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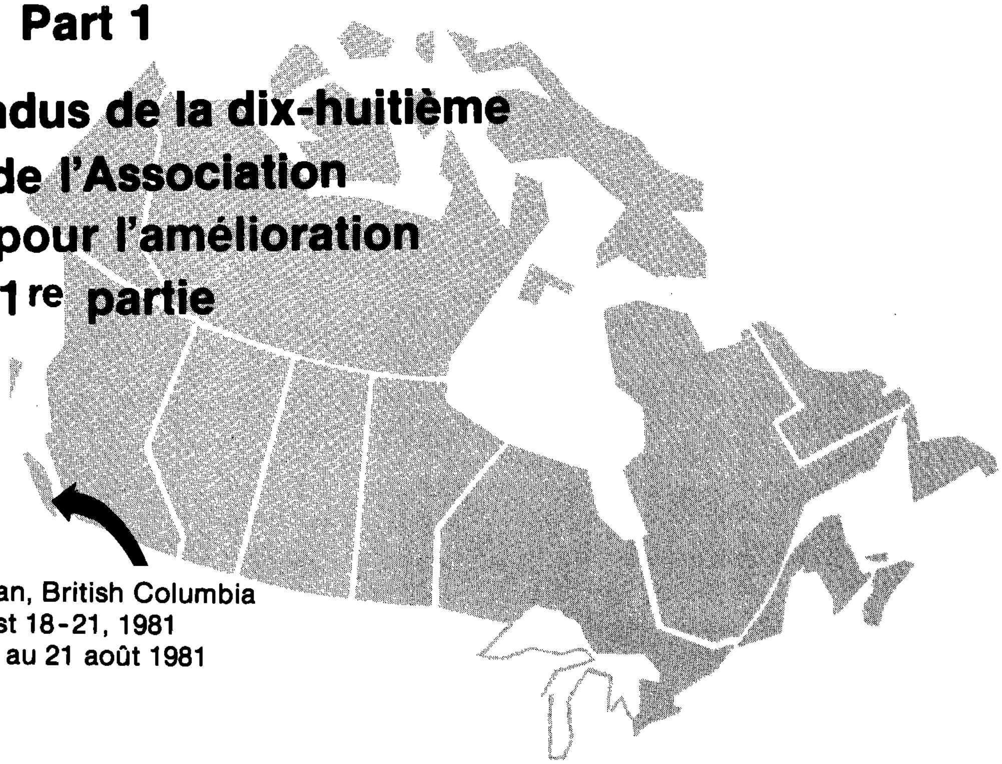
Proceedings of the eighteenth meeting of the Canadian Tree Improvement Association: Part 1

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



Duncan, British Columbia
August 18-21, 1981
du 18 au 21 août 1981

Minutes and members' reports

Procès-verbaux et rapports

PROCEEDINGS

OF THE

EIGHTEENTH MEETING

OF THE

CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 1:

MINUTES AND MEMBERS' REPORTS

HELD IN
DUNCAN, BRITISH COLUMBIA
AUGUST 18-21, 1981

EDITOR: C.W. YEATMAN

Part 1. Minutes and Members' Reports

Distributed to Association members and to others on request to the Editor, C.T.I.A./A.C.A.A., Chalk River, Ontario. Canada, K0J 1J0

Part 2. Symposium: Seed Orchards and Strategies for Tree Improvement.

Distributed worldwide to persons and organizations actively engaged or interested in forest genetics and tree improvement.

Additional Copies of this publication are available from:

Editor C.T.I.A./A.C.A.A.
Canadian Forestry Service
Petawawa National Forestry Institute
Chalk River, Ontario K0J 1J0

Produced by
Canadian Forestry Service,
Environment Canada,
for the
Canadian Tree Improvement Association,
Ottawa, 1982

COMPTES RENDUS

DE LA

DIX-HUITIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

1RE PARTIE:

PROCÈS-VERBAUX ET RAPPORTS DES MEMBRES

TENUE À
DUNCAN COLOMBIE-BRITANNIQUE
DU 18 AU 21 AOÛT 1981

RÉDACTEUR C.W. YEATMAN

1re partie. Procès-verbaux et rapports des membres.

Distribués aux membres de l'Association et aux autres sur demande au rédacteur, C.T.I.A./A.C.A.A., Chalk River, Ontario, Canada, KOJ 1J0

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Environnement Canada,
pour
l'Association canadienne pour l'amélioration des arbres,
Ottawa, 1982

PROCEEDINGS OF THE EIGHTEENTH MEETING OF

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association

Enquiries may be addressed to the authors or to Mr. M.J. Coles, Executive Secretary, C.T.I.A./A.C.A.A., N.B. Executive Forest Research Committee Inc. 500 Beaverbrook Court, Fredericton, N.B. E3B 5X4.

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The Ninteenth Meeting of the Association will be held in Toronto, Ontario, August 22-26, 1983. Speakers will be invited to address the topic of Vegetative Propagation and its Impact on Genetic Improvement and our Future Forests. Canadian and foreign visitors are welcome. Further information will be distributed in the fall 1982 to all members and to others on request. Enquiries concerning the 19th Meeting should be addressed to: Miss R.M. Rauter, Chairman, C.T.I.A./A.C.A.A., Forest Resources Branch, Ontario Ministry of Natural Resources, Parliament Buildings, Toronto, Ontario M7A 1W3.

To: *Dr. C.W. Yeatman, Editor, C.T.I.A./A.C.A.A.*
Canadian Forestry Service
Petawawa National Forestry Institute
Chalk River, Ontario K0J 1J0
CANADA

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COMPTES RENDUS DE LA DIX-HUITIÈME CONFÉRENCE

DE L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

Gracieuseté de l'Association

Les demandes de renseignements peuvent être adressées aux auteurs ou à M.J. Coles, Secrétaire exécutif, A.C.A.A./C.T.I.A., N.B. Executive Forest Research Committee Inc. 500 Beaverbrook Court, Fredericton, N.B. E3B 5X4.

SI VOTRE ADRESSE EST INEXACTE OU INCOMPLÈTE SUR L'ÉTIQUETTE, S.V.P. RETOURNER LA FICHE DE CORRECTION CI DESSOUS

Les autres qui seraient interessés à recevoir les comptes rendus, les avis de réunions, etc., peuvent retourner la formule pour être ajouté à la liste des membres correspondants (Canadiens) ou à la liste postale pour les comptes rendus seulement (bibliothèques, institutions, destination étrangères). Si vous ne désirez plus recevoir ces comptes rendus, veuillez cocher "rayer" et retourner la formule completée à l'éditeur.

La dix-neuvième conference de l'Association aura lieu à Toronto, Ontario, du 22 au 26 Août 1983. Des orateurs seront invités à s'adresser au sujet de la propagation végétative et son impact sur l'amélioration génétique et sur nos forêts futures. Tous sont bienvenues. Des informations supplémentaires seront distribuées durant l'automne de 1982 à tous les membres et à tous ceux qui en feront la demande. Ces demandes de renseignements concernant la dix-neuvième réunion devrons être adressées à: Miss R.M. Rauter, Chairman, C.T.I.A./A.C.A.A., Forest Resources Branch, Ontario Ministry of Natural Resources, Parliament Buildings, Toronto, Ontario M7A 1W3.

À: *Dr. C.W. Yeatman, éditeur, A.C.A.A./C.T.I.A.*
Environnement Canada
Service canadien des forets
Institut forestier national de Petawawa
Chalk River, Ontario K0J 1J0

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M. *Mlle.* . . . .

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June 1982

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Dr. Cheng Ying	Research Branch B.C. Ministry of Forests 1450 Government Street Victoria, B.C., V8W 3E7
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Mr. M.B. Barkhouse	Silviculture Forester Bowater Mersey Paper Co. P.O. Box 1150 Liverpool, N.S., B0T 1K0
Mr. B. Phillion	Ministry of Natural Resources Orono Tree Nursery Orono, Ontario, L0B 1M0

BUSINESS MEETING - MINUTES

J.C. Heaman chaired the 18th Business Meeting of the C.T.I.A./ A.C.A.A. which was called to order at 8:45 p.m. August 19, 1981.

207. MINUTES OF THE LAST MEETING

Motion: That the minutes of the 17th meeting be adopted as published.

Moved by B.S.P. Wang, seconded by J. Thompson. Carried.

208. MEMBERSHIP

The following nominees for Sponsoring and Active membership were presented:

a) New Members

1) Sponsoring

Mr. F.L.C. Reed	Assistant Deputy Minister Canadian Forestry Service Ottawa, Ontario

2) Active

Dr. J.E. Barker	Western Forest Products
Mr. C.A. Bartram	B.C. Ministry of Forests
Mr. J. Bégin	Canadian International Paper Co.
Mr. R.D. Bettle	N.B. Dept. of Natural Resources
Mr. P. Bizens	B.C. Ministry of Forests
Mr. T.J.B. Boyle	Canadian Forestry Service
Mr. W. Cheliak	Canadian Forestry Service/University of Alberta
Dr. U. El-Kassaby	University of British Columbia
Dr. R. Ho	Ontario Ministry of Natural Resources
Mr. J. Hood	Ontario Ministry of Natural Resources
Mr. B. Jaquish	B.C. Ministry of Forests
Ms. S.E.T. John	Canadian Forest Products
Dr. M.H. Knowles	Lakehead University
Dr. D.T. Lester	Crown Zellerbach
Dr. J. Maze	University of British Columbia
Mr. L.K. Miller	Ontario Ministry of Natural Resources
Mr. M.A. Mubareka	Fraser Company
Dr. W.H. Parker	Lakehead University
Ms. D. Roddy	Prince Albert Pulpwood Ltd.
Dr. S.D. Ross	B.C. Ministry of Forests
Mr. D. Simpson	Canadian Forestry Service
Mr. R.G. Wasser	Irving Company

3) Corresponding

The names of 66 new Corresponding Members were added to the list of Canadian addressees during 1979-81.

b) Change of Status from Active to Corresponding

A.C. Carlisle
K.C. Eng

c) Change of Status from Corresponding to Active

Mr. W.D. Baker
Mr. G. Dunsworth
Ms. Anita M.K. Fashler

Motion: That the prospective members (as listed) be duly elected.

Moved by K. Illingworth, seconded by D. Winston. Carried.

209. FINANCIAL STATEMENT

Financial statement prepared by C.W. Yeatman, Editor/Treasurer, was tabled for membership information and acceptance. It showed that as of July 29, 1981 the Association's account had a balance of $2,411.56.

Motion: That the financial statement as presented be accepted.

Moved by J.I. Klein, seconded by E.K. Morgenstern. Carried.

210. FINANCIAL CONTRIBUTIONS FOR THE 1981 SYMPOSIUM

J.C. Heaman explained that the forest industries and provincial Forest Services in B.C. and Alberta were approached for contributions to pay for travelling expenses of several invited symposium speakers. A total amount of $2,895.00 was kindly contributed by the following organizations.

British Columbia

British Columbia Forest Products Ltd.
Canadian Forest Products Ltd.
Crown Zellerbach Canada Ltd.
MacMillan Bloedel Ltd.
Northwood Pulp and Timber Ltd.
Pacific Forest Products Ltd.
Tahsis Company Ltd.
Weldwood of Canada Ltd.
West Fraser Mills Ltd.

Alberta

Alberta Forest Service
Canadian Forest Products Ltd., Alberta Operations
Procter and Gamble Cellulose Ltd.
St. Regis (Alberta) Ltd.

The membership expressed gratitude for the generous contributions provided by these organizations. Gratitude was also expressed for the luncheons provided by the Government of British Columbia and by the Research Branch of the B.C. Ministry of Forests.

211. EDITOR'S REPORT

The report of the Editor (C.W. Yeatman) outlining concerns and suggestions on publication of C.T.I.A./A.C.A.A. proceedings, membership and distribution list, and constitution and bylaws was presented for information and discussion. It was noted with appreciation that the Canadian Forestry Service will continue to publish the Proceedings, parts 1 and 2. However, constitution and bylaws and membership and distribution list will have to be published by the Association itself. The desirability of continuing to print and distribute the membership directory and list of foreign addressees was discussed and debated. It was finally agreed that the next executive should consider the cost and desirability of publishing and distributing the directory and make the appropriate decision.

The report noted that the number of Canadian addressees in July 1981 stood at 428, including 6 Honorary members, 24 Sponsoring members, 83 Active members, 204 Corresponding members and 110 libraries and institutions. In addition, foreign addressees included 184 in the United States and some 219 in other countries around the world. Members were reminded and requested to send corrections and additions to the Editor as they occur.

212. BUSINESS ARISING FROM PREVIOUS MEETINGS

a) EDUCATION COMMITTEE AND SCHOLARSHIP FUND

The report prepared by C.W. Yeatman of the Standing Committee on Forest Education appointed by the 17th meeting of the Association was read by F. Yeh. The Committee was formed to draw up terms of reference for a Forest Genetics Scholarship Fund in accordance with the motion (item 192) approved at the Association's 16th meeting. The Committee was instructed (item 200c): (a) to complete, if possible an agreement on terms of reference with appropriate co-sponsors for ratification by the Association's executive and subsequently, (b) to solicit contributors for the Scholarship Fund in accordance with the accepted terms of reference.

F. Yeh informed members that the Committee's efforts to find appropriate co-sponsor(s) were not successful; Canadian Pulp and Paper Association, Canadian Forestry Association, and Canadian Institute of Forestry were approached. Although there was widespread support for creating a scholarship fund, prospects for establishing it were not encouraging. Considerable discussion took place with members speaking both in favor and against continuing efforts to establish scholarship fund. Support was also voiced in favor of a proposal communicated in a letter by C.W. Yeatman suggesting that C.T.I.A./A.C.A.A. should take on a functional project in education and establish a prize or a scholarship. It was decided that the next executive consider various alternatives to continue the Association's involvement in improving quality of forest genetics education and training in Canada and decide on an appropriate course of action that may best serve this objective.

b) CONSTITUTION AND BYLAWS

N. Dhir informed members that the Constitution and Bylaws incorporating amendments approved by the 17th meeting of the Association had been printed and distributed to membership.

213. FUTURE MEETINGS

a) LOCATION OF 1983 MEETING

The chairman called to attention the resolution passed by the 17th meeting which stated that the 19th meeting of the Association be held in Ontario in 1983. R.M. Rauter confirmed that the Ontario Ministry of Natural Resources will host the meeting which will be held at Maple/Toronto.

The possibility of joint meeting in 1983 with North Central Tree Improvement was also explored (item 202e). However, it was learned that NCTIA had decided to hold its 1983 meeting at Wooster, Ohio and invited C.T.I.A./A.C.A.A. to coordinate meeting dates and programs in a manner that participants at both C.T.I.A./A.C.A.A. and NCTIA meetings can have opportunity to attend the two meetings. The invitation was well received and it was decided that next executive should discuss meeting dates and programs with the NCTIA to see if it can be arranged.

b) THEME FOR 19TH MEETING

Suggestions were asked for the symposium theme for the 19th meeting. These were: (1) indepth consideration of alternate breeding strategies (Rauter), (2) genetic improvement strategies in vegetative propagation production systems (Klein), (3) correspondence of realized genetic gains with predicted genetic gains (Jensen), (4) genetic improvement of hardwoods (Morgenstern), (5) provenance research: critical values related to tree breeding (Yeh). It was decided that the new executive take these suggestions into consideration to decide an appropriate theme for the 1983 meeting.

c) LOCATION OF 1985 MEETING

In accordance with the suggestions discussed at the 16th and 17th meetings, invitations were received from Nova Scotia Dept. of Lands and Forests for holding the meeting in Nova Scotia, and from Le Comité de recherche en génétique et amélioration forestières for holding the meeting in Québec City, Québec. The general consensus was that the 1985 meeting be held in Québec.

Motion: That the invitation from Le Comité de recherche en génétique et amélioration forestières to hold 20th meeting of C.T.I.A./A.C.A.A. in Québec City be accepted.

Moved by M. Crown, seconded by J. Bégin. Carried.

d) LOCATION OF 1987 MEETING

Suggestions were requested for possible locations for 1987 meeting. G. Kiss suggested Vernon, B.C.; T. Mullin suggested Nova Scotia; J. Klein suggested Edmonton, Alberta.

214. ELECTION OF OFFICERS

K. Illingworth and E.K. Morgenstern were appointed as nominating committee and proposed the following slate of officers:

Chairman	Miss R.M. Rauter
Vice-chairman	Dr. L. Zsuffa
Vice-chairman (Local Arrangements)	Mr. J. Hood
Executive Secretrary	Mr. J. Coles
Editor/Treasurer (see item 215b,c)	Dr. C.W. Yeatman

Additional nominations were called from the floor, but none were received.

Motion: That the slate of officers proposed by the nominating committee be elected.

Moved by K. Illingworth, seconded by O. Sziklai. Carried.

215. NEW BUSINESS

a) SEED REGULATIONS

D. Pollard briefly described a proposal for suggested involvement of C.T.I.A./A.C.A.A. in setting certain technical standards for Seed Regulations as part of Canada Seed Act.

Motion: That the Executive of C.T.I.A./A.C.A.A. appoint a sub committee to: (1) study the proposed regulations for forest tree seeds pertaining to the Canada Seeds Act, (2) appraise the proposed role of the C.T.I.A. in establishing standards for these Regulations, and (3) make recommendations to the Executive for further action.

Moved by D. Pollard, seconded by J. Klein. Carried.

b) AMENDMENTS TO CONSTITUTION AND BYLAWS (1981)

Motion: That the C.T.I.A./A.C.A.A. Constitution and Bylaws be amended by inserting the word underlined in Article IV.a and adding Article V.g. as follows:

Article IV.
Executive
a. The Executive of ... an Executive Secretary, an Editor and a Treasurer

Article V.
g. Treasurer

The Treasurer shall take office upon completion of the meeting which elected the new Executive. The Treasurer shall be responsible for receiving and distributing funds on behalf of the Association, and for maintaining accurate and up-to-date records of Association's accounts.

Moved by J. Klein, seconded by A. Gordon. Carried.

c) ELECTION OF TREASURER

Nominations for Treasurer were invited from the floor. Only one nomination was received, that of Dr. C.W. Yeatman.

Motion: That Dr. C.W. Yeatman be elected as Treasurer of C.T.I.A./A.C.A.A.

Moved by A. Gordon, seconded by G. Edwards. Carried.

216. ADJOURNMENT

Motion: That the 18th Business Meeting of the C.T.I.A./A.C.A.A. be adjourned.

Moved by G. Kiss, seconded by G. Edwards. Carried.

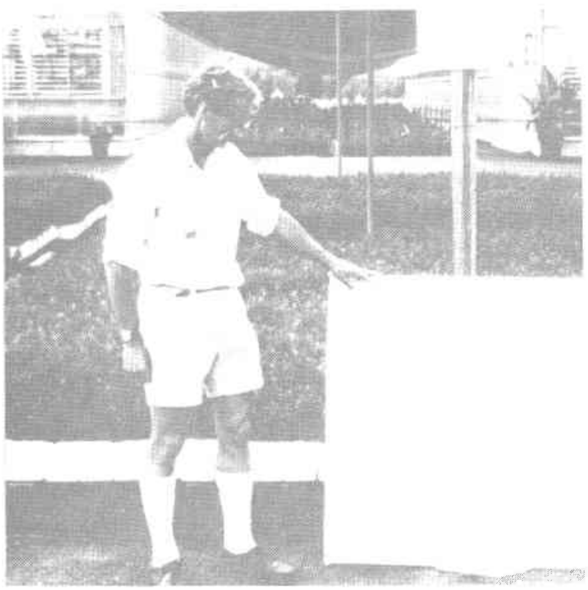
Narinder K. Dhir
Executive Secretary

FIELD TRIPS
VANCOUVER ISLAND
AUGUST 1981

C.T.I.A. / A.C.A.A. FIELD TRIP '81

"Any more smart questions?" HEATHER RUTHERGLEN (B.C. Forest Service) explains the Seed Extraction Plant at Duncan.

"Come on, get moving." HENNING JENSEN (B.C. Forest Service) herds his group around Koksilah Seed Orchard.



"The evidence is overwhel . . . " CHRIS HEAMAN describes progeny tests at Cowichan Lake Experiment Station.

"Gee, I wonder if they will grow in Ontario." MARIE RAUTER and BEN WANG at Cowichan Lake.

VANCOUVER ISLAND, B.C.

"Tell us another one." BOB ACKERMAN, OLA ROSVALL (Sweden), JERRY KLEIN, HANS VAN BUIJTENEN (Texas A&M), CHRIS MORGENSTERN, RON SMITH et al. at Mount Newton Seed Orchard.

"My glasses are here somewhere." ROY FAULKNER (British Forestry Commission) prepares to launch into the keynote speech.

"Pst! Beer's at back." WILLARD FOGAL (right) among friends at Saanichton Seed Orchard.

"This one we stole from Koksilah." DIANA ANDREW (Pacific Forest Products) and ALAN ORR-EWING admire contents of the Saanichton Seed Orchard, with JOHN CONWAY, LORNE BRACE, MIKE CROWN, and BRUCE DEVITT.

COWICHAN LAKE RESEARCH STATION

On the second afternoon, the members toured the British Columbia Ministry of Forests' Research Station and propagation centre at Cowichan Lake.

