitka spruce (*Picea sitchensis* Bong. Carr.) has also been studied through contract research. Two reports have been published (Owens and Molder 1973, 1974) and a third is in manuscript form. A science subvention grant was renewed in support of studies on precocious flowering of Douglas-fir and lodgepole pine (*Pinus contorta* Doug). through the application of gibberellins. Dr. C.G. Kuo, an N.R.C. Post-doctoral Fellow at the P.F.R.C., has completed his studies on the control of juvenility and flowering of western hemlock and grand fir (*Abies grandis* (Dougl.) Lindl.) through the application of plant regulatory substances and cultural treatments. A report covering the studies on 1-year-old seedlings of western hemlock is in preparation.

A final objective of the P.F.R.C. tree improvement program is to provide, upon request, forest reproductive material to research institutions, within and outside Canada. Seeds from 25 tree species from B.C. and the Yukon and pollen from six species have been collected and distributed, mostly in response to requests channelled through the C.F.S. Petawawa Seed Unit. Seeds were also collected for in-house balsam woolly aphid and white pine blister rust studies.

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Binder, W.D., G.M. Mitchell and D.J. Ballantyne. 1974. Pollen viability testing, storage and related physiology: A review of the literature with emphasis on Gymnosperm pollen. C.F.S. Rpt. BC-X-105.

Binder, W.D. and D.J. Ballantyne. 1975. The respiration and fertility of *Pseudotsuga menziesii* (Douglas fir) pollen. Can. J. Bot. In press.

Brix, H. and H. Barker. 1973. Rooting studies of Douglas-fir cuttings. C.F.S. Inf. Rpt. BC-X-87.

Brix, H. 1974. Rooting of cuttings from mature Douglas-fir. New Zealand J. For. Sci. 4(2).

Hedlin, A.F. 1974. Cone and seed insects of British Columbia. C.F.S. Rpt. BC-X-90.

Owens, J.N. and M. Molder. 1973. Bud development in western hemlock: I. The annual growth cycle of vegetative buds in western hemlock. Can. J. Bot. 51(11).

__________________________. 1974. Bud development in western hemlock: II. Initiation and early development of pollen cones and seed cones. Can. J. Bot. 52(2).

Piesch, R.F. 1974. Establishment of a western hemlock tree improvement program in coastal British Columbia. C.F.S. Inf. Rpt. BC-X-89.

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

O. Sziklai

Faculty of Forestry
University of British Columbia
Vancouver, British Columbia

ACADEMIC PROGRAM

Undergraduate

The undergraduate forestry course on "Forest Genetics" (For. 302) as an elective course was taken by 18 students during the second term of 1973/74. For the 1974/75 year, there were 25 students in this course.

Graduate

Completed:

Mrs. Maria Adela de Vescovi, M.Sc., "Comparative Karyotype Analysis of Four Douglas-Fir (Pseudotsuga menziesii (Mirb.) Franco) Provenances", May, 1974.

Mr. Emil Falkenhagen, Ph.D., "A Study of the Phenotypic and Genotypic Variation of 545 Single Tree Progenies of 38 Provenances of the I.U.F.R.O. Sitka Spruce (Picea sitchensis (Bong.) Carr.) Collection", May, 1974.

In residence:

Mr. Ken Bartram commenced his M.F. programme in September, 1974, on "Intra-specific Hybridization of Lodgepole Pine".

In absentia:

Mr. M.D. Meagher is in the process of completing his Ph.D. thesis on "Studies of Variation in Hemlock (Tsuga) Populations and Individuals from British Columbia".

RESEARCH PROGRAM

Forest genetics research concentrated mainly along the lines of studying the variations and heritabilities of progenies and provenances of selected Western North American conifers in the Pinaceae family.

Tree breeding program was devoted to select lodgepole pine trees from the most northerly range of the species in central Yukon. Twenty-four plus trees were selected during the summer of 1974. There is now a total of 184 plus trees which were selected between the 54th and 64th latitudes during the years of 1970, 1971 and 1974. Seed and scion samples were sent to Sweden where this species is substantially surpassing in volume production the native Swedish pine, and scions were provided for the B.C.F.S. and grafted in Prince George.

The selection in the summer of 1974 extended the most northerly range of lodgepole pine close to the 64th latitude and discovered stands over 3,000 feet elevation at this latitude. Presently, needle, wood, seed morphology, polyembryony and isozyme patterns are being studied from these samples.

PUBLICATIONS AND PAPERS

Sziklai, O. 1974. Juvenile-Mature Correlation. Invited paper I.U.F.R.O. Joint Meeting of Working Parties on Population Genetics (S.2.04.1), Breeding Theory (S.2.04.2) and Progeny Testing (S.2.04.3). August 30 - September 5, 1974.

Sziklai, O. 1974. Seed Orchards - Basic Concepts and Possibilities for Genetic Improvement. Northwest Lookout VII(3):13, 28, 37.

Accepted for Publication to "Silvae Genetica":

El-Lakany, M.H. and O. Sziklai. Effects of Seed Extracts on Radiosensitivity. 8 pp.

De-Vescovi, M.A. and O. Sziklai. Comparative Karyotype Analysis of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). 11 pp.

Reck, S. and O. Sziklai. Juvenile-Mature Correlation in Wood Characteristics of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). 11 pp.

Papers presented at the Northwest Scientific Association Meeting in Ellensburg, Wash. on March 28, 1975;

Nyland, E. and O. Sziklai. Some Observations on the Northerly Distribution of lodgepole pine in the Yukon.

De-Vescovi, M.A. and O. Sziklai. Observation on Needle Characteristics of lodgepole pine in Central Yukon.

Kvestich, A. and Peter Sziklai. Polyembryony of lodgepole pine in Central Yukon.