The Research Station was established in 1929 and was used initially for silvicultural projects; thinning, site classification and cone crop surveys. A camp was built to include bunkhouse and cook house to serve as a base for Reforestation Division's planting and snag-falling projects in the 1950's and early 1960's. These facilities are now maintained by Research Branch to provide accommodation and meals for visiting tours, training sessions and Ministry of Forests' field crews. The Federal Forestry Service also established a field laboratory there for studies of entomology and pathology but this is no longer in use. When Dr. Alan Orr-Ewing, the first tree breeder in British Columbia, started to accumulate material for tree improvement work in Douglas fir in the 1950's, the Research Station became the centre for much of this work and propagation of grafted and seedling material became a major function. A nursery was started to raise stock for progeny tests and research projects and a greenhouse was added later for container stock production. Each year since 1975 for example about 50,000 controlled cross seedlings have been raised for the Douglas fir breeding project.

As the programs expanded work on the other species was started, including the raising of seedlings for provenance studies in Interior spruce, Douglas fir and lodgepole pine, open-pollinated progenies for the western hemlock program and the development of yellow cedar projects.

With the advent of the Coastal Tree Improvement Council in 1979, the decision was made that all propagation for the orchards managed within the Cooperative and for clone banks would be centered on the Research Station. The facilities were therefore greatly expanded and by 1981 propagation in eight species amounted to over 32,000 grafts and 74,000 cuttings, (which included 40,000 cuttings of yellow cedar for use directly in high elevation reforestation).

Apart from the nursery complex, the experimental area comprises the breeding collection of Douglas fir, both clone banks of material grafted from selected trees, and seedlings from throughout the species' range, which will be available for wider breeding studies. Alan Orr-Ewing's collection of inbred material and some examples of older progeny tests also are on the area, while research into rootstock origins, graft incompatibility testing and other studies, such as cone stimulation, make use of the facilities and material. A hedged orchard of yellow cedar is maintained to provide material for direct reforestation by cuttings; also a plantation of seedlings and cuttings, which will eventually be available as a seed source for this species, is on the Research Station.

While emphasis on tree improvement has increased, silviculture research has been continued with the old thinning plots being maintained and the establishment of permanent sample plots, on which managed-stand yield tables can be based. Site classification work has also continued, including permanent demonstrations for teaching purposes.

At a second segment of the Research Station in the North Arm forest a few km away, a breeding collection of lodgepole pine, early trials with Pacific silver fir and land clearing for major clone bank projects are located.

With a single afternoon and almost 200 members on the tour, planning the field trip to cover as many points as possible posed a challenge, but this was met by splitting the tour into three parts and rotating groups among all stops. The North Arm forest had to be left out altogether.

One group started at the nursery and propagation houses. Here the techniques used for the British Columbia programs were demonstrated and the alternatives discussed. The grafting methods and, in particular, the methods of handling the rootstock and the developing ramets before they are large enough to ship to the orchards led to lively discussion. The methods used to root yellow cedar for production planting provided a look at what was, to many people, an unfamiliar species for reforestation and use of the Spencer Le Maire containers, in which the cuttings are taken right to the field site without root disturbance, received special attention. A look at the long-season Styro 8 seedlings from controlled pollinated families from the Douglas fir breeding project provided an opportunity to outline the objectives and progress of that project. (Details of these projects appear in the members reports.)

A second group was taken first to the hedging orchard of yellow cedar, a new concept in our reforestation program. Yellow cedar is a minor reforestation species but it has an important function in management of high elevation sites on the coast. Seed procurement and handling present a problem (which may be overcome eventually through cone stimulation techniques), and tests are showing already that rooted cuttings, which can be obtained very successfully from young material, will grow well compared to seedlings. The "orchard" consists of rows of half-sib families from selected parents from throughout the zone of utilization. The seedlings are clipped into bushy form to increase the number of cuttings available and to maintain juvenility.

This group then went on to see plantations of Douglas fir, and the oldest clone banks in B.C., dating from 1956 and 1958. These, with the more recent grafting, provided the basis for discussion of graft incompatibility in the species and the work that Ingemar Karlsson (Manager of the Research Station) is doing to select more compatible sources of rootstocks. Successful cone and pollen stimulation through girdling was also demonstrated. Time permitted only a brief glimpse of the 1971 plantation of wide interracial crosses now showing clear differences in performance.

The third group started with the silvicultural projects, including the oldest thinning plots in Douglas fir on the Pacific coast (which were established by Schenstrom in 1929), the fertilizer and thinning regimes of recently-established plots for the managed-stand-yield-tables, and finally a view of two selected plus tree parents used in the Douglas fir breeding program. These provided a basis for discussion of the selection criteria and an appraisal of the parent material needed for any breeding program.

The objective of the tour was to expose the members to the work at the Cowichan Lake Research Station, and while raising unanswered questions, it at least provided a physical picture of the tree improvement work that can be followed in detail in the members' reports and their publications. The tour also provided a breath of fresh air and gave those from outside B.C. a chance to see some stands and plantations for themselves. With the potential for growth modification seen at the thinning plots, the need for the breeders and managers to maintain close contact was emphasized.

The spouses and families joined the tour for lunch at the cookhouse and the C.T.I.A. owes a debt of gratitude to the Research Branch of the Ministry of Forests who provided an excellent meal for 200 people. Only the weather was a disappointment when, after a recent hot spell, it became cool and windy and only a few hardy souls stayed for a swim.

PANEL DISCUSSIONS

SPRUCES

HARD PINES

WEST COAST SPECIES

PANEL DISCUSSION

SPRUCES

Chairman: J. Coles
Panel Members: A. Gordon, G. Kiss
Rapporteur: N. Dhir

Accomplishments and work in progress on genetics, genetic improvement and related research on major species of genus Picea across Canada was reviewed and discussed. Although most of the work has been concentrated on white spruce and black spruce; starting in recent years, more attention is being paid to sitka spruce, Englemann spruce, red spruce and interspecific hybridization among selected spruce species.

Starting in 1950's through the work pioneered by Petawawa Forest Experiment Station, a large number of provenance research plantations have been established throughout Canada. These experiments are yielding valuable information on geographic variability, species adaptation, seed source hardiness and superiority. Research results demonstrating growth superiority and broad environmental adaptation of Ottawa Valley white spruce provenances in much of eastern Canada is an excellent example of practical application of such work. Provenance trials of sitka spruce have more recently been established throughout coastal British Columbia.

Genetic improvement programs to develop superior strains of seed through selection and breeding for forest regeneration are active in white spruce, black spruce and Englemann spruce in several provinces. Interest and emphasis on applied breeding for genetic improvement of these species has picked up momentum in recent years. Older and well established spruce breeding programs are found in Quebec, Ontario and British Columbia. In recent years Alberta, Saskatchewan, Manitoba, New Brunswick and Nova Scotia have started genetic improvement programs in black spruce and/or white spruce. Several of these programs are currently spending great deal of effort and resources in examining alternate breeding strategies and developing comprehensive long range breeding plans.

Over the past many years, a large number of white spruce and black spruce progeny test plantations have been established throughout much of the country to provide information useful for applied breeding. Results from these studies are providing valuable information on genetic structure of populations, genotype x environment interactions, inheritance patterns and correlations among traits, and breeding value of parent genotypes.

Research on flowering and seed production in spruces has expanded considerably in recent years. Studies in progress in various regions consist of phenology of flowering, effect of different fertilizer treatments and plantation spacings on cone production, control of cone and seed insects and diseases, early induction of flowering using accelerated growth and gibberellic acid treatment, etc. Results from many of these studies have already contributed useful information for seed orchard programs.

In summary, research and genetic improvement programs in spruces are active in all provinces with varying level of emphasis. With the increasing level of interest and support for tree improvement generally evident throughout Canada, prospects for more concentrated efforts on developing necessary knowledge on genetics and silviculture of spruces, and its applications to increase yield and quality of future forests, are indeed very encouraging.

PANEL DISCUSSION

HARD PINES

Chairman: J. Klein
Panel Members: C. Ying, T. Rudolph, G. Buchert
Rapporteur: C. Hewson

Lodgepole Pine Tree Selection

- In British Columbia insect and disease resistance is a primary consideration for selection. Also considered is stem and crown form and tree growth. Selected trees have approximately 10% height superiority over the stand mean. (C. Ying). A roadside selection program has been adopted. The age class distribution of the selected trees ranges from 65-145 years. This is very old but unfortunately younger stands seldom exist. (F. Yeh).

- In Alberta comparative measurements are made between selected trees and other dominants. Height superiority of the selected trees is between 12 and 17% (N. Dhir).

Jack Pine Tree Selection

- In the Central Provinces a low intensity selection method has been adopted. Tree form and crown shape as well as size are used as selection criteria (J. Klein).

- In Ontario a large number (400-600) of plus trees are selected for a single breeding zone to allow for future roguing. Included in the selection criteria are stem straightness, branch angle, branch size and crown form as well as dominant height (G. Buchert).

- In New Brunswick 100-150 parent trees are selected annually. Their goal is to select 1000-1500 trees. Wood quality parameters (fiber length and specific gravity) are measured at DBH and half heights.

Tree Improvement and Genetic Gain in Lodgepole Pine

- Establishing seedling seed orchards and roguing 75% of the families will result in a 15% genetic gain. A second generation clonal seed orchard will yield a 25% genetic gain. Standard error is about 30-40% of estimate for both programs (F. Yeh). In B.C. family information will be used to rogue first orchards (C. Ying). There is a trend to reforest areas at closer spacing to reduce crown size. By improving crown form through breeding, planting densities could be reduced. (H. Goodman).

Tree Improvement and Genetic Gain in Jack Pine

- In Ontario seedling seed orchards will be rogued according to family performance and results from progeny tests (G. Buchert). In the prairie provinces genetic gain is an estimate based on the mean performance of the open pollinated progeny tests. Clonal seed orchards are not established until progeny information is available (J. Klein).

- There is an opportunity to turn over generations rapidly and within twenty five years we should have great confidence in our breeding program and should be establishing seed orchards through a breeding program rather than establishing orchards using original parent tree material (T. Rudolph).

Establishment of Family Tests

- In Alberta four tests consisting of 400 families have been established. Most technical and establishment problems can be overcome by ensuring that the field staff are well trained and understand the program. It is essential that close checks are maintained throughout all phases of the propagating and establishing stages of the program (N. Dhir and D. Young). Proper planning at the greenhouse stage eliminates many handling problems (J. Klein).

PANEL DISCUSSION

WEST COAST SPECIES

Chairman: O. Sziklai
Panel Members: C. Heaman, M. Meagher, J. Maze, and special guest member, Alan Orr-Ewing
Rapporteur: A. Fashler

The discussion was opened by short statements from each panel member reviewing highlights of their individual member reports. J. Maze presented information on the patterns of variation and differentiation in several North American true fir (Abies) species. The current status of the British Columbia Ministry of Forests, western hemlock (Tsuga heterophylla) tree improvement program was summarized by M. Meagher. C. Heaman covered the progress in the breeding of Douglas-fir (Pseudotsuga menziesii) by the Ministry of Forests in coastal British Columbia.

Comments on the panel reports were made by Dr. Orr-Ewing. He stressed the need for continuity in forest genetics research, particularly in view of the long term nature of such activities.

The panel comments were closed by O. Sziklai with a very brief review of forest genetics and tree breeding at the Faculty of Forestry of the University of British Columbia.

Several questions were raised from the floor during the general discussion periods. The proportion of effort placed into selection was compared for Douglas-fir and western hemlock. Due to increased wages, intensive selection (1:5000) used for the early phase of Douglas-fir program was replaced by the lower initial selection intensity for the western hemlock program. Choice of the most appropriate selection intensity will depend on the number of trees being selected and on the silvical and genetic characteristics considered to be important. The ratio of effort placed on selection versus progeny testing was not available for the west coast species. However, the proportion of 1 to 4 selection to progeny testing was reported for northwestern Alberta.

The potential of vegetative propagation in western hemlock led to a discussion on the reliability and risk factors associated with early results from progeny testing. That is, although theoretically vegetative propagation can be utilized to establish clonal tests quickly and hence provide rapid generation turn-over and quick genetic gains, there is an associated risk with the reliability of results from young progeny tests. Reliability in early results can be increased by increasing the number of test sites. Many workers reported that by about eight years data from progeny tests were stabilizing enough to make early selections, although a time interval of ten to fifteen years was considered safer.

The B.C. Ministry of Forests' reply to a floor comment questioning the loss of the Douglas-fir inbreeding program was that the Ministry is responding more directly to the needs of the Coastal Tree Improvement Council and that all programs cannot be continued due to changing priorities and a lack of sufficient resources.

The final topic discussed involved the field verification of realized gains for Douglas-fir. Emphasis had been placed in the past on deriving genetic information from progeny tests alone. The adequacy of the results was questioned and the discussion pointed to the need to establish field tests to obtain reliable information on realized genetic gain. However, this subject is now becoming important to the Technical Planning Committee of the Coastal Tree Improvement Council and field tests to estimate these figures will soon be established.

CONTAINER SEED ORCHARD RESEARCH

C. Haeussler and S.D. Ross

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Key words: container seed orchards, flower stimulation, gibberellins, water stress.

A program of container seed orchard research was initiated in 1980 after a problem analysis by Ebell (1980) had indicated the great potential of this approach for accelerating the production of genetically improved seed. As envisaged, potted ramets would be cultured within an unheated polyethylene house the first 2-3 years for rapid vegetative growth; upon attaining adequate size flower stimulation treatments comprised of gibberellin (GAs) foliar sprays and induced water stress would be imposed on a biennial basis alternating with a year of cone maturation. In about 10 years when the ramets became too large for container culture, they would be outplanted to provide an immediately productive conventional seed orchard. This paper summarizes our progress to date (1980-81) and plans for future research.

DEMONSTRATION ORCHARD

A 12.2 m x 15.2 m x 5.2 m tall polyethylene house was constructed at the North Road Laboratory in Saanich and a demonstration container seed orchard program established in early May, 1980. Western hemlock (Tsuga heterophylla (Raf. Sarg.) and white spruce (Picea glauca (Moench.) Voss) were chosen as major test species, the former because of its demonstrated responsiveness to hormonal flower stimulation (Ross et al. 1981), and the latter because of the great need for a consistant seed supply.

The potted 2- to 5-year-old western hemlock cuttings and 2- to 3-year-old white spruce grafts used were left-over production stock received only in late May and consequently left for treatment in the original containers and growing media. Western hemlock was represented by 1 to 15 ramets each of 34 clones (292 total). Half the ramets per clone received a slower stimulation treatment consisting of water stress and weekly foliar sprays of GA 4/7 (initially at 200 then 100 mg L^{-1}) beginning on 12 June and continuing 7 weeks for western hemlock and 12 weeks for white spruce. In the autumn, all ramets were repotted into 4.6 L or 9.2 L pots containing a hogfuel: sand (14.1) media with fertilizers preincorporated.

The stock used in this trial was of generally poor quality. This was especially true for the white spruce grafts which had just previously been transplanted from the orchard as vegetative buds were beginning to flush; the western hemlock cuttings had been grown continuously in pots and were severly rootbound. Under this weakened condition the treated ramets of both species suffered severely from the flower stimulation treatments (Table 1). An inability with the instrumentation at hand to adequately monitor and control plant water potential, together with excessive temperature build ups that from time to time exceeded 35°C within the polyethylene house, further compounded the problem. From previous studies (Ross et al. 1981) we know that the same GA 4/7 foliar spray is only very slightly phytotoxic when applied to healthy western hemlock.

The surviving western hemlock cuttings, however, flowered profusely in response to GA 4/7 + water stress treatment (Table 1). Treated ramets averaged 175 pollen cones and 32 seed cones each, as compared to 2 and 0.5 each, respectively, for controls. Eighty-eight percent of the ramets representing 100% of the clones produced pollen cones, and the respective percentages for female flowering (79% and 97%) were similarly high. Although other studies had shown that exogenously applied GA 4/7 will induce precocious female flowering, the level of male flowering far exceeded anything previously observed for field-grown or potted stock cultured outdoors (Ross et al. 1981, Brix and Portlock, in prep.). The work of Pollard (in prep.) indicates that this may be related to the severe water stress and high air temperatures experienced by the potted cuttings within the polyethylene house. There are also indications from studies on other species that the polyethylene-house environment is preferentially beneficial for male flowering (Brondbo 1969, Tompsett 1978, Luukkanen 1980; Ross unpublished results).

Despite the severe defoliation and shoot dieback, the induced seed cones are developing normally; they will be harvested in the fall for determination of total and filled seed. Copious quantities of pollen were shed, samples of which were collected for viability testing.

In contrast to western hemlock, only a few white spruce grafts flowered with or without GA 4/7 + water stress treatment (Table 1). Although spruce as a genus is more recalcitrant than western hemlock, the polyethylene-house environment and GA 4/7 applications have been particularly effective in promoting flowering in Sitka and Norway spruce (Tompsett 1978, Luukkanen 1980). There are probably several reasons why the treatment was ineffectual in the present trial. Firstly, treatment was apparently initiated too late in the season to influence cone-bud differentiation. Secondly, white spruce may be similar to Douglas fir (Ross, unpublished results) in that GA 4/7 is only marginally effective when applied as an aqueous foliar spray versus direct injection into the phloem and xylem as in the other studies on spruce. Finally, the problem of over stressing of recently transplanted stock has already been discussed.

Table 1. Flowering and growth response by potted western hemlock cuttings and white spruce grafts within a polyethylene house to gibberellin (GA 4/7) and water stress (WS) treatment.

Treatment Response	western hemlock		white spruce	
	Untreated controls	GA 4/7 + WS treated	Untreated controls	GA4/7 + WS treated
Growth				
Ramet mortality (%)	5	32***[3]	0	4
Leader dieback (%)[1]	0	20***	2	22
Defoliation (%)[1]	1	26***	11	42
Shoot Elongation (mm)[2]	299	195***	130	127
Female Flowering[1]				
Seed cones/ramet (no.)	0.5	32***	0.2	0.5
Ramets flowering (%)	3	79***	2	3
Clones flowering (%)	10	97**	3	11
Male Flowering				
Pollen cones/ramet (no.)	2	175***	<0.1	<0.1
Ramets flowering (%)	10	88***	1	1
Clones flowering (%)	24	100**	3	4

[1] Based on surviving ramets

[2] Based on undamaged ramets

[3] Treatment effect significant at $P \leq 0.01$ (**) and $P \leq 0.001$ (***) based on paired t-test of ramets within clones.

RESEARCH PROGRAM

Research in support of the container seed orchard program was intensified in 1981. A new tree physiologist was hired. Up to 200 ramets each of good female and/or male flowering plus-tree clones of western hemlock (11 clones) and white spruce (20 clones) were propagated and will provide abundant high quality experimental material for research beginning in 1982. There are also plans to triple the existing area of polyethylene houses.

In priorizing research needs, the strategy was adopted that we first need to better define the biological requirements for early and continued abundant seed production, and then develop more cost-effective cultural and treatment regimes for operational use.

Studies initiated in 1981 had the following objectives:

1. Delineate the critical period(s) for influencing seed-, and pollen-cone differentiation in white spruce;

2. Determine the optimum timing and duration of water stressing used in conjunction with GAs;

3. Test hypothesis that the polyethylene-house is environmentally beneficial to male flowering, whereas female flowering is better outdoors; and

4. Determine optimum media and container sizes for the initial growth-acceleration phase of ramet culture.

Research was also initiated, using Douglas fir as the test species, to develop improved GA formulations and more cost-effective methods for their application. In the application of pesticides, improved target coverage has been achieved with greatly reduced quantities of expensive chemicals using ultra low volume (ULV) spray equipment; pesticidal activity is further enhanced if oil-base instead of aqueous formulations are used. Preliminary assessment of ULV sprays of aqueous and anti-evaporant oil formulations of GA 4/7 is presently underway, with further testing of additional oils scheduled for 1981. Also being evaluated at the suggestion of Dr. R.P. Pharis (Univ. of Calgary) is a dimethyl derivative of GA 4 which, in the dwarf-corn bioassay system, has been found to be up to 10 times more effective than the GA 4 free acid we are presently using.

Because of their ability to flower profusely at a very young age in response to GA 3, yellow cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) and western red cedar (*Thuja placata* Donn) are ideal candidates for the container seed orchard. Up to 6 additional ramets of each clone in yellow cedar orchard No. 37 and red cedar orchard No. 39 were propagated in 1981 and will be used to establish a direct comparison of outdoor and polyethylene-housed container orchards with soil-based seed orchards. A separate study was initiated in 1981, using field-grown seedlings and cuttings, to determine the optimum timing, duration and frequency of GA 3 applications for promotion of female and male flowering in these species.

Additional key needs that future research will address include: better methods for monitoring and controlling water stress, improved horticultural regimes for growth, flower stimulation and cone maturation; and crown-training regimes that will extend the time that stock can be practically managed for cone production in pots, and that will also increase the proportion of shoots with high potentials for differentiating seed and pollen cones.

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A BREEDING PROGRAM IN COASTAL DOUGLAS FIR (P. MENZIESII MIRB. (FRANCO)) 1979-1981

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Key words: Douglas fir, recurrent selection, progeny testing, diallels.

Tree improvement work in coastal Douglas fir has been taking place since 1957 with early emphasis on selection and seed orchard establishment. Emphasis is now placed on a breeding program where controlled-pollinated progeny of the original plus tree selections are being established in field trials. Selections will be made in the pedigreed F1 material for the second generation of seed orchards and information will be generated to guide breeding approaches and to permit some culling of the first seed production orchards. Since 1975, eleven new test sites have been planted annually, bringing the current total to 66. Some preliminary measurements have been made but the present work still is devoted largely towards crossing and establishing the plantations.

BACKGROUND

Plus tree selection in a program for improvement in coastal Douglas fir was started for the British Columbia Forest Service in 1957 by Dr. Alan Orr-Ewing and, aided by the forest companies and by the University of British Columbia, was continued actively until 1966. By that time a workable breeding population had been assembled and priorities for the limited funds had to be directed toward test plantation establishment and maintenance.

Selection has continued to fill gaps in the initial coverage and as the provenance plantations provide more reliable information, this population is being refined.

The selected trees were grafted for use in the first level seed orchards. They were also established in a clone bank at Cowichan Lake Research Station. This serves as an archive for the artificial preservation of a gene pool and as a breeding arboretum. As cones and pollen have been produced there and in the seed orchards, a breeding program has been developed.

Although the background of the breeding program has been given in previous biennial reports, an outline is repeated here so that the current work can be seen in perspective.

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, 0-600 m.

The objectives are:

(a) the production of progenies by crossing between selected plus trees and their establishment in test plantations for second generation selection,

(b) the estimation of genetic parameters to guide future breeding decisions,

(c) The study of the occurrence and importance of genotype-by-environment interactions so that the populations may be grouped effectively,

(d) The testing of the parents to permit some culling of the first seed orchards through a ranking of general combining ability.

Although reciprocal effects are being ignored at present, some information will be generated on reciprocal effects by the inclusion of reciprocal combinations where available.

A disconnected, modified diallel mating design is being used and five crosses per parent are expected to provide adequate information and yet represent a feasible project. Each cross is represented in the field tests by almost 200 seedlings, and the sites are being distributed to sample the range of coastal environments from 0-600 m elevation.

Each modified diallel comprises six parent trees taken, theoretically, at random from the total population. The allocation of parents as male or female components in the diallel depends on the available numbers of reproductive buds. Thus, a completed modified diallel contains 15 crosses. Groups of 5-10 of these diallels are being planted annually, but 10 percent of the crosses are sown in the following year to provide a bridge between years of planting.

Crossing for this program was started in 1974, with the first plantations planted in fall, 1975. The project has continued to expand annually as suitable clones came into flower production. One of the advantages of the disconnected modified diallel is that failure of crosses will affect only that individual unit, and balanced planting designs can be stipulated. Incomplete groups can be held and completed in another year.

The stock is grown as long-season, styro-8 plugs. These are sown in the greenhouse in early spring, ready for planting in the fall or following spring. The field design comprises four replications of four-tree row plots. All crosses are planted on the eleven test sites, which are widely distributed to provide information on genotype-by-environment interactions. The test sites are selected from the available logging and rehabilitation sites. The most important criteria are homogeneity and distribution with respect to biogeoclimatic subzones where Douglas fir is the prime species.

As with any single breeding approach, the diallel project has both strong and weak features but it does meet the stated objectives of providing in a single program both information and material for future breeding.

By using full-sib families, the breeder can control the levels of inbreeding within the successive breeding and seed-producing populations. Levels of inbreeding in the initial population are not known but can be examined using isoenzyme techniques, but subsequent changes can be controlled by the breeder. The disconnected modified diallel groupings have the advantage of permitting the accumulation of balanced entries for field testing.

On the other hand, the scale of the project, in which five crosses must be made and planted to evaluate each parent, and the reduced precision of estimating general combining ability by the diallel groupings, can be seen as weaknesses. These will be most important if parental evaluation and orchard culling are given high priority, but under the present British Columbia situation, with mixed wind-pollinated seedling and clonal orchards, the priority has to be given to selection of new material for the replacement orchards. Lack of uniformity of sites which reach almost 3.5 hectares, relatively small numbers of seedlings per family on any site and the confounding of sites and years are related to the scale of the program and represent possible, but acknowledged, weaknesses.

The strength of the program lies in there now being over 200,000 seedlings of known parental origin scattered widely across the coastal area. These progenies result from rigid mating and planting designs and precise information on the population will soon be available.

From this brief outline it will be seen that this is an extensive program and that during the early stages major efforts have to be devoted to producing the cross-pollinated families and establishing the test sites. Achievement is measured in terms of area planted, parent trees brought into the testing program and crosses made. Weeding and general site maintenance are essential and with 77 test sites already in the field, this function assumes major proportions.

Two more seasons of controlled pollination have been carried out since the last report and this has brought a total of 312 parents into the plantation phases. A total of 66 test sites, each of about 3.5 ha, have been planted. A further 11 sites are being laid out currently to receive the stock now growing at the Cowichan Lake Research Station. As the provisional objective of 350 parent trees within the program is approached, fewer parents are available for crossing each year and with a poor crop year in 1980, a small expansion of this program resulted. Progress to date is summarised in Table 1.

Table 1 Progress in E.P. 708 - A Breeding Program in Coastal Douglas fir

Series	Sowing Year	Parents	Modified Diallel groups	Crosses Planted *	Test Sites
I	1975	60	10	177	11
II	1976	30	5	99	11
III	1977	54	9	165	11
IV	1978	54	9	170	11
V	1979	48	8	153	11
VI	1980	48	8	140	11
VII	1981 ***	18	3	55	11
TOTALS		312	52	959	77

* Includes 10% overlap crosses and reciprocal samples.
*** Crosses now in greenhouse at Cowichan for planting 1981-82.

To permit interpretation of GE effects, a start was made in 1980 to collect ecological information on the test sites. Most of the work to date has been based on mapping undisturbed land before logging, but the examination of the test sites will include samples from disturbed sites also. The work of the first year was largely exploratory and seventeen sites were examined. A report is being prepared.

The moist summer of 1980 gave exceptionally good survival and growth but browsing by grouse, deer, rabbits and stem chewing by voles still present serious problems. Fencing would bring only partial protection and some trials using open-ended milk cartons to protect terminal buds and current growth are showing promise.

With such a long term project there is a tendency to measure the plots as soon as they are established but while general inferences may be possible, no action can be taken on the data and it will not be until the 10-year data are collected that useful interpretation can be expected. If priorities permit, measurements will be taken in the fifth or sixth years after planting to provide preliminary information.

Maintenance and measurements have been continued on the wide interracial crosses planted by Dr. Orr-Ewing but generalizations are not easy. It is clear, however, that crosses between parents from coastal British Columbia and those from coastal locations in Washington, Oregon and California can produce vigorous stock for B.C. coastal conditions. These plantations also present a means of investigating juvenile-mature correlations.

TREE BREEDING AND ASSOCIATED RESEARCH, BRITISH COLUMBIA MINISTRY OF FORESTS, 1979-1981

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Key words: tree improvement cooperatives, tree breeding, provenance, propagation, seed orchards.

TREE IMPROVEMENT ROLES WITHIN THE MINISTRY OF FORESTS

The genetic improvement of forests can be considered in two main phases: (1) the scientific production and testing of genetically-improved breeds; (2) the mass replication of tested breeds in production seed orchards on a scale commensurate with operational goals. British Columbia is unusual inasmuch as the responsibility for these two phases resides, largely through historical development than design, in sections of two different branches of the Ministry of Forests viz., the Research and the Silviculture Branches respectively. Each phase has its own Program Manager and budget, although integration is achieved through daily working contacts, as well as through more formal means such as technical committees, councils, etc. This report is concerned primarily with summarizing recent developments affecting tree improvement in British Columbia and, particularly, progress within the Tree Improvement Section of the Research Branch.

ENABLING LEGISLATION AND THE DEVELOPMENT OF COOPERATIVES

During the period 1979-81, British Columbia witnessed developments of major consequence for tree improvement, seed orchards and associated research. These were enabled by Provincial legislation, the Forest Act (1978) which, among many innovations, fosters a cooperative Ministry/Industry approach to solving timber supply problems. In particular, it provides for funding through credits against stumpage, and cut-incentives for intensive forestry programs developed within the context of a rolling Five Year Forest and Range Program plan. Tree improvement cooperatives, incorporating senior personnel from the Ministry and major licencees, have been formed; the Coast Tree Improvement Council (C.T.I.C.) in 1979 (M. Crown 1979); the Interior Tree Improvement Council (I.T.I.C.) in 1981. Working through technical planning committees, comprising tree breeders and forest managers from all sectors, these councils have provisionally identified a need for a total of 316 ha of cooperatively-managed seed orchards of ten coniferous species. The orchards are to yield sufficient seed for the nursery production of 120 million seedlings annually by 1994. Genetic improvement is an integral part of the overall program. It is against this background that the following enumeration of program highlights, services and resources is presented. Reports detailing individual programs have also been prepared for these proceedings by J.C. Heaman, I. Karlsson, G. Kiss, M. Meagher, C. Ying and J.E. Webber.

PROGRAMS

Components of the role assigned to the Tree Improvement Section include:

1. Producing and testing genetically-improved breeds of those species named in the cooperative programs; estimating genetically-based increases in wood yields to guide future breeding strategies and to provide a basis for the allocation of cut-incentives to industrial cooperators in the program;
2. Conducting research on problems associated with seed orchards, breed production and the genetics of species in the program;
3. Propagation for all breeding arboreta, coastal seed orchards and clone banks;
4. Establishing and maintaining master clone banks and gene archives;
5. Establishing work criteria, monitoring and adjudicating cost claims from the private sector for tree-improvement work done on approved programs;
6. Developing and maintaining research stations at Cowichan, Vernon, Red Rock and Saanich to facilitate the above and other forest research, meetings, training sessions and public information.

In responding to this mandate, highlights of the past two years are:

1. Completion of the Vernon Research Station and Seed Orchard facility, comprising offices, physiology labs, pollen extraction and cold-storage facilities, greenhouses, lathhouse and service areas located on some 60 ha; Vernon is to be the centre for tree improvement, seed orchard management and associated research in the southern Interior;
2. Completion of a propagation facility at Cowichan Lake, comprising five large greenhouses, rooting house and service buildings; expansion of adjacent nursery and clone bank areas;
3. Production at Cowichan, in the first year of operation, of 33,000 grafts and 60,000 rooted cuttings, with 100,000 rootstock under cultivation for future needs;
4. Completion of planned matings and planting in the coastal Douglas fir recurrent selection program, bringing to 66 the total number of 3.5 ha progeny tests now established; planting of two series of o.p. progeny tests of western hemlock at eight locations each;

continuation of parent tree selection and propagation in hemlock, true firs, lodgepole pine, Sitka and the interior spruces;

5. Maintenance and assessment of all progeny tests, as scheduled, and identification of clones for the constitution of three $1\frac{1}{2}$-generation orchards of interior spruce. Completion of selection and propagation for the establishment of four first-generation orchards of lodgepole pine;

6. Maintenance and scheduled assessment of provenance experiments with Sitka spruce, white spruce, Douglas fir and lodgepole pine; establishment of new trials with amabilis fir and grand fir at six locations; preparation of ten test sites to receive noble fir trials in autumn, 1981. The assessment of 780 wind-pollinated families of lodgepole pine is providing indications of genetically-based susceptibility to gall and stem rusts and terminal weevil in that species.

   It is pertinent to record that the total area under arboreta, progeny and provenance tests now totals some 775 ha containing more that 800,000 trees;

7. Clearing, cultivation, fencing and establishment of master clone banks continued at Cowichan Lake, Vancouver Island, and Barnes Creek, some 60 km from Vernon;

8. Participation by tree improvement staff in the development of cooperatives - including such activities as definition of work criteria for cost claims; participation in seed orchard managememt committees; training workshops for parent-tree selection, scion collection and propagation;

9. Technical advice and participation by tree improvement staff in a 27 minute film on tree improvement.

STAFF

Staff, including the Program Manager and Technical Advisor, Dr. Francis Yeh, now totals 8 professionals. The provenance program, for two years somewhat neglected through transfer of the writer to the role of Program Manager, was recently taken over by Dr. Cheng Ying, in turn vacating the position of lodgepole pine breeder - as yet unfilled. Barry Jaquish came to the Section recently from the University of Alberta. He will work with Gyula Kiss at Vernon, specifically addressing himself to progeny testing in white and Engelmann spruce.

In addition, physiological research on flower induction and enhancement, accelerated growth, pollen processing and management and other topics in support of the overall program is being conducted by staff of the Branch's Tree Physiology Section, notably Dr. Joe Webber, now joined by Dr. Steve Ross who was, until recently, with Weyerhaeuser Co. at Centralia, Washington.

During the past six months all breeding programs benefitted enormously from the critical guidance of Dr. C.J.A. Shelbourne, on leave of absence from the Forest Research Institute, Rotorua, New Zealand. Tony's assignment included a review of the entire breeding and genetics program, especially in coastal Douglas fir, and its interaction with the seed orchard program. The coastal programs are also under review by a technical subcommittee (of the C.T.I.C.) on breeding strategies, a group comprising tree geneticists and breeders from all sectors - public, private and academic (U.B.C.).

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COWICHAN LAKE RESEARCH STATION, B.C.
1979-1981

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Key words: supplemental pollination, compatible rootstock, rooted cuttings.

Research projects at the Station include supplemental pollination in the Douglas fir clonebanks; development of compatible rootstocks in Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) and rooting of cuttings in yellow cedar (Chamaecyparis nootkatensis (D. Don) Spach).

SUPPLEMENTAL POLLINATION IN DOUGLAS FIR (E.P. 780-07)

In the spring of 1980, a study to determine the effects of supplemental pollination ("boosting") in Douglas fir was carried out on 20 trees in a 15 year old plantation at Cowichan Lake Research Station. Earlier experiments suggested that supplemental pollination could reduce seed yield by increasing cone abortion. This effect was greatest if pollination was carried out in cloudy or wet weather.

Flower development was monitored closely and weather conditions recorded. It was planned to restrict pollen application as far as possible to extreme weather conditions, both wet and dry. However, since there were insufficient rainy days during the pollination period, some trees were boosted in early morning while the relative humidity was still high.

Unfortunately, a heavy infestation of cone insects made meaningful seed counts for the different treatments impossible. However, Table 1 shows the mean percentage figures for frequencies of cone abortion for the two relative humidity groups.

Table 1. Effect of Relative Humidity on Cone Abortion (percent)

	Relative Humidity at time of boosting	
	20-50%	50-100%
Boosted	8	38
Control	8	21

There is a close relationship between relative humidity at the time of boosting and cone abortion. This was even more pronounced when it was raining at the time of application.

Generally, it appears that to minimize cone abortion, supplemental pollination should be done only during dry and warm conditions and should not start until the relative humidity is below 50%

COMPATIBILITY TESTING OF DOULGAS FIR ROOTSTOCKS (E.P. 648.02)

Rootstock of 42 different origins, mostly from crosses between clones showing high graft compatibility, were grafted in 1979 with tester clones. These graft unions were cut off in February 1981 and are now being sectioned and assessed for compatibility using the micro-technique method (Copes 1967).

The results from this screening technique will be integrated with observations of transplanting shock, flushing time, vigor, and height growth of the scions during the first two growing seasons, to identify the best crosses for use as rootstocks for production grafting.

Seedlings from the same 42 families were planted in the field in 1979 for long term observation. These seedlings were grafted in March 1981. This study will compare the early tests for delayed incompatibility with later field performance. Also, it will provide guidance for selection of parents for rootstock production and provide material for establishing selected rootstock genotypes by rooted cuttings.

EFFECT OF UNDERSTOCK ON VIGOR AND CONE PRODUCTION IN GRAFTED DOUGLAS FIR (E.P. 648.10)

In 1978, controlled crosses were made in a complete diallel design, omitting selfs, between six Douglas fir clones of high graft compatibility. The objectives of this study are:

(a) to gain information on the influence of rootstock vigor on graft compatibility and on growth performance of the grafts, and
(b) to determine if flowering patterns of the rootstocks influence the flowering of the grafts.

Twenty seedlings from each of the 30 cross combinations were planted on a field site at Skutz Falls, near Lake Cowichan in the fall of 1980. These crosses will be assessed for growth and flower production.

Another 25 seedlings from each cross were potted and grafted in the greenhouse in March 1981. Five plus tree clones: 2 "heavy" cone producers, 1 "intermediate" cone producer and 2 "non-producers", are being used as testers. These grafts will be planted in the field after two years and differences in compatibility, growth rate and cone production will be studied.

HEDGING ORCHARD OF YELLOW CEDAR (E.P. 750.03)

The hedged bank of yellow cedar from a variety of high elevation sources, which was established at the Cowichan Lake Research Station to provide material for the large scale production of rooted cuttings, was described in the previous report. The seedlings, which are planted in rows 3.75 m apart, 90 cm between seedlings, have now reached productive size.

Practical trials in 1980 with a few thousand cuttings using Spencer-Lemaire containers rooted with over 80% success. The use of Spencer-Lemaire containers has the advantage that the cuttings can be planted directly from the container to the field, without unnecessary disturbance of the delicate root systems.

Following this success, some 75,000 cuttings were clipped from the hedging orchard in January 1981 and set in Spencer-Lemaire containers in greenhouses. The resulting stock will be planted under production conditions in fall 1981. In some of these plantations family identity will be maintained and survival and growth plots established.

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GENETIC IMPROVEMENT OF WHITE AND ENGELMANN SPRUCE IN BRITISH COLUMBIA 1979-1981

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Key words: white spruce, Engelmann spruce, tree improvement, progeny trials, tree breeding, hybridization.

The objective of this project is to produce genetically-improved seed of white and Engelmann spruce (Picea glauca (Moench) Voss, P. engelmannii Parry).

The following progress has been made in the program since my last report (Kiss 1978a):

OPEN-POLLINATED PROGENY TRIALS

Six-year (9 years from seed) height measurements were carried out at all the open-pollinated progeny test sites. Analysis of the data indicated that a gain of 10-15% in height growth can be attained by establishing the top 25% of the original parents in clonal seed orchards. While 6-year results are by no means conclusive, they will be used as guidelines in establishing "one-and-a-half" generation orchards. By the time these orchards reach production age (estimated 10-15 years) further data from the progeny tests should permit more reliable estimates of gain and provide a basis for more rigorous culling.

The data also indicate that the more-vigorous families survive better than slower-growing ones, a difference which is especially striking in the presence of competing vegetation.

Another result, not directly related to tree breeding, was that progenies survived, grew and expressed differences better on well-prepared sites than on poorly-prepared ones. For example, in 1978, the average seedling height at the well-prepared Red Rock plantation (Kiss 1975) was 104.6 cm, while the average height at the unprepared Quesnel site was 72.9 cm. This represented over 43% difference in height growth alone. Survival was 98% at Red Rock and only 86% at Quesnel. Similar results are found on test sites of other selection units.

BREEDING ARBORETUM

The Vernon Breeding Arboretum (Kiss 1978 b) is near completion. Strobili production on established ramets increased steadily (Kiss 1977b, 1978b, 1979) until 1981 when production suffered a drop. Probably, this could be attributed to the cold, wet summer in 1980, coupled with heavy irrigation. This year we intend to stress some ramets by reducing irrigation, the objective being to increase strobili yield in 1982.

The drip irrigation used at Vernon utilizes treated municipal effluent. It has been applied for the last two summers without deleterious effects.

The Trinity Creek Breeding Arboretum (Kiss 1978a) had to be abandoned due to drought problems resulting from low precipitation and shallow soil. It has been replaced by a new clone bank at Barnes Creek, 60 km north-east of Vernon.

NOTES OF INTEREST

Grafting

To establish a Picetum at the Vernon site, various species of *Picea* have been grafted onto British Columbia white spruce rootstock. To date, little incompatibility has been found. For further information, contact this writer.

Albinism

To date, three of the 181 selected trees from the Prince George selection unit have been identified as carriers of albino genes. This trait appears to be controlled by a single gene with at least two alleles. One of the alleles is recessive and undetectable in heterozygous condition. The other allele appears more like a co-dominant as it can be identified in the heterozygous condition by examining the needles. The tips of the needles, when exposed to direct sunlight, turn golden yellow. This gives the appearance of a "golden-hue" to the branches. Both alleles are lethal in the homozygous condition.

The trait deserves further investigation as two of the carriers are included in the open-pollinated progeny trials and score high in overall ranking (5th and 48th out of 174).

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THE ROLE AND ACCOMPLISHMENTS OF THE SILVICULTURE BRANCH B.C. MINISTRY OF FORESTS, IN COOPERATIVE TREE IMPROVEMENT, 1979-1981

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Key Words: tree improvement cooperatives, seed orchards, root pruning, booster pollination, propagation.

Cooperative tree improvement in B.C. is a recent development involving the Ministry of Forests and numerous forest companies. A coastal cooperative has been active since 1979, an interior cooperative is currently being established. The workload is shared and costs incurred by the companies are re-imbursed through credit to stumpage accounts as per Section 88 of the Forest Act. This paper describes the role of the Silviculture Branch in these cooperatives and reviews recent Branch accomplishments, both collectively and by three administrative regions.

STRUCTURE AND ROLE OF THE SILVICULTURE BRANCH, MINISTRY OF FORESTS

Each cooperative is headed by a Council, consisting of upper management staff, which is responsible for making recommendations to the provincial Chief Forester regarding program objectives, strategies, agency involvement, allocation of workload and research needs. At the planning level Technical Planning Committees (TPC's) review seed orchard working plans and other associated tree improvement projects and input technically to the Councils. One committee now exists for the Coast; two will be formed in the interior (a southern and central TPC). A coordinator is assigned to each TPC and is primarily responsible for the administration of projects, review of the technical aspects of the program and the adjudication of industrial cost claims. Coordinators also serve as secretaries to Council.

The Silviculture Branch plays an active role within this structure. Administratively, the Branch Director and Manager of the Seed Production sit on both Councils. The coordinator positions are filled by Branch personnel. The Branch is also responsible for the management of all cooperative orchards assigned to the Ministry. Three project foresters provide technical direction, conduct trials, prepare orchard working plans and develop orchard management prescriptions. Technical staff provide direct supervision of orchard management operations and manage specific orchards. A planning officer and orchard pest management officer complete the staffing picture. In all, nine professional and eight technical positions within the Branch participate directly in cooperative tree improvement.