SEMINAR: APPLIED GENETICS IN FOREST MANAGEMENT (PROCEEDINGS, PART 2) LIST OF AUTHORS AND TITLES

CONTENTS

FIELD TRIPS

During the afternoons of Tuesday, August 19 and Thursday, August 21, members of the C.T.I.A., L.S.F.T.I.C. and C.I.F., led by C.W. Yeatman toured the Petawawa Forest Experiment Station.

Tour I - August 19 included:

Pine Graft Arboretum

(1) Range-wide jack pine provenance test to study the genetic and environmental components of phenotypic variation with geographic source.

(2) Scots pine clones of southern Ontario and European origin established to:

i) test, select and breed for growing Christmas trees

ii) test early flowering Scots pine clones as parents for graft root stocks

iii) demonstrate clonal differences in winter hardiness and insect and disease susceptibility.

(3) Lodgepole pine and hybrids with jack pine have proven to be highly susceptible to sweetfern blister rust (*Cronartium comptoniae* Arth.).

(4) Red pine clones from trees found near Bancroft, Ontario, reflect the extreme fastigate form of the ortets.

Young Creek Area

(1) Exp. No. 79 - Black spruce provenances to observe variation among provenances of Ontario, Quebec, Maritimes and Newfoundland origin.

(2) Exp. No. 96-G - Red pine provenances from Eastern Canada and Lake States to test for variation in survival and growth.

(3) Exp. No. 125 - Sixteen Lake States provenances of jack pine to compare provenances for differences in survival, hardiness and growth.

(4) Exp. No. 40 - Twelve Ontario jack pine provenances to evaluate provenance differences in growth rate, crown form and insect resistance.

Thomas Field

(1) I.U.F.R.O. Norway spruce provenances to study geographic variation in yield, hardiness and white pine weevil damage.

Fuelwood Area

(1) Exp. No. 120-B - Norway spruce open pollinated progeny test to:

i) evaluate plus and minus progenies

ii) identify superior seed parent trees

iii) incorporate the best progenies into a breeding program for improved Norway spruce.

(2) Exp. No. 95-H - Fourteen provenances of red spruce to locate populations that are superior in silvicultural characters and can be used directly in forest planting. Demonstrates introgressive hybridization with black spruce.

Headquarters Area

(1) Tree climbing and seed collection demonstration.

(2) Seed extraction and seed storage.

Tour II - August 21 included:

Sturgeon Lake Area

(1) Exp. No. 332-4 - A jack pine progeny test of trees and stands in the Upper Ottawa Valley.

(2) Plus tree selection in natural stands in jack pine 11-years-old regenerated after fire and 70-year-old pine of the same population.

Hudson's Place

(1) Exp. No. 4 - 57-year-old Norway spruce of German origin demonstrates differences in winter hardiness, white pine weevil damage, crown form and growth and yield.

(2) Exp. No. 13 - Dunkeld, Scotland hybrid larch test.

(3) Exp. No. 11 - 58-year-old red spruce of Quebec origin was planted to observe hardiness, growth and morphology of this species that is not native to Petawawa.

Corry Lake Nursery

(1) Exp. No. 341-A-1 - Hybridization of *Picea mariana*, *P. omorika* and *P. glehnii* to determine crossability patterns, survival, hardiness, susceptibility to insects and disease, and growth of the hybrids. The hybrids *P. omorika* x *mariana* and *P. mariana* x *glehnii* are heterotic in this test where they are taller than the parental species.

Cottage Road Plantation

(1) Exp. No. 331-1 - Demonstration of 5 x 5 diallel cross in local white spruce. Virescent mutants have been observed in some combinations, inbreeding depression is evident, parents differ in general combining ability.

Seed Centre

(1) Seed testing, research, certification and seed bank.

Tree Physiology

(1) Growth acceleration, early testing and biochemical studies.

Ottawa Valley Field Trip - August 22

The tour of the Ottawa Valley by bus was led by Dr. Morgenstern, P.F.E.S., and Dr. Zsuffa, O.M.N.R., Maple, and included the following itinerary:

STOP 1 Westmeath - Beachburg road

Brief description of the Ottawa Valley area, forest types and white spruce populations in the Beachburg vicinity and view of natural white spruce remaining in Beachburg area.

STOP 2 Hubert Farm, Ross Twp.

Test of hard pine (*Pinus densiflora*, *P. nigra*, *P. sylvestris*) hybrids planted in 1974 by Ontario Ministry of Natural Resources.

STOP 3 Rook Farm, Wilberforce Twp.

Hybrid popolar clonal test established 1973 by O.M.N.R. Individual trees reach 4 m. in height in 1975. Best clones are fast growing, winter hardy and disease resistant.

STOP 4 Leitrim

Experimental plantations of exotic poplar species and their hybrids and a hybrid poplar clonal test, Ottawa District. Established by O.M.N.R. in 1970 and 1972. There are a great number of diversified trees in these plantations. Some populations show interesting forms and outstanding growth, with the tallest trees exceeding 10 m in height in 1975.

OTTAWA VALLEY SNAPSHOTS

FIELD TRIP -- 22 AUGUST 1975

Louis Zsuffa tells all about poplar

Louis and Don Fowler look at it both ways.

Keith Illingworth listens to the professor, Oscar Sziklai.

Don Fowler, John Santon and Al Gordon debate in earnest.

Kris Morgenstern takes the high view.

Kit Yeatman, John Santon and Narinder Dhir admire the poplar plantations.

ATTENDANCE - GENETICS '75

C.T.I.A., L.S.F.T.I.C., C.I.F. - Joint Meeting
Petawawa Forest Experiment Station
Chalk River, Ontario, August, 1975

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