ACCOMPLISHMENTS

Several accomplishments involving group staff efforts can be highlighted. These include:

1. Formulation of an interim Seed Orchard Planning Zone Map based on input from ecologists and forest geneticists (Figure 1);
2. Preliminary planning for the interior cooperative program - review of species needs and priorities, identification of seed orchard opportunities and estimation of funding requirements;
3. Input into a recently completed tree improvement film entitled, "Seeds For Tomorrow";
4. Input into a technical audit entitled, "Review of Practises Relating to the Treatment of Seed Orchard Seed and Seedlings";
5. Completion of a parent tree selection guideline and revision of the field form to reflect cooperative needs;
6. Revision of ramet/seedling seed yield data for seed orchard planning.

COAST HIGHLIGHTS

The Silviculture Branch is presently responsible for the management of four Douglas-fir orchards covering 23.6 ha on the coast. Management highlights include:

1. The harvest of 81.6 and 14.3 kg of seed in 1979 and 1980 respectively (sufficient for 7.25 million plantable seedlings);
2. The successful induction of early and profuse flowering through root pruning;
3. The control of seed insects with the insecticide dimethoate;
4. The operational application of booster pollen by hand and helicopter;
5. The collection of baseline soil moisture and nutrient data to aid future management.

Several trials were implemented to promote better orchard management. These include screening of various insecticides, evaluations of short and long term effects of root pruning, and studies of flower abortion rates. Further orchard management studies in nutrient status, soil moisture, cone induction, pollination and insect control are currently being developed.

Individual orchards were also expanded or reconstituted as per TPC recommendations. Site preparation work continued for an additional 25.4 ha of new cooperative orchards to be managed by the Ministry.

Administratively, the development of cooperative procedures and policies is noteworthy. An annual events schedule, breeding strategy review sub-committee, standards and procedures of work performance, detailed financial arrangements and composite working plan formats are now in place.

SOUTHERN INTERIOR HIGHLIGHTS

The purchase of 60 ha near Vernon in 1979 marked an important step for the southern interior orchard program. This property has subsequently been site prepared and fenced and will, along with the Skimikin Forest Reserve (near Salmon Arm), contain all cooperative orchards managed by the Ministry in this region.

Orchard establishment operations, initiated in 1979, progressed quickly. Six young interior spruce orchards totalling 17.6 ha have been planted at Skimikin. A small western white pine seed production plantation was also established from a genetically rust resistant strain obtained from the USDA, Idaho. At Vernon, two interior spruce orchards totalling 4.2 ha were recently planted. A total of 16 orchards spanning 51 ha are planned for establishment on these two sites. Interior spruce will form the main species component.

Management within these young orchards consisted primarily of additional cultivation, establishment of cover crops and growing stock maintenance (pruning, weeding, fertilizing). Trickle irrigation systems were also installed. A small seed crop totalling 90 g was harvested in 1980 from four of the orchards at Skimikin.

Several trials have been implemented and include:

1. A preliminary evaluation of booster pollination and monitoring of foreign pollen;
2. A comparison of various weed control methods - herbicides, mulches, manual;
3. Monitoring and control of spruce cone rust and insects;
4. Determination of the effects of fertilizers on stock vigour and flowering;
5. Studies of the effects of Accelerated Optimum Growth, root pruning, and ramet spacing on flowering.

In addition a detailed soil survey has been completed at Skimikin, the results of which have been included in draft orchard working plans.

Parent tree selection/collection activities also comprised an important portion of the work. To date over 1300 interior spruce have been selected in the southern interior. In anticipation of an expanded selection effort, two workshops were conducted to review procedures. A commensurate grafting program of approximately 12,000 grafts/year continued at Skimikin.

CENTRAL INTERIOR HIGHLIGHTS

Seed orchard activities in the central interior are presently confined to the Red Rock Forest Reserve (near Prince George). The Silviculture Branch manages four lodgepole pine orchards spanning 14.8 ha, the most recent of which was established in 1979, and maintains over 75 ha of tree improvement plantations. Recent planning indicates that all pine orchards will require expansion to meet seed needs.

Highlights include orchard working plan preparation, additional site cultivation, establishment of cover crops and application of 28 litres of booster pollen (collected over the past two years from natural stands and an adjacent provenance trial). Soil and nutrient analyses were also completed. A fertilizer trial in one orchard demonstrated increased tree vigour, cone size, seed production and seed viability. The significant incidence of insect and disease problems, especially in lodgepole pine, also prompted intensified pest monitoring and control actions.

To date over 1500 interior spruce parent trees have been selected in the central interior. A collectable cone crop in 1979 enabled the harvest of open-pollinated seed from over 900 parent trees for progeny testing. Helicopters have been used extensively for this work and a safety plan to help ensure safe work practises was accepted by the Workers' Compensation Board.

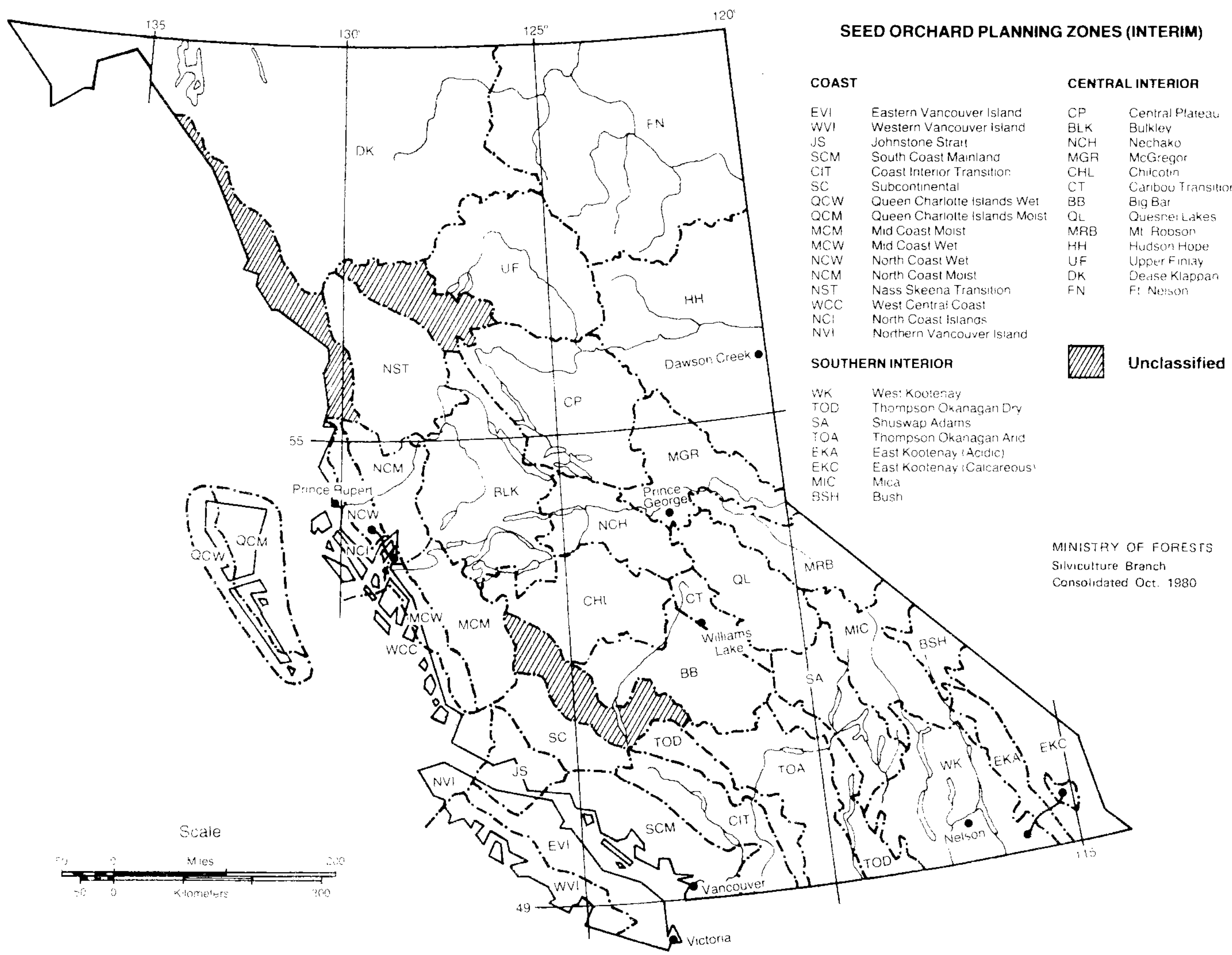

Figure 1. Seed orchard planning zones (interior).

WESTERN HEMLOCK TREE IMPROVEMENT FOR COASTAL BRITISH COLUMBIA 1979-1981

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Key words: Tsuga heterophylla, tree selection, progeny testing, provenance testing, breeding.

The program began April 1, 1977. It entails screening of many parent (plus) trees per seed zone for GCA via open-pollinated progeny tests. Population studies may supplement those tests to define seed zones better and increase breeding options. A number of support studies are planned or underway to develop techniques and to assist in interpretation and application of results when the progeny tests are evaluated, perhaps at 15 years.

Tree selection, seed and scion collection have all continued and accelerated due to the commencement of the B.C. Government - Industry Cooperative tree-improvement program (Crown, 1980). To date, 1078 trees, including 26 obtained from U.S. cooperators, have been selected. Most are propagated clonally by grafting or rooting, or both, for seed orchards and clone banks. All trees were selected to targets set by arbitrary seed-orchard planning zones and elevation bands. Most selections were made from the ground, but some inaccessible areas were sampled from a helicopter. A good 1979 seed crop yielded 162 useable seed collections; no crop developed in 1980, but prospects for 1981 appear favourable.

A second series of open-pollinated progeny tests was established for the West Vancouver Island Zone (Seed Zone 1010) and the third has been sown to test trees from the Johnstone Straits zone (Seed Zones 1020 north and 1040 north). Survival of the first test series averaged 88%, and ranged from 78% to 98% after 1 year in the field.

Data from the Canadian Forestry Service population test and from progeny tests established by Tahsis Co. were useful in drawing up clonal lists for 3 of the 7 seed orchards approved by the Tree-Improvement Cooperative. All seed orchard clonal lists were checked to determine suitability to the Co-op standards, and revised where necessary.

Support studies continued, with expansion to a complete 13-parent diallel among convenient study trees being attempted. Pollen has been collected from the disjunct, "Interior" portion of the species' range, and some has been received from Tsuga canadensis from Ontario. A small quantity of T. tchekiangensis Hous, has been received from China and will be used to test the crossability of that species with T. heterophylla.

Forintek Canada, Vancouver, has conducted a study of the importance of tree size and stem form on the potential lumber-recovery value in order to set impartial standards for hemlock parent-tree selection. Forintek Canada continues to determine wood specific gravity for all possible parents to facilitate selection of parents for seed orchards and to establish a data base for correlations from progeny tests.

Cone-induction research using potted propagules was begun by the Ministry's Research Branch to expand on and refine techniques developed by the Canadian Forestry Service and Weyerhaeuser Co. (Ross et al. 1981). Results to date are very encouraging.

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PHYSIOLOGY RESEARCH AND TREE IMPROVEMENT IN B.C. 1979-1981

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Key words: pollen, viability tests, pollination, boosting, cone enhancement, gibberellins, seed orchards, maturation.

The rapid establishment of Tree Improvement and Seed Orchard programmes in British Columbia is accelerating the need for developing and implementing physiology research results. Priorities have been established and two areas of research are being emphasized:

1) Pollen Management

Factors affecting harvesting, storage and reapplication of pollen are being considered. Pollination mechanisms, pollen flow, and resultant seed yields are being investigated to improve seed production and genetic value of seed orchard crops.

2) Cone Enhancement and Early Maturity

Cultural treatments known to affect coning response and their possible application for seed orchard management are being tested. In particular, gibberellin (G/A 4/7), fertilizer ($Ca(NO_3)_2$) and root pruning treatments are being examined for possible application to increase production by young seed orchard stock.

A second approach being investigated is the reduction of the non-coning, juvenile phase. Growth acceleration of germinants rapidly increases size, and may also accelerate sexual development.

Much of this research has been limited to Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) but programmes involving white spruce (*Picea glauca* (Moench) Voss) and lodgepole pine (Pinus contorta Dougl.) are being developed also. A brief summary of this research and current experiments is given below.

POLLEN STORAGE AND VIABILITY TESTING

Maintaining pollen viability over its storage period is an integral part of all breeding and seed orchard programs. Because yearly production of pollen is not reliable, access to viable stored pollen can facilitate yearly mating schemes and improve production and genetic value of seed from young orchards.

Freeze-drying techniques (Ching and Ching, 1964) adapted for Douglas fir pollen have been tested and can successfully maintain pollen fertility for at least four years, and perhaps longer. Two series testing three- and four-year old Douglas fir pollen confirm storage conditions: pollen dried to between two and six percent moisture content and stored at reduced temperatures (-26^{o}C) in evacuated containers produces the highest filled-seed yield using controlled pollination techniques.

Series-one pollen was stored in flame-sealed ampules whereas Series-two pollen was stored in re-useable serum vials. No real difference in filled-seed set was observed for container type. However, pollen from evacuated, vacuum-sealed containers consistently produced better filled-seed yields than pollen from non-evacuated, airtight containers (63% versus 46% increases respectively over filled-seed yields from pollen stored in control containers).

Pollen viability tests involving adenosine triphosphate (ATP) analysis, conductivity measurements, germination assays, (Ching et al. 1975, Ching and Ching 1976) and tetrazolium stains have not correlated to field "fertility" tests (controlled pollination). Although these tests are useful for distinguishing live from dead pollen they can not be used to predict potential filled-seed yield. Work is continuing with other viability assays such as measuring respiration rates (Binder and Ballantyne 1975) in an effort to better understand the effect of pollen viability on pollination, fertilization and seed yields.

SUPPLEMENTAL POLLINATION

Improving seed production and genetic value in Douglas fir seed orchards is possible by application of pollen to receptive strobili. However, results are largely dependent on time and method of application, and natural pollen supply.

To determine optimum receptivity of Douglas fir seed cones (measured as filled-seed yield), "boosting" was done at five dates as determined by the number of days beyond bud burst. No significant drop in filled-seed yield was observed up to six days after bud burst but the eighth day treatment was significantly lower. These results confirm that boosting should be done as early as possible to avoid competition from foreign, contaminating pollen and certainly within six days to realize maximum seed yields.

Application technique also affects results. Hand boosting allows greatest control and yields highest results but is labour intensive. Applying pollen from a helicopter is efficient but has yet to show a significant increase in seed yield over unboosted controls. The major problem with helicopter boosting is getting enough pollen to the receptive cones.

A third technique was developed to increase efficiency over hand boosting but also control the amount of pollen each tree received. A conical mist blower was built with a front and rear diameter of 1.22 m and 0.66 m, respectively, and a length of 1.83 m. An air stream moving from the face at about 20 kmph was created by a 0.61 m axial fan blade operating at approximately 1400 rpm. Pollen was forced into the air stream under 40 psi pressure. The cone was mounted on a trailer and pulled by a tractor. Significant increases in seed yields were observed and the results compared favourably to hand boosting.

Development of operational boosting techniques will continue in an effort to maximize seed orchard production and improve genetic value. Our next important question to answer is: what degree of contamination are we facing and can it be reduced by boosting?

CONE ENHANCEMENT

Factors involved in the natural production of male and female strobili are not fully known. However, numerous research trials have shown that flower production can be affected by moisture stress, fertilizer application, hormone treatment and a variety of cultural techniques (root pruning, girdling, etc.)

To test the effect of hormone application on flower production by 11-year old half-sib Douglas fir seedling in a seed orchard, a solution of gibberellin 4/7 was fed "intravenously" through cut branch stubs on the third whorl. This test was superimposed on three levels of $Ca(NO_3)_2$. Within each block, treated trees were stratified as trees with a previous history of flowering and those without. Half of these trees were treated with gibberellin and the other half served as controls.

Gibberellin treatment resulted in an average three-fold increase in female strobilus production. No effect on male production was observed. Although calcium nitrate (225 and 450 kg/ha) increased seed cone production, the difference was not significant. In terms of overall production, trees with a previous history of flowering produced approximately three times more flowers than those trees without a history of flowering. For both classes of tree, gibberellin treatment resulted in an approximate three fold increase in coning.

Foliar spray treatments of GA 4/7 resulted in significant, 5-fold seed cone increases in 8-year old Douglas fir seedlings. The effect was not uniform, with largest increases observed on trees which had flowered previously.

In both trials, seed derived from trees induced to flower by GA treatments showed no significant differences in either filled-seed yileds, seed germination or early growth performance.

This work is continuing to better understand factors involved in coning response. Dr. Steve Ross, formerly with Weyerhaeuser, has now joined our staff and will provide valuable experience in cone enhancement/induction research.

EARLY MATURATION (ACCELERATED GROWTH)

Trials at Michigan State University indicate that accelerating the growth of spruce seedlings under 24 h photoperiod and 20° C may induce significant coning response within four years from seed (Young and Hanover 1976).

To test this approach, seed from white spruce parent trees was germinated and subjected to growth acceleration. After eight months, seedling height averaged 23.6 cm compared to 2.5 cm for controls. The accelerated seedlings and their corresponding controls are planted at two sites (Vernon and Saanich). These plants have now completed their third year of growth and the effect of both growth acceleration on the seedlings and site on growth and early maturation (coning response) will be monitored yearly.

A similar trial with lodgepole pine is now completing its accelerated growth stage and will assess response at several climatically different sites, plus compare the growth and coning response of grafts.

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THE LODGEPOLE PINE IMPROVEMENT PROGRAM IN BRITISH COLUMBIA

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Key Words: lodgepole pine, selection, breeding, flower production

Lodgepole pine occupies nearly 39 percent of the productive forest land and accounts for 32 percent of the mature timber volume in the interior region of British Columbia. An increasing annual harvest is now approaching 15 million M^3, next only to spruce. Over 11 million seedlings were planted in 1979, and it is estimated that annual planting will increase to over 40 million in the next decade. The importance of planting genetically-improved seed is, therefore, self-evident.

Although some northern parental selections were grafted and established in clone banks in the early part of the decade (see below), genetic improvement in lodgepole pine was started formally in 1975 (Wheeler 1978, 1980). Considerable progress has been made. This report presents a brief summary of progress on parent tree selection, breeding orchard establishment and information on flowering.

PARENT TREES AND BREEDING ORCHARDS

The original plan delineated 4 selection units as target areas for breeding effort (Wheeler 1978). In general, these selection units represent a wet transitional zone with relatively high site productivities and/or high priority regions for intensive silviculture.

Five hundred and sixty-five parent trees have been selected. Figure 1 gives the number and location of the selections in each unit. They were grafted and planted in breeding orchards at Red Rock Research Station. The success of our grafting in the greenhouse was approximately 85 percent. Later survival of the grafts in breeding orchards is nearly 95 percent.

FLOWER PRODUCTION AND GRAFTS

Flower production in the SK* and SCA* clonebanks has been recorded since they were established in 1972. The average number of female conelets and pollen clusters per flowering graft is summarized by year.

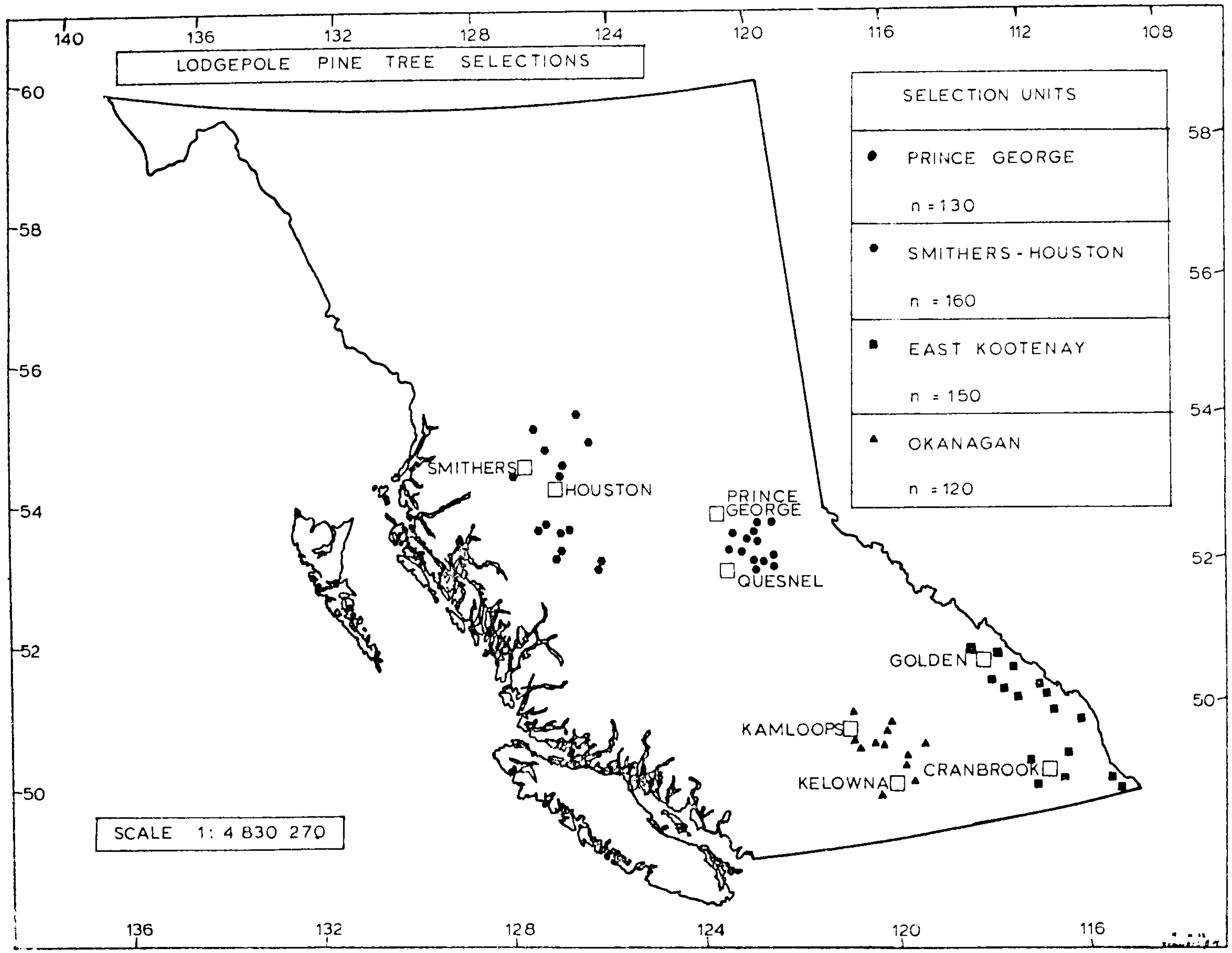

Figure 1. Lodgepole pine tree selections, British Columbia.

Year	SCA Clonebank		SK Clonebank	
	Female conelets	Pollen clusters	Female conelets	Pollen clusters
1973	1	0	0	0
1974	2	0	1	0
1975	5	0	2	0
1977	18	0	3	0
1979	56	7	23	5
1980	86	7	63	10

Female conelet production increases steadily with age of grafts. All the living grafts (678) bore females in 1980, and produced a total of 49,571 conelets. Assuming 80 percent of them developed to mature cones, each averaging 20 seeds per cone, 693,134 seeds could be harvested in 1980. This suggests that as far as cone production is concerned, Red Rock is a suitable location for lodgepole pine seed orchards of at least central and northern origins.

On the other hand, only half of these grafts produced male strobili in 1980. However, there is no clear evidence that male flower production would be enhanced by either north - or southward-transfer.

EFFECT OF ACCELERATED GROWTH ON FLOWERING

An exploratory study on the effect of continuous light on flower promotion was initiated in 1976 (Wheeler 1979). Seedlings grown under 24-hour daylength for 6 months were then outplanted in the Research Nursery at Red Rock. By the 4th growing season, 1980, the frequency of flowering trees and the average number of female flowers per flowering tree were roughly 600 percent greater for accelerated seedlings (81%, 18 flowers/tree) than for controls (12%, 3.6 flowers/tree). The control seedlings have yet to produce male flowers, whereas 18 percent of the "accelerated" seedlings produced an average of 10 male clusters in 1980.

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* Most of the parent trees originated from north of Latitude 53°. They were selected by Professor O. Sziklai of U.B.C. for two Swedish forest companies, Stora Kopparberg (SK) and Svenska Cellulosa (SCA). The B.C. Ministry of Forests participated in the collection and processing of seeds and scions and established clone banks at Red Rock (Illingworth 1975). Eighty-three clones are included in the SK and 75 clones in the SCA collections. Five ramets of each clone were planted initially in the two clonebanks.

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PROVENANCE RESEARCH BY BRITISH COLUMBIA FOREST SERVICE, 1977-1979

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Key Words: provenance, genecology, Douglas fir, Sitka spruce, lodgepole pine, Abies.

Provenance research in British Columbia has been carried out by the B.C. Ministry of Forests since the early 1960's, when L. Roche made a genecological study of interior spruce and R.L. Schmidt established most of the present Douglas fir trials. Expansion of provenance research into other species was accomplished mostly during the period when K. Illingworth was in charge of the provenance research program. A total of 138 testing plots which cover 235.9 hectares has been established throughout the Province. Provenance research has been focussed on the major commercial species: Douglas fir, lodgepole pine, Sitka spruce and more recently, the true firs. Previously, establishment and maintenance received high priority to ensure the safety and quality of the tests. Future effort will emphasize the interpretation and practical application of information from these studies.

This report broadly outlines the provenance program and its highlights. Details were reported in papers by K. Illingworth in two volumes of the Proceedings of the IUFRO Joint Meeting, Vancouver, Canada, 1978, published by B.C. Ministry of Forests.

STATUS OF THE PROVENANCE RESEARCH PROGRAM

The following table summarizes the extent and scale of the provenance trials of different species in this Province:

Species	Number of Provenances	Number of Tests	Year of Establishment*
Douglas fir (Coast)	88	35	1968
Douglas fir (Interior)	12	4	1970
Spruce (Interior)	40	7	1966
Sitka spruce	43	14	1973
Lodgepole pine	182	72	1971
Grand fir	23	4	1980
Amabilis fir	9	2	1980
Noble fir	23	10	1981

* Trials were often divided into series and established in different years.

Year listed refers to the oldest trials.

LODGEPOLE PINE

The core of the lodgepole pine provenance program is the range-wide study which involves 150 provenances over 60 testing sites in the Interior region of British Columbia. The 60 sites are located in 12 regions representing 12 broad latitudinal and geoclimatic zones (Fig. 1). Sixty provenances were included in each test and 10 provenances are common to all the 60 sites.

The most recent assessment was done in 1979, 6 years after planting. Mean survival over the 60 sites was 91.6%, despite severe damage by various animals (horses, voles) at two sites and flooding at a third. Most sites had over 90% survival.

Height growth showed a very broad geographic pattern; provenances of coastal origin, and those from above latitude 60 degrees and below latitude 49 degrees had poor height growth. Excluding those provenances, no consistent geographic pattern can be established. For example, origins of the 10 tallest provenances averaged over the 5 sites in Region 8 (Fig. 1) cover a range of nearly 5 degrees of longitude (see table below). However, evidence suggests that the provenances from the interior wet belt are most vigorous as well as adaptable to a wide range of sites in the southern and central interior of the province.

The 10 Tallest Provenances Averaged over 5 Sites in Region 8.

PROV. NO.	LOCATION	LAT.	LONG.	MEAN HEIGHT (cm)	RELATIVE HEIGHT C%
14	Wentworth Cr.	50 58	120 20	171	123
42	Champion L.	49 11	117 35	168	121
45	Settlers Rd.	50 31	115 44	168	121
23	Udy Cr.	53 01	123 14	167	120
15	Esperon L.	50 03	119 39	163	117
1	Trapping Cr.	49 35	119 01	161	116
18	Chilco	51 39	123 45	160	115
19	Nithi R.	54 03	125 05	160	115
17	Oie L.	52 00	121 12	160	115

DOUGLAS FIR

The Douglas fir provenance study consists of four series:

(01) A range-wide collection of 77 provenances tested in 5 coastal climatic zones to determine geographic variations and to compare their adaptability and vigour in constrasting environments;

(02) Five pairs of low and high elevation provenances planted at 6 sites spanning a range of elevation from 60 to 1035 m. to test the feasibility of seed transfer across altitudinal intervals;

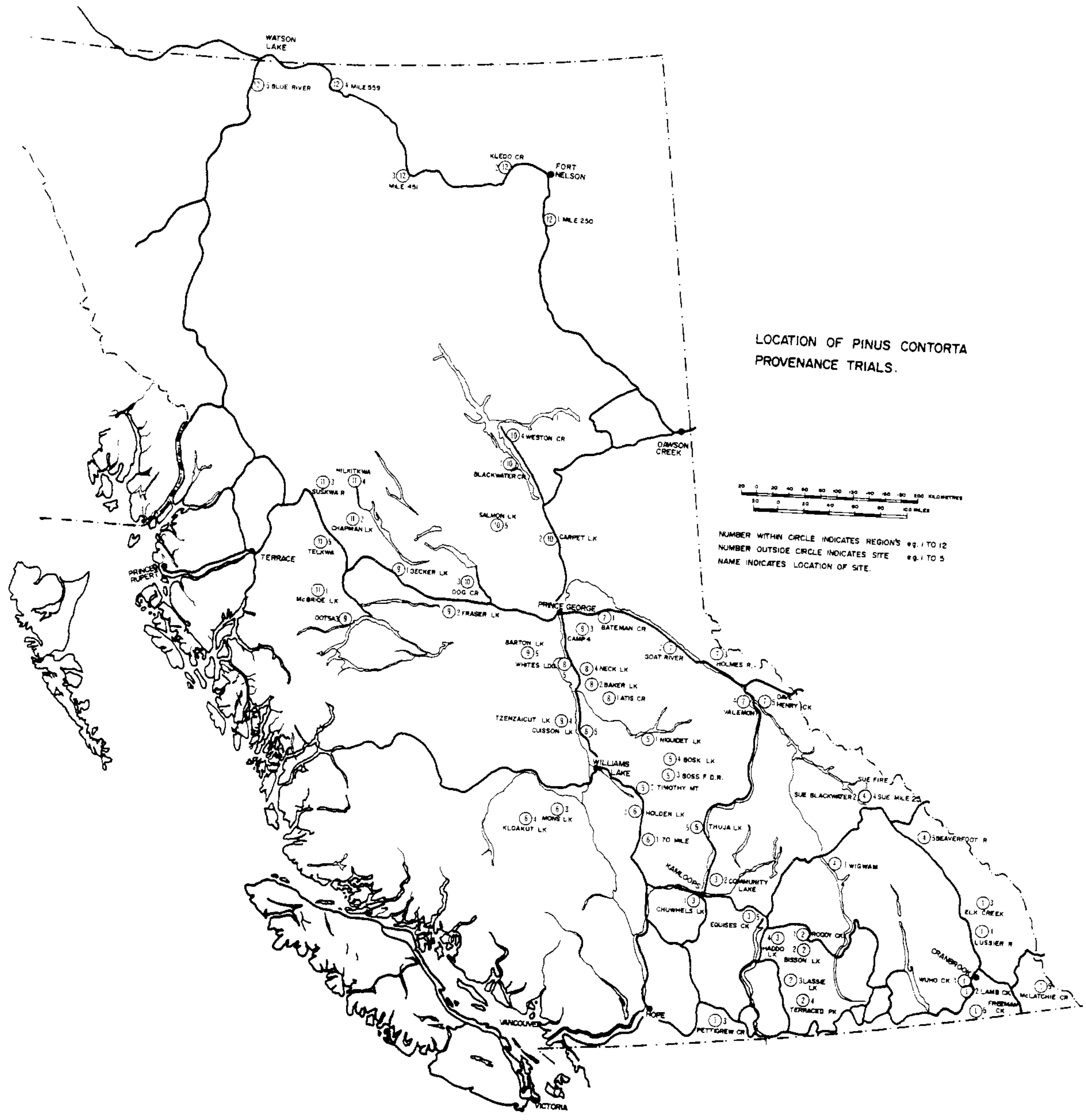

Figure 1. Location of Pinus contorta provenance trials.

(03 Five provenances selected from a wide geographic area plus one or two local sources, tested at 22 sites representing a wide range of site conditions, to assess provenance x site ineraction and to identify hardiness zones:

(04) To compare select coastal and interior provenances at high elevation sites, four interior wet-belt and 3 coastal high elevation provenances are tested at 3 high elevation sites (750-975 m) on Vancouver Island.

Figure 2 shows the locations of the test sites.

Field performance in terms of hieght growth differed significantly among provenances. The range of differences was wider in the less rigorous environments. Despite this considerable variation in provenance mean height, the pattern with respect to geographic origin is not well defined.

The importance of altitudinal transfer of seed sources became obvious only at the highest elevation site (Lookout Mtn., 1035 m) and the lowest elevation site (Oyster River, 60 m) (Fig. 2, Series 02); high elevation provenances were generally taller than the low elevation ones at Lookout Mtn. and vice versa at Oyster River. No difference in growth was found between high and low elevation provenances at the other 4 intermediate elevation sites. The results indicate that seed can be transferred across a considerable range of elevations without serious consequences.

In general, provenances from the Coastal Western Hemlock (CWH) zone (Klinka et al 1979) outgrew those from the drier coastal Douglas fir (CDF) zone at sites located in CWH or CDF zones. In coastal British Columbia, CWH provides optimal growth environment. Douglas fir stands in this zone must overcome severe competition from the climax dominant species in order to become established. Natural selection would favor the genotypes with vigorous vegetative growth.

SITKA SPRUCE

Three series of field tests were established throughout coastal British Columbia. The test selections were from among 43 populations spanning a latitudinal range of 17 degrees from Brookings, Oregon, to Yakutat, Alaska.

Survival was better than 90 percent at all 13 test sites 3 years after planting. Strong clinal variation, inversely correlated with latitude and distance from the Coast, was shown in growth, winter injury and time of bud flushing. Introduction of provenances from as far south as the Oregon Coast will markedly increase the yield of Sitka spruce plantations on Vancouver Island and the Queen Charlotte Islands. However, the tests are very young. Prudence calls for the continued use of local seed sources, particularly for planting cold, mainland valleys.

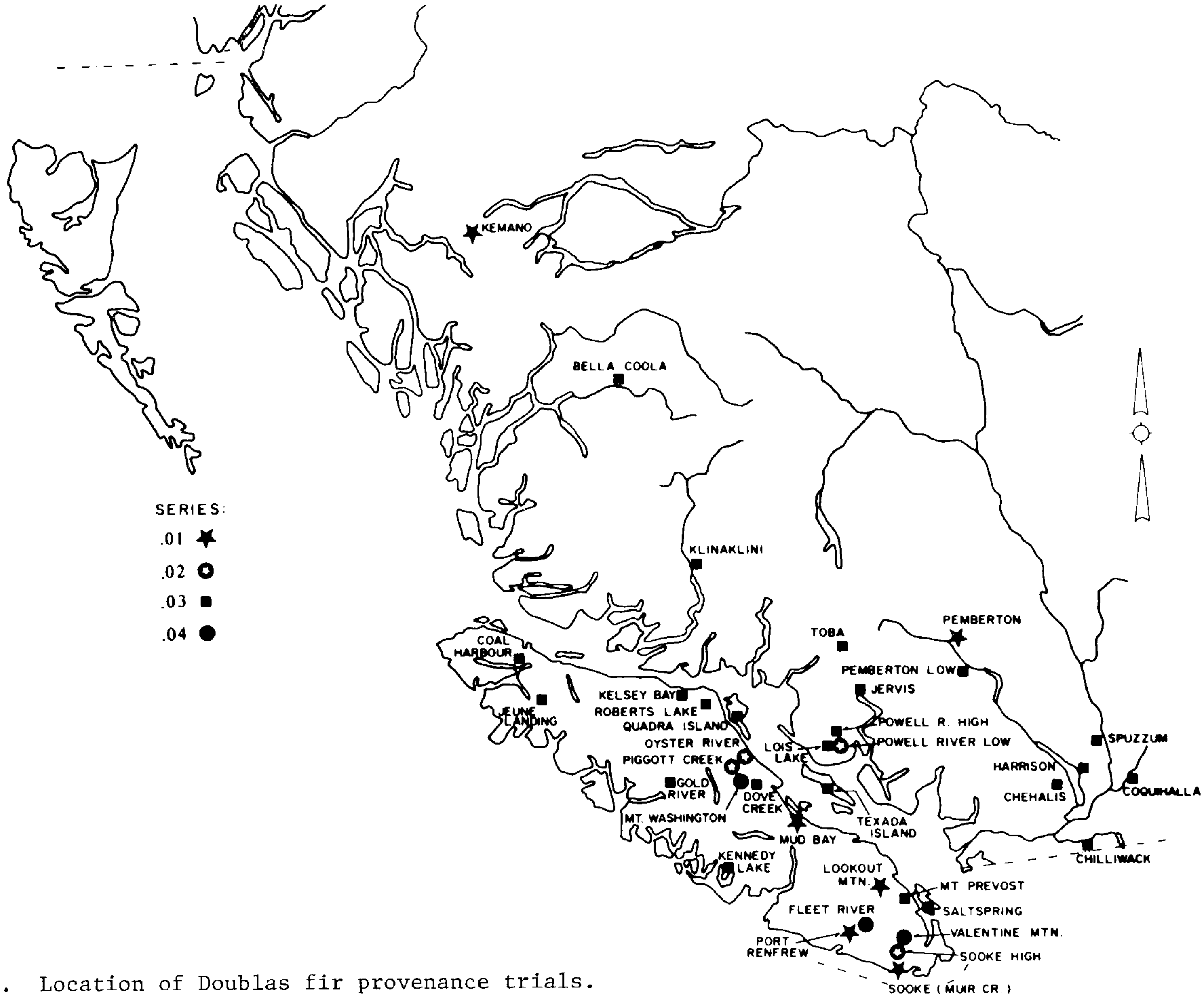

Figure 2. Location of Doublas fir provenance trials.

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TREE SEED RESEARCH, PACIFIC FOREST RESEARCH CENTRE 1979-1980

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Key Words: seed prechilling, moisture content, seed fungus, seed blight, spruce cone rust, Douglas-fir cone gall midge, Douglas-fir cone moth, spruce seedworm

This report describes the work of D.G. Edwards on redrying and storage of seeds of Abies (Mill.) species, and the official seed testing program at Pacific Forest Research Centre. It also covers the studies of J.R. Sutherland on the seed fungus (Caloscypha fulgens (Persoon) Boudier), seed-borne Sirococcus blight (Sirococcus strobilinus Preuss), and inland spruce cone rust (Chrysomyxa pirolata Wint.). The research work of G.E. Miller (replacing A.F. Hedlin) on the Douglas-fir cone gall midge (Contarinia oregonensis Foote), the Douglas-fir cone moth (Barbara colfaxiana (Kearfott)) and the spruce seedworm (Cydia youngana (Kearfott)) is described also.

IMPROVING THE USE EFFICIENCY OF SEEDLOTS

D.G. Edwards

Work has concentrated on determining how long prechilled (stratified) seeds can be stored and the optimum moisture content during prechilling. It has been shown (Edwards 1980a) that prechilled seeds of Abies amabilis (Dougl.) Forbes, A. grandis (Dougl.) Lindl., and A. lasiocarpa (Hook.) Nutt. can be stored in a refrigerator for 12 months without any significant reduction in germination, if they are dried to a moisture content of 25% (of fresh weight). Similar results have also been obtained for Abies procera Rehd. seeds (Edwards, unpublished).

In 28-day, standard germination tests, seeds dried to 35% after a 4-week prechill treatment germinated best of all, with final germination percentages being significantly higher than in seeds at other moisture levels. However, they could not be reliably stored for 6 months, since germination usually began in the refrigerator beyond that time. When dried to 35% and stored for at least 3 months, germination was essentially complete, i.e., within 0.5% of the final germination percentage, by the 14th day of the test. These germination rates were approximately 2-7 times greater than in seeds prechilled, but not dried or stored, and were 6.5-17 times greater than in unprechilled seeds. Other trials on approximately 30 additional A. amabilis seedlots have confirmed that drying prechilled seeds to 35%, followed by 3 months' cold storage, produces better germination than prechilling alone (Edwards and Leadem, B.C. Min. of Forests, unpublished).

These increases in germination should be advantageous in the nursery, even if there is no requirement per se to store prechilled seeds. Aside from germination increases, prechilling could be applied relatively independently of sowing day; e.g., a 1-month prechill could begin anytime up to 6 months before sowing. As a corollary, sowing date would become more flexible since there is a period of several months in which seeds can be stored without germination beginning prematurely (Edwards 1980b).

A field trial of the procedure, using 150,000 A. amabilis seedlings in a container nursery, has been undertaken collaboratively with the B.C. Ministry of Forests at Campbell River on Vancouver Island. Early results show that seeds dried to 35% and stored for 3 months germinated 2-10 times faster during the first 2 weeks after sowing than seeds prechilled 2 or 3 months (but not dried or stored). The differences decreased by the 4th week after sowing.

CONE AND SEED DISEASE RESEARCH

Jack R. Sutherland

Research continues on the seed fungus (Caloscypha fulgens), seed-borne Sirococcus blight (Sirococcus strobilinus) and inland spruce cone rust (Chrysomyxa pirolata). Recent research on the seed fungus showed several differences between the isozyme patterns of disease-free and pathogen-infested samples, but the main difference was in the latter's high alkaline phosphatase (ALP) activity. By using gel electrophoresis a qualitative analysis was developed, based on presence or absence of ALP, to distinguish infested from disease-free seedlots, and the high ALP activity of infested samples was determined to be of pathogen origin. A qualitative assay for disease incidence was developed by determining the ALP activity of samples with known numbers of diseased seeds and using a prediction equation relating enzyme activity to diseae incidence. A Can. J. For. Res. paper is in press.

Work on Sirococcus blight demonstrated that it is seed-borne on spruce in coastal B.C. container nurseries. The pathogen was detected in over 60% of the spruce (interior and Sitka) seedlots with blight histories. The pathogen was present in 0.3-3.1% of the seeds of infested seedlots. Seeds with shrunken contents yielded the pathogen 7-9 times more often than seeds with normal-appearing contents. A paper has been accepted for publication in Can. J. Botany.

Studies (Can. For. Serv. Res. Notes, in press) over the past 3 years show that cone rust drastically reduces seed production and that seeds from diseased cones often germinate abnormally. Significant progress is being made in determining the exact sequence of events in the pathogen's life history, and the ecology and methods for eradicating the rust's alternate hosts.

CONE AND SEED INSECT STUDIES

G.E. Miller

Mr. A.F. Hedlin retired in December, 1979. The study is now lead by Mr. G.E. Miller. Sampling techniques are being developed for Douglas-fir cones and Douglas-fir cone gall midge (*Contarinia oregonensis*) eggs. Evidence for a sex pheromone in cone gall midge has been collected and a chemical identification program has begun.

Studies on attraction in Douglas-fir cone moth (*Barbara colfaxiana*) have shown that the optimal blend of Z-9-dodecen-1-ol: Z-9-dodecen-1-yl acetate is 75:25. The effects of factors such as trap height, trap design, trap colour, attractant dispenser, and release rates on trap catches are being studied. Studies on host attractants of Douglas-fir cone moth have been temporarily discontinued. Studies on sex and host attractants in the spruce seedworm (*Cydia youngana*) are continuing but have been inconclusive to date.

Several insecticides have been screened for effectiveness against Douglas-fir cone and seed insects but none were consistently effective. Delayed flowering is sometimes effective in reducing cone gall midge damage but is not a reliable control technique.

Dr. T.S. Sahota is studying aspects of the induction of prolonged diapause in the Douglas-fir cone moth, namely: i) attempts are being made to physiologically differentiate pupae entering prolonged diapause from those that diapause only one winter, and ii) cone producing and non-producing trees are being examined to determine if such trees differ chemically and if they do, whether or not chemical constituents of the host affect induction of prolonged diapause. Preliminary results indicate that producing and non-producing trees differ in their isozyme complexes, specifically in the quantities of total proteins, acid phosphatase and esterase.

OFFICIAL TESTING OF TREE SEEDS

D.G. Edwards

Since the Pacific Forest Research Centre became an official member of the International Seed Testing Association (ISTA) in 1978, official testing of commercial seedlots has increased markedly. Certificates of seed quality for 107 seedlots, from eight species, were issued during 1979/80 and an additional 152 tests were completed on seedlots not requiring certificates.

	Number and type* of certificate			
	1979		1980	
	Blue	Orange	Blue	Orange
Abies grandis			1	
Picea glauca			4	
Picea pungens			1	
Picea sitchensis			1	
Pinus caribaea	1		2	
Pinus contorta	5	19	36	26
Pseudotsuga menziesii			9	
Thuja plicata			2	
Total	25		82	

* "Blue" certificates apply only to the sample submitted by the owner. "Orange" certificates require official sampling and sealing of the container and the test results apply to the entire seedlot.

Almost all the seedlots tested were also certified for Source Identity under the OECD Regulations (see report by D.F.W. Pollard).

A "Seed Bulletin", an informally written newsletter, was created in 1980 primarily as a means of communication with seed dealers in the Pacific region on such matters as clarification of certification and seed testing rules and regulations, sample sizes, lead-in times for test completion and recent publications. Bulletins will be issued irregularly and will be sent to other seed analysts and inspectors throughout the CFS for informational purposes.

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TREE AND SEED IMPROVEMENT AT THE PACIFIC FOREST RESEARCH CENTRE

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Key Words: western hemlock, provenances, flower enhancement, gibberellins, reproductive morphology, seed certification.

A project entitled PC-49 Tree and Seed Improvement: BC and Yukon Conifers was established in 1978 to provide a comprehensive range of research and services for improving gene resources in BC and the Yukon. Research during the past two years has been focussed on a large provenance trial of western hemlock Tsuga heterophylla (Raf.) Sarg., and on flower enhancement methods for this species. Good progress has also been made with guidelines for reproductive bud recognition and isozyme characterization methods for western conifers, particularly lodgepole pine. Seed certification services have been maintained and elaborated where necessary, and Regulations for Forest Tree Seeds pertaining to the revised Canada Seeds Act have been drafted. Progress on these items is outlined below; a separate report on seed research and testing services has been submitted by D.G.W. Edwards.

WESTERN HEMLOCK PROVENANCE TRIAL

The Canadian Forestry Service, in collaboration with forest industries in BC, established a trial of 15 provenances of western hemlock at four test sites on Vancouver Island in 1971. After inspection in 1979, one of the test sites (Quatse Lake) was cleared of an excessive invasion of naturally-seeded seedlings through a cooperative agreement between the CFS, the BC Ministry of Forests and Western Forest Products Ltd. (formerly Rayonier Canada Ltd.).

The ten-year height and dbh measurements were made at all sites in spring 1981 and will be reported at a future date. A full analysis of all unpublished data is also planned. Height measurements were made in 1971, 1972, 1973, 1974, 1976 and 1977.

Within- and among-provenance variations in important juvenile characters (flushing and growth cessation) have been investigated among open-pollinated families of parent clones of the original provenance collections. These too will be reported later.

Seeds of *Tsuga chinensis* (lat. 33.2°N, long. 107°E, elev. 1700 m) have been received from Nanjing, Peoples Republic of China, and will be used to expand the *Tsuga* arboretum at this Centre.

FLOWER ENHANCEMENT

The combination of gibberellic acid ($A_{4/7}$) and fertilizer ($Ca(NO_3)_2$) has proved to be effective in the enhancement of strobilus production in young seedlings and rooted cuttings of western hemlock. Against this now routine treatment we have successfully superimposed other treatments, in particular moisture stress (Holger Brix) and temperature (author). High moisture stress and high temperature both contribute to strobilus enhancement, to the extent that, without proper consideration of these factors, strobilus production may be quite limited. Results of these investigations will be published shortly.

Experiments have also been conducted into the optimum timing of enhancement treatments, the effects of late-season temperatures, and the combined effects fo photoperiod and thermoperiod. Again results will be published as warranted.

RECOGNITION OF REPRODUCTIVE STRUCTURES

A series of leaflets describing the reproductive morphology of western conifers is being prepared by Slavoj Eis. While the primary need for such materials has been felt in the cone crop assessment scheme in the Region, the leaflets are expected to receive a wider audience concerned with tree improvement, seed orchard management, and forestry education. The series is to be produced as self-explanatory leaflets that may be tied together with an introductory section and title covers. Leaflets are currently available for four species (see publications).

Cone Crop Bulletins were published in 1980 and 1981 for the Pacific and Yukon Region. A more intensive forecasting system is under development for southern Vancouver Island, and a pilot inventory of lodgeple pine seed resources is to be conducted in the Yukon.

BIOCHEMICAL CHARACTERIZATION OF SEEDS

Isozyme analysis has been improved through the acquisition of iso-electric focussing equipment. A series of lodgepole pine seedlots with known terpenoid patterns are currently under study, together with two sets of 100-tree collections representative of two interior stands. The investigator, Eleanor McMullan, has been accepted for PhD studies at the Swedish University of Agricultural Sciences, Umea, beginning August 1981.

CERTIFICATION OF FOREST TREE SEED UNDER THE O.E.C.D. SCHEME

As Certifying Authority for the Pacific and Yukon Region of the CFS, seed inspectors of this Centre inspected and certified the following quantities of seed for export:

	1979 - 80		1980 - 81	
	No. of certificates	Total wt. (kg.)	No. of certificates	Total wt. (kg.)
Pseudotsuga menziesii	31	448.4	22	220.8
Pinus contorta var.latifolia	66	603.4	116	1173.0
Pinus ponderosa	3	53.4	-	-
Pinus monticola	-	-	1	14.9
Picea sitchensis	44	932.2	25	569.0
Picea engelmanni	-	-	1	.35
Tsuga heterophylla	-	-	2	3.8
Abies amabilis	2	12.9	-	-
Abies lasiocarpa	-	-	1	2.3
Total	146	2050.3	168	1984.15

All the above seedlots were certified for Source Identity. Regulations for other O.E.C.D. categories of seed are in preparation.

The certifying officer participated in the 1980 Biennial Meeting of the O.E.C.D. Representatives of Designated Authorities in Paris, and the IUFRO Working Party Meeting" *Pinus contorta* as an exotic species" in Norway and Sweden, August 1980.

REGULATIONS FOR FOREST TREE SEEDS

Regulations pertaining to the revised Canada Seeds Act (awaiting passage through the Canadian parliament) have been drafted and are under review. The Regulations as envisaged call for active involvement of the CTIA in establishment of standards for certain categories of seeds. A more thorough debate of the issue is expected in the next two years.

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MACMILLAN BLOEDEL LIMITED PROGRESS REPORT 1980-1981

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Key Words: seed orchards, clonebanks, progeny tests, provenance tests

MacMillan Bloedel Limited has been involved in several tree improvement/forest genetics activities during the period covered by this report. These activities have included seed orchard establishment, clonebank management and progeny and provenance test measurements.

SEED ORCHARDS

The establishment and essential completion of five clonal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii) seed orchards continued on the Company's two seed orchard sites. These orchards are established primarily for Company use.

MacMillan Bloedel Limited is a member of the Coastal Tree Improvement Cooperative (C.T.I.C.) and is committed to establishing and managing an additional four clonal seed orchards:

- western hemlock (Tsuga heterophylla (Raf.) Sarg.)
- amabilis fir (Abies amabilis (Dougl.) Forbes)
- western redcedar (Thuja plicata Donn)
- yellow cypress (Chamaecyparis nootkatensis (D. Don) Spach)

Activities related to these orchards have been restricted to parent tree selection and propagation.

CLONEBANKS

The Company is also managing both a western hemlock and a poplar/willow clonebank within the C.T.I.C. The western hemlock clonebank is comprised of rooted and grafted ramets of the same clones. This clonebank will allow study of the growth habits and seed production of the two types of propagules. The poplar/willow clonebank is comprised of 56 Salix species and cultivars, 11 black cottonwood (Populus trichocarpa Torr & Gray) parent tree selections and 16 Populus species and cultivars. The primary function of this clonebank is to provide cuttings for use in streamside stabilization.

PROGENY TESTS

Western White Pine (Pinus monticola Dougl.)

This test was initiated in 1978 to evaluate, under plantation conditions, the open-pollinated progeny of selected white pine trees. Parent trees were selected as being either rust free, rust cankers inactivated in the branches or infected with active rust. Plantations were established on two sites considered potentially good white pine reforestation sites.

In 1980, after two years in the field, the trees were assessed for survival, height growth and rust incidence. Survival has been excellent and only one site is showing any signs of rust infection. On that site there appears to be no difference in the rust infection levels of the three groups. Each group has 40% of the families showing some rust incidence.

Analysis of variance of the height data identified a highly significant (.01) location effect and location x family interaction. The plantation will be assessed again in 1982.

PROVENANCE TESTS

Noble fir (Abies procera Rehd.)

Plantations were established in the fall of 1977 on five sites to test the potential value of noble fir as a timber species on Vancouver Island. Six noble fir provenances from Washington and Oregon were used in a randomized complete block design with 25-tree row plots. Four replications were planted at each test location. Statistical analysis of the survival data after two growing seasons showed highly significant (.01) differences between locations and provenances. As an example, one test had a mean survival of only 33%, while two provenances in that test had survivals of 86% and 78% respectively.

Species comparison tests were established in conjunction with the noble fir provenance tests. Species additional to noble fir were: amabilis fir, Douglas-fir, western hemlock, mountain hemlock (Tsuga mertensiana (Bong.) Carr.) and western larch (Larix occidentalis Nutt.). These tests were established as randomized complete blocks with 25-tree row plots and four replications at each site. Survivals were assessed at the same time as the provenance tests. Statistical analysis showed highly significant (.01) differences between locations and species. Noble fir had survival equal to or greater than the other species in all plantations. This test will receive fifth year measurements in 1982.

Western Larch

Four plantations were established in the fall of 1977 with the objective of determining the performance of four provenances of western larch on a variety of sites. Four provenances from high quality stands in southeastern British Columbia were used. A randomized complete block design was used with 25 trees per provenance, replicated four times per site.

Survival after two growing seasons was assessed and statistical analysis showed significant differences (.05) between locations and provenances. However, only one provenance in one location had a survival rate as high as 80%.

Species comparison tests were established along with the provenance tests. Species included were western larch, Douglas-fir and lodgepole pine (*Pinus contorta* Dougl. var. *contorta*). A randomized complete block design with 16-tree row plots and two replications per site was used for this test. These tests were assessed at the same time as the provenance tests. Overall survivals were lodgepole pine - 76%, western larch - 66%, and Douglas-fir 34%.

STUDIES IN NATURAL POPULATIONS OF SOME NORTH AMERICAN ABIES

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Key words: Abies, population differentiation, population variation,

This report outlines work done in conjunction with Dr. W.H. Parker, Lakehead University, Thunder Bay, Ontario. The objectives of these studies are: 1) to determine patterns of relationships and variation of trees growing in nature, and 2) relate those patterns to variables that describe the environment and growth habits of the trees. Such information is of relevance in understanding the biology of forest trees, identifying potential sources of variation that may have an impact on re-forestation decisions, and identifying sources of certain genetic material for breeding experiments.

Over the last two years, studies have centered on Abies amabilis (Dougl.) Forbes and A. lasicoarpa (Hook.) Nutt. in the Nass River drainage, north of Terrace, B.C., A. lasiocarpa and A. balsamea (L.) Mill. in western Canada, A. procera Rehd. and A. magnifica A. Murr. in the Cascade, Coast and Sierra Nevada Mountains of western United States and A. balsamea in western Ontario. As well, preliminary analyses have been performed on combined samples of A. lasiocarpa and A. balsamea from Vancouver Island and western Washington east through the Rocky Mountains of Canada to western Saskatchewan and western Ontario.

Analyses have been based on population samples; the material being analyzed consisting of cones, needles from cone-bearing branches and, for most studies, needles from immature trees. Most of the data gathered have been structural; we have some chemical data. The data have been subjected to multivariate analyses.

Specific findings are listed below

1) Abies amabilis and A. lasiocarpa from the Nass River drainage.

   a) The two species have not hybridized.
   b) Population differentiation is related to edaphically odd sites (lava beds), physiographically sites of restricted areal distribution (canyon bottoms) and geographic distribution.
   c) Immature trees show the same patterns of relationships as the mature.
   d) Populations of immature trees are less variable than populations of sexually mature trees from the same site. This has been interpreted as reflecting more age-classes in the populations of sexually mature trees.

2) Abies lasiocarpa and A. balsamea from western Canada

   a) The two species represent two poorly differented taxa that meet at the Rocky Mountains and not in central Alberta as has been previously hypothesized.
   b) There is no indication of modern hybridization between the two taxa.
   c) Population differention that occurs is not related to environmental variables. It could represent selective forces in ecologically different sites, or factors other than selection.
   d) Points a) to c) above are based on structural data. Chemical data does not refute the above except that it indicates that geographic distribution is related to population differentiation.

3) Abies procera and A. magnifica

   a) Based on analyses of needle data, both from cone bearing branches and immature trees, these two species are separate with the southern limit of A. procera and northern limit of A. magnifica being in southern Oregon in the vicinity of Crater Lake. Based on cone characters, these two species form an intergrading series connected by A.magnifica var. shastensis Lemmon in n. California and s. Oregon.
   b) Population differentiation is related to geographic distribution as well or site history (i.e., whether or not populations became established following deforestation, either by logging or fire). Periodic disturbance is a common feature of forests in North America. Thus, one is led to the hypothesis that some types of population differentiation are cyclic in nature indicating that selection, like drift, can produce cyclic changes in gene frequency.

c) Populations of mature trees are more variable than populations of immature trees from the same site (see discussion under 1) d) above).
d) The combination of c) and b) above would imply a high degree of genetic heterozygosity in Abies procera and A. magnifica, and perhaps other trees.
e) The taxon called A. magnifica var. shastensis is polyphyletic (has evolved from more than one ancestor).

4) Abies balsamea from western Ontario

a) Population differentiation has occurred but is not readily explainable by any enviromental variable.
b) The relationships between populations of immature trees are not the same as the relationships between populations of mature trees.
c) Based on a) and b) above, it is hypothesized that selection does not explain population differentiation.

5) Abies lasiocarpa and A. balsamea from Vancouver Island and western Washington to western Ontario

a) These data were collected over several different years so analyses were done on residuals derived from multiple regression analysis. This was done to remove the effect of covariates (and hopefully size).
b) The data indicate that differentiation within A. lasiocarpa and A. balsamea, excluding plants from Vancouver Island, is weak at best. Plants from Vancouver Island are distinct from the rest.
c) These results are preliminary only and further interpretations must await more thought, analysis and data. However, it is interesting to note that, like Hunt and vonRudloff (1979), our data indicates A. lasiocarpa from Vancouver Island is different from the remainder of A. lasiocarpa and A. balsamea.

d) Cone data are not yet complete.

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

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Key Words: forest genetics, education, isozyme, variation, karyotype.

UNDERGRADUATE PROGRAM

Beside the usual elective Forest Genetics course offered to undergraduate students, a similar course was given to 78 3rd and 4th year undergraduate students at the Nanking Technological College in China from September 16th to October 15th, 1980.

As a result of increased interest in tree improvement in British Columbia, a Guided Independent Study course in forest genetics is now in preparation.

GRADUATE AND RESEARCH PROGRAM

Research programs relate to variation and heritability studies of western conifers, and graduate programs generally have correlated with the above objectives. Completed graduate programs included El-Kassaby's Ph.D. dissertation - who was the 9th student to receive Ph.D. degree in forest genetics on "Isozyme Patterns of a Selected Pseudosuga menziesii (Mirb.) Franco Population".

Open pollinated seed samples were collected from 42 Douglas-fir trees in September 1978. The indivduality of cone lots and subsequent seed lots had been retained in these trees. The trees are located in the University of British Columbnia Research Forest, Haney, B.C. and were studied previously for phenology, growth, and flower and cone production by Griffith (1968)

Isozyme variations were studied (using the gel electrophoresis technique) for both the haploid megagametophyte and the diploid embryo tissues at 27 loci, coding for 18 different enzymes for each tree separately.

The objectives of this study were:

1. to study the mode of inheritance for these loci;
2. to determine the linkage relationships among these loci;
3. to estimate the outcrossing rate (t) for this popluation;
4. to determine the most effective sample size for estimating allelic frequencies
5. to study the amount and organization of isozyme variation in this population and compare the results with the variation for some quantitative traits, and
6. to study the association between isozyme genotypes and quantitative traits.

The results from the inheritance analyses for the 14 heterozygous enzyme systems showed that these electrophoretic variants segregated in a co-dominant fashion with distinct simple Mendelian expression. The linkage study yielded two tightly linked pairs (AAT-2;PGI-2) and (AAT-3:SOD) with recombination frequencies of 1.5 and 22.4 percent respectively. In addition, 7 loosely linked pairs were detected with recombination frequencies varying between 32.7 and 41.9 percent. It was not possible to study three-point linkage due to the lack of appropriate combinations. Conditional probabilities were used to estimate the outcrossing rate (t) in the population using 4 enzyme systems. The estimated outcrossing rate was 0.9 with a standard deviation of 0.11, giving an inbreeding rate of 10 percent. By the minimum sampling criterion it was estimated that sample sizes between 42 and 60 trees from the base population are optimal to obtain reliable estimates for the allelic frequencies. Striking agreement on the appointment of genetic variation was found between results obtained from the gene diversity analysis for the electrophoretic data and the analysis of variance for 7 different quantitative traits. These 2 independent sets of informaton confirmed that the majority of the variation existed within and not between poplulations Finally, the association between the mother trees' genotypes and the performance of their half-sib families showed that the mother trees appeared to exert minimal influence on those characteristics analyzed. The pollen parent contribution to the genetic constitution of the progenies should be investigated and it is recommended that isozyme studies should be extended to full-sib progenies.

Nelson, M.F. thesis was the 11th in forest genetics and he investigated the "Variation in Growth Efficiency of Selected Western Hemlock [Tsuga heterophylla (Raf.) Sarg.]Trees.

Eighty western hemlock trees, in the age range of 15 to 48 years, were selected on three Crown Zellerbach tree farms in northwestern Oregon and southwestern Washington to sample the range of variation in growth efficiency. Growth efficiency is defined as the ability of the crown to produce the maximum amount of wood in relation to its crown surface area. Seclection of the trees was based on the crown index ratio (live crown length/crown width).

The objectives of the study were to estimate:

1) the range of variation in growth efficiency of invididual trees,
2) how variation in growth efficiency of individual trees could be utilized to maximize volume on a unit area, and
3) the efficiency of narrow crown western hemlock trees as wood producers.

Results from regression analysis showed that there was sufficient variation in growth efficiency, with a range of the standardized residuals exceeding at least ± 2.0 standard errors of the estimate for all three regression models. Based on this range it is suggested that selection of ten year basal area increment or gross stem volume for western hemlock in relation to crown surface area or sapwood basal area may be worthwhile.

The significance of the variation in growth efficiency becomes apparent when the higher growth efficiency classes are selected. It is estimated that selection of the higher growth efficiency classes rather than the average may increase ten year basal area increment/hectare by 39 to 45 percent.

It appears from the trees measured that there is little relationship between growth efficiency and the degree of slenderness of the crown.

Presently Musoke is close to completing her M.F. thesis on "Junvenile-mature Correlation of Selected Douglas-fir Provenances and Progenies", and Collangeli now has samples from seven of the eight *Pseudotsuga* species to complete her M.Sc. thesis on "Comparative Karyotype Analysis of *Pseudotsuga* Genus".

Dr. Y.A. El-Kassaby is writing up his research results for publication, assisting undergraduate and graduate students in their thesis preparation as a NSERC Postdoctorate Fellow.

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TREE IMPROVEMENT IN ALBERTA, 1979-1981

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Key Words: selection, tree breeding, seed orchards, seed production, lodgepole pine, white spruce.

The Alberta tree improvement program is in its sixth year of operation. During this period, the interest, acceptance, and participation by the forest industries in the program work and related activities has steadily increased. As a result, the work on several projects on genetic improvement of lodgepole pine and white spruce, although still in planning or very early stages, has progressed very well. This report very briefly describes progress on the work carried out by the Alberta Forest Service, British Columbia Forest Products Ltd., Canadian Forest Products Ltd., Procter and Gamble Cellulose, Ltd., and Simpson Timber Company (Alberta) Ltd. over the past two years.

PROGRAM DEVELOPMENT

The FMA forest industries and the Alberta Forest Service held a series of meetings to finalize details relating to obligations, roles, and responsibilities of the participants in the co-operative tree improvement projects. Agreement was reached in principle, with regard to sharing of costs and work loads for various activities and phases, with the exception of seed orchards. A formal agreement was signed by British Columbia Forest Products Ltd. and the Alberta Forest Service affirming commitment of both parties to work co-operatively to initiate and carry out work on specified projects; and the description of cost and work sharing arrangements was provided. The same agreement is expected to be formally agreed bilaterally by the Forest Service and each of the other FMA forest industries.

The work on several projects is at a stage where commitments of sizeable resources are required on part of the forest industries to ensure continuation and successful completion of work under progress. The industries collectively approached the Forest Service for incentives in return for carrying out genetic tree improvement and intensive silviculture work. A Silviculture Improvement Advisory Committee, consisting of members from industry and the Alberta Forest Service, was formed to explore this issue in depth and make recommendations. Separately, the Alberta Forest Service and FMA industries successfully concluded discussions on a proposal which is expected to expedite development of seed orchards in the province. Under the proposal, the Forest Service may purchase and provide land to forest industries who in return will be obliged to bear all costs of establishing and operating seed orchards and provide the Forest Service with a portion of the seed crop required for its own use.

ASSEMBLY OF BREEDING STOCK

The selection of superior trees to provide base material for selection and breeding projects continued with most of the efforts directed at white spruce in central and northwestern Alberta. A total of 83 white spruce and 40 lodgepole pine trees were selected. Cone and/or scion collections were made from the selected trees. Field work for most of this work was carried out by Procter and Gamble Cellulose, Simpson Timber Company, and the Alberta Forest Service.

PROGENY TESTING

As part of genetic improvement of lodgepole pine in breeding region B1, four open pollinated half-sib family field trials were established jointly by the Alberta Forest Service, Procter and Gamble Cellulose, Canadian Forest Products, and British Columbia Forest Products. Region B1 contains 14 800 km^2 area covering parts of the Grande Prairie and Whitecourt Forests. The field trials were outplanted in the spring, 1981 using container stock produced from OP seedlots obtained from selected superior trees located mostly within the region. The field design consisted of blocks in reps layout (5 replications, 4 tree row plots) with 400 families grouped in 25 unique and independent sets of 16 families each.

Site treatment and development of four test sites for establishment of field trials as part of the genetic improvement of lodgepole pine in breeding region C was completed jointly by Simpson Timber Company, and the Alberta Forest Service. The planting stock for these trials is being produced by the Alberta Forest Service and outplanting will be done in spring, 1982.

Procter and Gamble Cellulose completed a field establishment of an experiment designed to estimate the difference in growth performance of open pollinated progeny of selected superior vs. randomly found lodgepole pine trees. Two field trials were established using planting stock produced from seedlots collected from 20 superior and 20 random trees selected from five local stands.

SEED ORCHARDS

A 15 ha lodgepole pine seed orchard plantation was established in spring, 1980 in the Grande Prairie Forest jointly by Procter and

Gamble Cellulose and the Alberta Forest Service. Planting stock for this plantation was produced from a seedlot formed by bulking seed obtained from 201 selected superior trees. The planting was done at 3 m (between rows) X 1 m (within row) spacing and it will be progressively thinned to retain about 20 percent of the best trees for seed production. This plantation was primarily established to evaluate effectiveness of phenotypic mass selection as an alternate breeding scheme to provide relatively low cost seed that may be economical for use in direct seeding programs.

Procter and Gamble Cellulose began work to define the criteria to select a suitable seed orchard site within the Grande Prairie general area (440 km northwest of Edmonton) during 1980. Surveys of available agriculture land were made in order to locate a site with coarse textured soil, ready availability of water for irrigation and micro-climate that would aid in seed production of white spruce and lodgepole pine.

The Alberta Forest Service started the site development for a white spruce seed orchard to be located at Smoky Lake. Fencing of the site was completed and work started on the installation of an irrigation system.

The Alberta Forest Service and Procter and Gamble Cellulose initiated a co-operative study to monitor flowering and seed production response of white spruce grafts at several southern locations to identify the best climate for locating seed orchards of this species. One field trial was established in summer, 1981 at Brooks in southeastern Alberta. Two additional plantations, one each in central and northwestern Alberta, will be established in 1982. Each plantation contains 3 or 4 ramets each of 10-16 white spruce ortets originating from northern Alberta. One set of this material was established earlier by the British Columbia Forest Service in its clone bank at Vernon.

SEED PRODUCTION AND SEED COLLECTION AREAS

No new seed production or seed collection areas were established in the province during the past two years. The Alberta Forest Service is currently reviewing its commitment and approach to this work. It is anticipated that work on locating and earmarking excellent quality stands as cone collection reserves will resume later this year and intensify in the following years. In the meantime, a study was started to develop and define methods, procedures, and criteria for objective evaluation of phenotypic quality of natural white spruce stands.

GENETICS AND TREE IMPROVEMENT RESEARCH ALBERTA FOREST SERVICE, 1979-1981

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Key Words: forest genetics, tree breeding, tree seed, provenance studies, species tests, seed production, genetic variability, white spruce, lodgepole pine, tamarack.

The genetics and tree improvement research program of the Alberta Forest Service is still in its early stages. The work is divided into four projects: species testing, provenance research, genetic studies, and seed production and related studies. This report describes the progress of work carried out over the past two years.

SPECIES TESTING

Work on species testing was started in 1976 to evaluate the comparative performance of promising native and exotic tree species and to determine their suitability for forest regeneration in various regions of the province. Acquisition of seedlots for species testing research nears completion and field establishment of all experimental plantations required as part of this project is expected to be concluded in 1986.

A larch species trial using container seedling stock was established at Smoky Lake to test and compare field performance of tamarack (1 seedlot), Siberian (raivola) larch (1 seedlot), and Western larch (8 seedlots). At the end of nearly two growing seasons in the field, all seedlots showed excellent survival and the mean height of the three species was: tamarack 28 cm, Siberian larch 36 cm, Western larch 37 cm.

A field trial was established on a nutrient poor sandy soil site to monitor and compare field performance of white spruce, black spruce, lodgepole pine, tamarack, and white birch in pure and mixed planting with green alder (Alnus crispa). The experimental design consisted of replicated row plantings of the five species with and without alternating rows of green alder.

Greenhouse production of experimental planting stock was completed for field outplanting of two additional experiments:
1. A pine species test to compare performance of red pine, ponderosa pine,

lodgepole pine, and jack pine. Each species is represented by 1-7 seed sources.

2. A maple species trial (sugar maple, Japanese maple, and red maple) to determine the adaptability and winter hardiness of selected seedlots of these species for possible use in amenity or ornamental plantings in Alberta.

PROVENANCE RESEARCH

As part of an extensive series of white spruce provenance trials to be established throughout the province, planting stock to provide materials for three additional field trials was transplanted in separate nursery experiments. Twelve similar experiments were earlier established in nursery transplant beds during 1976-1979. Field outplanting of these experiments started in the spring of 1980 using 4-year-old planting stock and the establishment of six field trials was completed by spring of 1981. One of the three field trials established in spring, 1980 in the foothills region of southern Alberta showed severe mortality (82%), with the exception of local seed sources and the seed sources originating from the foothills due north of the plantation region. The plantation failure was attributed to winter desication since the 1980-81 winter had an unusually low snowfall and frequent warm temperatures. The plantation site was replanted with surplus stock in spring, 1981.

Observations on flushing dates of the white spruce provenances established in the fifteen separate nursery experiments were started in 1979 and continued in 1980 and 1981. The experimental design permits evaluation of flushing dates relative to the geographic origin of 19 seed sources in three different years on seedlings of 3 different ages (1 year old, 2 year old, and 3 year old). Data from this study has been compiled and statistical analyses are expected to be completed later this year.

Outplanting of two scots pine seed source trials, consisting of 25 seed sources originating from above 50°N latitudes in the U.S.S.R. was completed in spring, 1980. One field plantation was established in central Alberta and the other in northern Alberta. Each of the plantations included a lodgepole pine seedlot for comparison purposes. These plantations are part of a co-operative study initiated by the U.S. Forest Service.

A ponderosa pine seed source trial established in the nursery in 1977 was outplanted as a field trial in central Alberta in 1980. It contains 14 seed sources of relatively high elevation origins from North Dakota, South Dakota, Montana, Wyoming, and Colorado. Evaluation of a Norway maple seed source trial established in the nursery in 1978 showed that none of the seedlots are winter hardy in a central Alberta test environment. This trial was part of a co-operative study initiated by the Petawawa National Forestry Institute and consisted of 12 single tree of bulk seedlots from three geographic origins from the U.S.S.R..

GENETIC STUDIES

A study was started to evaluate genetic variability and correlations among open pollinated seedlots of 37 parent trees from a white spruce stand from which seed was collected in two different seed crop years. Data on seedling performance (height, shoot and root dry weights) was recorded in two greenhouse test environments and evaluation of the results is in progress. The remaining seedlings from this experiment will be outplanted in a field trial to be established in 1982.

A greenhouse study of genetic variability in 114 open pollinated families of lodgepole pine originating from 38 stands located in west-central Alberta was concluded. It was interesting to note that families/stands effects were significant for all traits (seed germination count, cotyledon number, seedling height, shoot and root dry weights, and shoot:root ratio), whereas stand effects were found to be significant only for seed germination count, cotyledon number, and shoot:root ratio. Additional data on seedling height was collected from another greenhouse study of 240 open pollinated families originating from 60 stands located in central Alberta. The data on greenhouse performance of lodgepole pine families is being accumulated for the purpose of calculating genotypic and phenotypic correlations with the later field performance of the same families in order to develop a possible criteria for screening poorer families based on greenhouse test results.

SEED PRODUCTION AND RELATED STUDIES

A study on seed quality of seed collected in two different seed years from each of 37 seed trees from a seed production area was completed. Analysis of variance of seed germination data showed highly significant ($p \leq 0.01$) differences due to seed years, seed trees, and cold stratification treatments. All interactions among the main effects were also statistically significant. Overall mean germination percentages were as follows:

1976:	40 ± 4 (unstratified)	86 ± 2 (stratified)
1979:	63 ± 4 (unstratified)	98 ± 1 (stratified)

Thousand seed weight (adjusted to 6% moisture content) of seed trees from seed crops of the two different years was not significantly correlated ($r=.24$). The mean germination percentage of the seedlots (unstratified seed) showed highly significant correlation between seed years ($r=.66$). However, it was interesting to note that mean germination of stratified seedlots showed extremely poor correlation ($r=.05$) between seed years. No relationship was found between seed weight and germination capacity of seedlots in either year.

Several reports in recent literature have reported successful induction of early flowering in white spruce and lodgepole pine by applying a continuous photoperiod and high levels of nutrients to the seedlings of these species while being grown in a greenhouse prior to outplanting. In light of this, a study was started in 1979 to evaluate greenhouse response of white spruce and lodgepole pine to a continuous photoperiod and heavier application of nutrients, and to subsequently monitor flowering and seed production response of these materials in a field trial. Seedlings of both species were grown in a greenhouse under the prescribed (accelerated growth) environment for eight months. At the end of this period, the mean height of white spruce seedlings was 69 cm compared to 33 cm for lodgepole pine. Conventionally reared seedlings of the same seedlots of white spruce and lodgepole pine averaged 12.5 cm and 7.2 cm respectively. The substantial difference in height growth of white spruce and lodgepole pine under an accelerated growth environment for eight months is attributed to differing growth habits of the two species. White spruce showed continuous height growth throughout the eight months period, while lodgepole pine set bud after every 2-3 weeks of active height growth and stayed dormant for 2-4 weeks before flushing and resuming height growth.

At the end of the greenhouse study, seedlings produced under the accelerated growth environment were outplanted as a research plantation for future monitoring of growth, development, flowering, and seed production response of these. Conventionally reared seedlings were established as a control for comparing results.

PLANT PROPAGATION AND SEED BANK

Apart from the production of planting stock for the Alberta Forest Service genetics and tree improvement research projects, plant propagation facilities of the Genetics Section, Alberta Forest Service are also responsible for the production of planting stock for co-operative genetic improvement projects with the forest industries of the province. During the report period, total production was 101,800 seedlings and 1,676 grafts.

An experimental study designed to develop a new growing schedule and nutrient prescription for greenhouse production of tamarack container stock was satisfactorily concluded. Several difficulties were being encountered earlier in growing tamarack seedling crop using a standard growing regime adopted for production of other conifer seedlings. Tamarack seedlings produced under this growing regime generally showed poor root growth, excessive lush top growth and spindly stems.

A total of 403 seedlot entries were added to the seed bank. The number of seedlots extracted and processed was 358. These represented open pollinated seedlots of selected trees and seed source stands, as well as general collections made for building inventory for experimental work and seed exchanges with other agencies.

Systematic germination testing of nearly 2,500 research seedlots in the seed bank was started and 321 germination tests were completed. It was decided that if sufficient seed can be spared, all seedlots will be germination tested at least once (as far as possible within the second or third month of their storage). For the purpose of monitoring seed quality in the long term, a set of 40 reference seedlots composed of subsets of a varying number of seedlots of the major species in the seed bank, was selected for testing moisture content and germinability each year. This set will be progressively expanded every year to include a few more entries from the new seedlots being added to the seed bank.

A study was conducted on the effect of extended cone after-ripening of white spruce cones on seed yield and seed quality. Green cones nearing maturity were collected from 15 trees. Each of these collections were divided into two parts and separately air-dried at approximately $20^{\circ}/15^{\circ}C$ day/night temperature for two and four weeks before being kilned and extracted. Both treatments were found to give similar seed yield, seed germination, and seed weight. As a result of this study, a standard two weeks air-drying period was adopted for drying white spruce cones before kilning and extraction.

GENETIC IMPROVEMENT OF JACK PINE FOR THE PRAIRIE PROVINCES, 1979-81

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Keywords: Pinus banksiana, family test, grafting, seed orchard, clone bank, progeny test

Height measurements at five years after planting are now on hand for all three family tests of the Northern Forest Research Centre's jack pine breeding program. These data have been used to a limited extent. Parent clones ranking near the top for their family test in progeny mean height, with reasonably favorable grafting records and scion producion, were selected and grafted for establishment of seed orchards by cooperators. There was some progress toward clone bank completion.

A draft manuscript for a comprehensive report on the jack pine breeding program has been reviewed, and is now being revised.

CLONE BANK

A major share of program resources has been absorbed by clone bank development during the past two years. Stocking remains at about 60%, the same level reported in 1979 (Klein 1980 b). Grafts on hand in pots will, when planted, increase stocking to about 85%. Grafting success was achieved with some difficult clones by collecting scions in November or March and grafting in March on dormant understock. Clones which have yielded little or no grafting success were established in the clone bank by transplanting the primary ramets from a preliminary clone bank. I have intended to try late fall grafting for difficult clones, but have not yet been able to have understocks and time available then.

We are still refining the technique for rearing understocks. Watering and feeding by sub-irrigation during the container-rearing period resulted in straighter stems on the 1981 understocks, with much less staking and tying than was required for previous crops. Morphology of winter growth in the greenhouse has been unsatisfactory, despite manipulation of photoperiod and temperature. Now we will try storing the seedlings outdoors in their containers through the winter, then potting them up to complete their growth in a second summer.

APPLICATION OF FAMILY TEST RESULTS

Cooperative grafting of progeny-tested clones was done for the western breeding district in 1979 (Klein 1980 b) and 1980, for the eastern breeding district in 1980, and for the central breeding district in 1981. Selection was based on progeny mean height superiority in each district's family test at five years from planting. Mean height of the progenies of selected clones was 8.5% and 7.2% above the test mean for the eastern and western district tests, respectively. Up to 300 scions of 26 clones have been grafted for one seed orchard. The resulting ramets were planted in a clone bank (Prince Albert Pulpwood Ltd.), lined out at a nursery to await development of an orchard site (Saskatchewan Forestry Branch), or planted in a seed orchard (Manitoba Forestry Branch). Ten-year results should support a more ambitious scale of application. Controlled mating of clone bank ramets will soon be practicable for high-ranking genotypes which are difficult to graft, and may prove to be the generally superior method for producing jack pine seed orchard trees.

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FOREST GENETICS AT THE UNIVERSITY OF ALBERTA, 1979-81

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Key Words: Isozymes, electrophoresis, population genetics, differentiation, mating systems, hybridization, polyploidy, leaf wax alkanes.

Forest genetics activities at The University of Alberta have focussed on the area of population genetics, utilizing starch-gel electrophoresis as the principle research technique. Over the past two years, several projects investigating jack and lodgepole pines, Douglas-fir, trembling aspen, white spruce, and birches have been completed or initiated.

ENZYME VARIATION OF JACK AND LODGEPOLE PINE

Megagametophytes of 410 lodgepole pine (*Pinus contorta* var. *latifolia* (Dougl.) Engelm.), jack pine (*P. banksiana* Lamb.), and putative hybrids from ten Alberta populations were subjected to starch-gel electrophoresis. Twenty-one loci in 14 enzyme systems were scored to characterize allozyme variation of the taxa and clarify evolutionary relationships between the two species. Six loci exhibited high levels of heterozygosity (>45%) in at least one of the species. Differences in allozyme frequencies at eight loci permitted differentiation between the two parental taxa. Sixty-four percent of the loci in jack pine and 75% of the loci in lodgepole pine were polymorphic. Average heterozygosity of jack pine was .127, while that of lodgepole pine was .187. Jack pine had 2.07 alleles/locus, while lodgepole pine had 2.47 alleles/locus. Nei's genetic distance between the two species was .113. The reduced variability of jack pine could be the result of its evolution from a lodgepole pine-like ancestor after passage through a genetic bottleneck. Laboratory portions of this study were carried out while I was a visiting scientist at the Population Genetics Laboratory, B.C. Ministry of Forests. Francis Yeh and I are preparing a manuscript from this study.

ENZYME VARIATION OF DOUGLAS-FIR

Megagametophytes of 99 Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) from five foothill populations in Alberta were subjected to starch-gel electrophoresis. Twenty-six loci in 17 enzyme systems were scored to characterize allozyme variation within and among the populations. Eight loci exhibited high levels (>.45) of heterozygosity; average heterozygosity was .231. Alleles at five loci had frequencies markedly different from those reported for B.C. populations. 67% of the loci were polymorphic. Genetic distances between Alberta and coastal B.C. populations were similar to those reported between other tree species.

Laboratory portion of this study were completed while I was a visiting scientist at the Population Genetics Laboratory, B.C. Ministry of Forests. Francis Yeh and I are preparing a manuscript from the results. A subsequent collection was made from four nearby populations in the Porcupine Hills to study local differentiation of enzyme loci. Results will be reported at the 17th IUFRO Congress at Kyoto, Japan, in October 1981.

GENIC VARIATION OF TREMBLING ASPEN

Mr. William M. Cheliak completed his M.Sc. thesis on "Genic variation of trembling aspen in Alberta" in 1980. 256 clones in eight aspen populations in Alberta were studied to delineate variability in leaf morphology. Starch-gel electrophoresis was used to study crude enzyme extracts from dormant vegetative bud tissue from 222 clones in seven of these eight populations. The eight morphological characters and two derived ratio characters showed significant among-population variation. Discriminant analysis showed groupings of populations at similar latitudes. A total of 76 alleles coding for 26 putative loci were found in the populations studied. Average observed population heterozygosity was 0.52, with 2.3 alleles per locus and 85% of the loci polymorphic. A model was developed which indicated vegetative reproduction, with mutations accumulating by Muller's ratchet, could cause the high levels of variation maintained in the population. Within-population variation accounted for 94% of the total gene diversity.

Manuscripts reporting on this study are in various stages of preparation and review. This study was supported by a CFS Research Agreement within the Department of Forest Science and NSERC. Mr. John King and I are continuing this study with detailed investigation of individual clones to see if we can find evidence of somatic mutations within clones and "daughter" clones derived by mutation from other clones.

LEAF WAX OF TREMBLING ASPEN

Mr. Barry C. Jaquish completed his M.Sc. thesis, "Natural variation in the leaf epicuticular wax alkanes and leaf wax morphology of trembling aspen (<u>Populus tremuloides</u> Michx.)". Gas-liquid chromatography was used to analyze the hydrocarbon fraction of leaf epicuticular waxes, and to describe the inter- and intraclonal, temporal, sexual and geographic variation in the hydrocarbons. The hydrocarbons were composed of seven normal-alkanes, with odd-numbered compounds predominating. Significant differences in alkane percentages existed among clones and crown strata, and between leaf types. Broad-sense heritabilities for all of the alkane characters except nC25 were high (>.60), indicating differences in the alkane characters are largely due to genetic differences among clones. The unique clonal alkane profiles indicated leaf wax alkanes have potential as clone delineators. All alkanes except nC23 and nC25 varied significantly over the growing season. The major transition in alkane concentrations occurred six weeks following leaf flush and may be related to the cessation of surface wax deposition. Staminate clones contained significantly higher concentrations of nC23 and nC25, and lower concentrations of nC26 and nC27 than pistillate clones. Discriminant analysis correctly classified 83% of the clones to their appropriate sex. Scanning electron microscopy revealed pistillate wax is composed of dense, cruciform-shaped platey crystals which are oriented perpendicular to the leaf surface, while staminate waxes are less dense and are oriented horizontal to the leaf surface. This variability in wax morphology may give the selective advantage to pistillate clones in hotter environments and to staminate clones in cooler environments. Alkane concentrations were significantly correlated with elevation and average daily temperature. Significant differences among populations were found for all alkanes except nonocosane (nC29). Cluster and discriminant analyses of the alkane characters delineated two distinct groups of Alberta aspen.

This study was supported by a CFS Research Agreement.

A NEW POLYPLOID BIRCH SPECIES

During a portion of my study leave, Burton V. Barnes and I completed a study of unusual birches, which we believe are octoploids (n=56) that arose from unreduced gametes of Betula x purpusii Schneider and reduced gametes of yellow birch (B. alleghaniensis Britton). Although polyploids account for 26% of temperate zone woody plants, we know of no other recent evidence of natural polyploidy. We are completing a manuscript describing and naming this birch and will submit it for publication shortly.

NURSERY SELECTION OF LODGEPOLE PINE AND WHITE SPRUCE

With the cooperation of Dr. Narinder Dhir of the Alberta Forest Service we have been studying the genetic effects of nursery selection (for seed size) in lodgepole pine and white spruce (Picea glauca (Moench) Voss). Seed from unsorted and sorted seed lots of several populations has been subjected to starch-gel electrophoresis, and the isozymes scored. This study is being supported by the Dean's Agriculture Canada Grant.

MATING SYSTEMS

Mr. Cheliak has been working on a Ph.D. study of the mating system and fitness selection components of jack pine. We expect the laboratory analysis of isozymes to be completed by the end of this summer (1981), with Mr. Cheliak writing his dissertation this fall and winter. Mr. King and I expect to start a study of the mating system and population structure of white spruce this fall. Preliminary work has been done on identifying isozyme loci and alleles and their inheritance. We are negotiating a contract with the Alberta Forest Service through Dr. N. Dhir to support this work.

SPECIFIC GRAVITY AND FIBRE LENGTH VARIATION OF TREMBLING ASPEN

Mr. Alvin D. Yanchuk has begun an M.Sc. study of variation of wood specific gravity and fibre length within and among clones of Populus tremuloides in central Alberta. This study is supported by a CFS Research Agreement with the Department and NSERC funds to Dr. M. Micko of the Department of Agricultural Engineering.

NEW PERSONNEL

Ms. Hansi Klemm joined the population genetics (electrophoresis) laboratory as a Biological Technician in September, 1980; she has assumed the major responsibility for the day-to-day operation of the laboratory. Mr. James Lavoie joined the Department as a Biological Technologist in October, 1980; approximately 80% of his time has been spent in the population genetics laboratory. Dr. Francis C. Yeh, Technical Advisor - Genetics, Research Branch, B.C. Ministry of Forests, was appointed Associate Academic Staff member (Associate Professor) in 1980. Dr. Yeh serves on graduate student committees, presents occasional seminars and lectures, and provides advice to the genetics program.

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TREE IMPROVEMENT IN SASKATCHEWAN

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Key Words: provenance tests, fertilization.

Tree improvement activities over the past two years have concentrated on: plus tree selection, planting of provenance tests, mass selection in nursery beds, fertilizing in the Maloneck seed production area, and grafting. White spruce (*Picea glauca* (Moench) Voss) has received the most attention. Provenance tests are planned for the exotic species of lodgepole pine (*Pinus contorta* var *latifolia* Engelm), red pine (*Pinus resinosa* Ait) and Scots pine (*Pinus sylvestris* L). A jack pine (*Pinus banksiana* Lamb) provincial provenance test was sown this spring (1981) and will be planted in the spring of 1982.

WHITE SPRUCE

No plus trees were selected in 1980, 20 were selected in 1979 and grafted in the spring of 1980. The grafted material has been placed in a clone bank pending sufficient numbers of ortets to establish a clonal seed orchard.

Mass selected 3-0 and 2-2 seedlings are chosen each spring and fall for a seedling seed orchard.

The Maloneck plantation was established during the years 1939 to 1942. The plantation has been used for a seed production area since 1975. The seed obtained from this stand has germinated consistently above average (85% vs 70%); therefore, if by fertilizing, cone crops could be induced annually, the results would be very beneficial.

An experiment was set up with the assistance of the Northern Forest Research Centre to determine whether, with fertilizer applications, cone production could be augmented in good years and be maintained in poor seed years (Brace 1978). The experimental prescriptions involve different levels of nitrogen and phosphorous on one tenth acre (0.13 ha) plots.

The duration of the experiment is six to eight years. Annual cone counts on selected plot trees will determine whether the fertilizer applications have any effect on cone production.

PROVENANCE TESTS

The range-wide white spruce provenance test was planted in three locations in the fall and spring of 1980, 1981 respectively. The design employed is the augmented randomized complete block design (Federer 1961). The provincial breakdown by sources is:

Saskatchewan	14	Nova Scotia	2
Alberta	14	North West Territories	1
British Columbia	12	Ontario	9
Manitoba	12	Prince Edward Island	2
New Brunswick	1	Quebec	6
Newfoundland	1	Yukon	2

Each plot has twenty-five (25) trees at two by two metre spacing with thirty-six (36) plots per block and four blocks per location.

The lodgepole pine provenance test is composed of sources from Alberta (9), British Columbia (17) and the Inland Empire Co-operative (12) from Montana, Idaho and Washington. This test will be planted at three different locations in 1982.

The red pine test will be out planted in 1983 at three locations across the province. Sources for this test are from Ontario (13), New Brunswick (1), Nova Scotia (1), Wisconsin (1) and Michigan (2).

The Scot's pine provenance test was planted this spring (1981) at a single location. This test has a total of seventy-one (71) provenances from European and Asian portions of the Soviet Union. Of these sources sixty-seven (67) are north of 50° latitude. The general geographic locations are:

Murmansk, Karel and Arkhangel	7
North Central Russia	6
Western Russia	6
Central Russia	7
Eastern Russia	6
Southern Russia and Caucasus	7
Ural Mountains	8
East of Urals and Kazakh	3
Ob River and Altay Mtns.	3
Yenisey River	6
Angara River and L. Baykal	6
Chita, Amur, Khabarov, Yakutsk	6

The sources were gathered by the U. S. Forest Service and distributed to various agencies including the Northern Forest Research Centre from which Saskatchewan received its stock. (Read 1978).

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JACK PINE TREE IMPROVEMENT, PRINCE ALBERT PULPWOOD

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Major emphasis in Prince Albert Pulpwood's operations is being placed on silviculture and forest management. A jack pine (Pinus banksiana) tree improvement program to augment this was established in 1977 under the direction of Dr. Bruce Zobel. The direction of the program was outlined in a previous report (Orynik, 1979) and progress has been good. Our established 2-hectare clonal seed orchard, based on thirty very intensively selected trees, was expanded this year to 7.2 hectares through a large field grafting program. This orchard will be rogued on the basis of open and control pollinated trials. The first of the open pollinated trials will begin in the spring of 1982 with the control pollinated trials beginning after flower production starts.

One hundred less-intensively selected trees have also been chosen, and another one hundred will be picked by the fall of 1982. The progeny from these trees will be planted in the field trials over the next four years and the results of these tests will be used to establish a second seed orchard from which we will obtain seed of higher genetic quality than the present orchard. The first of these progeny trials was planted this spring in five replications on different sites throughout our lease area.

Wood specific gravity has been determined for the thirty intensively selected trees and will also be determined for the next one hundred less intensively selected trees we choose. Once the range of wood specific gravity is found for trees in Northern Saskatchewan, wood density will be used as a selection criterion. This will ensure against selecting trees which are fast growing but have a high water and air, rather than fibre, content.

A clone bank on the seed orchard site will be expanded this year so that it contains all the genetic material in the orchard and a second clone bank of this material will be established in 1982 at another location for insurance purposes.

In 1979 we received from the Canadian Forestry Service, several grafts of the twenty best families (based on 5-year measurements) of their jack pine progeny trials in Northern Saskatchewan. These have been established in our clone bank and will be incorporated into our program on the basis of the ten year progeny trial results.

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TREE BREEDING AND EVALUATION - MORDEN RESEARCH STATION 1980-1981

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Key Words: native Canadian trees, prairie adapted provenances, Salix, Populus, Betula.

Several promising native tree sources were identified from among the more than 150 accessions received annually by the Morden Arboretum. A weeping willow, 'Prairie Cascade', was introduced in 1981 and selection work was continued to identify a hardier golden willow. Populus breeding emphasized the genetic basis of cutting rootability; selection was continued for this factor and for shelterbelt adaptability. Species susceptibility to birch borer damage was evaluated and several white barked selections were identified which possessed a degree of resistance.

PRAIRIE ADAPTED PROVENANCES OF VALUABLE CANADIAN TREES

Available commercial sources of Fraxinus americana (white ash) have consistently failed to establish in the prairie region. New provenances obtained from northern Canadian sources (Petawawa, Ontario) and northern U.S. sources (Minnesota) have developed excellent specimens at Morden while nearby commercial sources failed during severe winters. The adapted sources will be distributed for shade tree production in prairie Canada.

Populus grandidentata (large toothed aspen) obtained from its north western continental distribution in south eastern Manitoba performs well at Morden. Female clones predominate in Manitoba but one male clone discovered in 1981 served as a pollen source for production of seed. Seed production may provide a commercial procedure for production of trees.

Acer rubrum (red maple) obtained from its north western continental distribution near Kenora, Ontario has proven the most adapted source for possible prairie production. The incidence of sunscald to tree trunks appears to be the limiting factor to wider use of the red maple in prairie regions.

Quercus bicolor (swamp white oak) obtained in 1966 from Minnesota offers potential to extend the narrow range of oaks available for the prairie region.

IMPROVEMENT OF SALIX

A breeding program with the objective of developing an adapted weeping willow for the prairie region has resulted in the release of the 'Prairie Cascade' cultivar in 1981. This new cultivar should enable reliable prairie production of weeping willows for the first time.

Crossing and selection work is continuing with the objective of developing a hardier replacement for the golden willow (*Salix alba* 'Vitellina').

IMPROVEMENT OF *POPULUS*

P. x *canescens* 'Tower' a columnar hybrid introduced in 1979 from Morden has become widely accepted by commercial nursery growers. Studies have developed a reliable propagation procedure which uses 2 cm long root cuttings given a 2 week warm preconditioning in moist peat moss prior to planting in peat pots in the greenhouse in March or April. The small plants produced are then field planted in late May and result in a saleable 1 m plant by fall.

Studies of intersectional species hybrids were continued with objectives to recombine disease resistance, propagation ease and hardiness. The rootability of hardwood cuttings was found to have strong genetic control. Several selections were identified amongst these first generation intersectional hybrids.

Other advanced breeding lines include columnar silver poplars, columnar cottonwood hybrids and progenies of *P.* x *jackii* 'Northwest' with higher levels of disease resistance.

SELECTION FOR BORER RESISTANCE IN *BETULA*

Birch borer and drought damage has caused widespread losses to prairie birch plantings particularly to European birch and its weeping cultivars. The native dark barked *Betula occidentalis* (syn. *fontinalis*), fountain birch, has been found to offer apparent resistance. This species is cold and drought tolerant and although lacking in white exfoliating bark it has produced some such hybrid seedlings. Several white barked selections were increased by grafting and will be evaluated.

In addition to this native species the Asiatic Chinese paper birch (*Betula albo sinensis septentrionalis*) appears promising as a borer resistant species.

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GENETICS OF GENECOLOGY OF SPRUCE, SAULT STE. MARIE, ONTARIO, 1979 AND 1980

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Keywords: Picea, genecology, genetic variation in spruce forest ecosystems, hybridization, Piceta

The program in genecology and genetics of spruce seeks to provide a broad scientific basis for tree improvement and to enhance our understanding of the structure and functioning of ecosystems and how this may be used for their best management.

The objectives are (1) to elucidate the contribution of species, forms, provenances and hybrids in productivity systems; (2) to collect and interpret information on genetic parameters particularly genotype x environment interaction, in regard to genecology and phylogeny of the genus Picea; and (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, etc. as compared with local sources.

The program includes intra and interspecific hybridization studies, some range-wide provenance and local seed source studies and Piceta.

HYBRIDIZATION

Breeding in 1979 was confined almost entirely to one area, Sault Ste. Marie. Twenty-two interspecific crosses with controls involving fifteen species of spruce were attempted using several clones. Some of these were repeat crosses, both to obtain repeatability estimates, and to increase stocks of particular hybrid clones. Picea omorika clones as female parents were crossed with different pollen sources of P. omorika, P. glauca, P. engelmannii, P. sitchensis, P. chihuahuana, P. koyamai, P. orientalis, P. pungens, P. abies, P. schrenkiana, P. asperata, P. breweriana, P. likiangensis, and P. maximowiczii. Clones of P. rubens as female parents were crossed with P. rubens, P. glauca, P. engelmannii, P. pungens, P. sitchensis, P. chihuahuana, P. orientalis, P. breweriana and P. mexicana. P. mexicana was crossed with P. glauca. In addition, hybrid P. rubens x P. omorika was crossed with local pollen sources of P. glauca, P. mariana and P. rubens.

Of the foregoing, P. omorika x P. pungens, P. abies, P. schrenkiana, P. asperata and P. breweriana were failures with all clones and pollen sources. It is noteworthy that the first three have been consistent failures over several years. P. rubens x P. engelmannii, P. pungens, P. chihuahuana,

P. orientalis, P. breweriana and P. mexicana were also failures with all clones and pollen sources, as also was P. mexicana x P. glauca. However, P. omorika x P. glauca, an older cross (Jeffers 1971), and P. omorika x P. sitchensis (Eklundh 1943), as well as P. omorika x P. engelmannii, previously reported (Gordon 1975a), provided good repeatability data, as did P. omorika x P. chihuahuana (Gordon 1976a). Crossability of the latter remains very low, but consistent.

Repeatability was achieved with P. rubens x P. glauca (Gordon 1978; cf. Bongarten and Hanover in press), and P. sitchensis (Gordon 1978). Crossability, as expected, was extremely low.

For the first time, limited success (not from all clones) was achieved with P. omorika x P. koyamai and P. omorika x P. orientalis. Crossability was very low, and slightly better with P. orientalis. The putative hybrid seedlings exhibit hybrid characteristics. Both these crosses were first reported by Wright (1955) but the progenies were subsequently invalidated (Santamour 1967).

Two other new crosses were P. omorika x P. maximowiczii, a very uncommon Japanese species and P. likiangensis, a Chinese species of limited distribution. The crossability using P. maximowiczii was extremely low and the progeny still unconfirmed. However with P. likiangensis it was 50 to 100%, matching the unusually high and useful crossability of P. omorika x P. rubens and P. omorika x P. mariana (Gordon 1975b, 1976b; Fowler 1980). Progeny of the P. omorika x P. likiangensis cross have been confirmed.

In 1980 breeding was conducted over a latitudinal range in Ontario from Sault Ste. Marie and Algonquin Districts to Simcoe District in the south. Thirty-five interspecific crosses representing fifteen species of spruce were attempted. Eighteen interspecific crosses were successful. Some crosses were repeats to obtain repeatability estimates as well as to increase clonal stocks. Others were new.

Female parents were clones of P. orientalis, P. omorika, P. rubens, P. mariana, P. mexicana, P. sitchensis and P. X lutzii (P. sitchensis x P. glauca). Male parents were P. orientalis, P. rubens, P. mariana, P. sitchensis, P. glauca, P. pungens, P. likiangensis, P. koyamai, P. maximowiczii, P. asperata and P. abies. It was not necessary to attempt all possible combinations.

The least responsive clones were of P. mariana, crossing successfully only with other P. mariana, as well as one doubtful cross with P. asperata. Disappointingly, P. mariana when crossed with P. sitchensis, was also unsuccessful. Fowler et al. (1980) reported this as a new cross going back at least to 1978. Crosses in the reciprocal direction, however, were successful for the first time. P. sitchensis as the female parent crossed with Ontario P. mariana. Crossability was low, but the small number of confirmed hybrid seedlings are distinctly heterotic. P. sitchensis, of course, also crossed easily again with P. glauca. P. sitchensis x P. likiangensis as a new cross was first accomplished by workers in Britain in 1970 (Faulkner 1971). This cross was repeated successfully. Crossability is very low and the seedlings are interesting but do not appear to be heterotic.

P. sitchensis x P. rubens first reported in this direction in 1978 (Gordon 1980) were unsuccessful in the 1980 season. The reciprocal, P. rubens x P. sitchensis, however, a new cross in 1976 (Gordon 1978) was successfully repeated with new clones and different pollen parents. The seedlings produced in 1976 have been confirmed and are very promising.

P. X *lutzii* was crossed successfully with *P. rubens*. The seedlings however are abnormal. *P. sitchensis* failed as usual with *P. abies* and also with *P. maximowiczii*.

P. omorika x *P. asperata*, *P. orientalis*, *P. koyamai* and *P. maximowiczii* appear successful but the seedlings await confirmation.

As yet, unconfirmed crosses occurred with *P. rubens* x *P. koyamai*, and *P. asperata* (both doubtful), *P. sitchensis* and *P. glauca*. Confirmed successes were with *P. rubens* x *P. orientalis*, *P. maximowiczii* (new) and *P. likiangensis* (new). Although we first successfully made the cross *P. rubens* x *P. orientalis* in 1974, we have had little success repeating it. Fowler (1969) reporting on work of Holst, and Jeffers (1971) reported this cross with little comment. The progeny of the present cross are very vigorous regardless of parental provenance. Crossability was moderate, varying from less than 1% to about 6% and similar to that of *P. rubens* x *P. likiangensis*.

P. mexicana was crossed successfully with *P. rubens*, repeat cross (Gordon 1980); and, utilizing different parents, with *P. glauca* with much greater crossability than was previously noted (Gordon 1980). A new and unexpected cross was *P. mexicana* x *P. likiangensis*. Crossability was moderate and all progeny were confirmed. *P. mexicana* failed to cross with *P. mariana*.

PRODUCTION AND APPLICATION OF INTERSPECIFIC HYBRIDS

Data illustrating eight years of development of *P. omorika* x *P. rubens* hybrids, reciprocals and controls was presented to the Canada-Ontario Joint Forestry Research Committee (COJFRC), Information Session for Forest Managers, February 1979, as an example of interspecific breeding contributing to tree improvement.

Other work of this program consists of flower induction studies, rooting techniques used for rapid multiplication of hybrid stock, and genotype x environment, etc. studies in our Piceta.

The work of this Unit is otherwise largely occupied with productivity and nutrient cycling studies in spruce forest eocsystem research (Gordon 1979; Blum *et al*. 1980, etc. *ibid* 1980).

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RESEARCH ON SEED-CONE RECEPTIVITY, SEED PRODUCTION POTENTIAL, CONE INDUCTION AND HAPLOID PLANT CULTURE

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Key Words: Picea glauca, Picea mariana, Populus species

The studies on seed-cone receptivity and seed production potential, and cone induction were initiated in the spring of 1980 and encompassed white (Picea glauca [Moench] Voss) and black spruces (P. mariana [Mill.] B.S.P.). The objectives were (1) to determine the optimal time for controlled pollination, (2) to define the seed production potential per cone, and (3) to induce cone production.

Research on haploid plant culture and vegetative propagation in vitro started in April, 1981, after the setup of a biotechnology laboratory. The objectives were to produce poplar (Populus L. spp.) and white spruce haploids, and clone a specific genotype through in vitro technique. Dr. Y. Raj[1] is associated with the study and the poplar material was supplied by Dr. L. Zsuffa[1].

SEED-CONE RECEPTIVITY

In white spruce, the proximal end of a seed cone emerged from the bud scales and was the area to be receptive first. Receptivity of a seed cone lasted for about 10 days. The end of receptivity was signalled by the enclosure of cone scales. Optimal receptivity occurred when seed cones approached the end of receptivity and this coincided with the peak of pollen shedding. It was evident that seed cones, pollinated once at this stage, produced the most filled seed, on the average of 41.6 per cone.

SEED PRODUCTION POTENTIAL

Total cone scales in white spruce averaged 67.8 per cone. The fertile scales consisted of 43.6 per cone and the sterile scales 24 per cone. The sterile scales were located at the proximal and distal ends of a cone, and the distal end had more sterile scales (12.8) than the proximal end (11.3). The seed production potential was 88 seeds per cone.

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In black spruce, total cone scales averaged 57.8 per cone of which 27.2 scales were fertile and 30.5 scales were sterile. The fertile cone scales located at the mid-portion of a cone. There were more sterile cone scales at the proximal end (18.6) than at the distal end of a cone (11.9). The seed production potential averaged 54 seeds per cone.

CONE INDUCTION

Two studies were carried out in cone induction. In one study, gibberellic acid (GA) 4/7/9 (100 micrograms/week) was applied to white and black spruces for 2 to 8 weeks. In the other study, white spruce trees were girdled, root-pruned or both.

GA is effective in inducing pollen and seed cones. In white spruce, GA increased the average seed-cone production by 6-fold and the average pollen-cone production by 2-fold after an 8-week treatment. The increase in black spruce was 4-fold in seed-cone production and 10-fold in pollen-cone production. Clones responded differently to GA treatments. Pollen viability and tree height growth were not affected by the treatment.

Root pruning appeared to be better than girdling in increasing cone production. Root pruning resulted in 5-fold increase in seed cones and 1.5-fold in pollen cones over the controls. The response was highly variable by clone. A combination of girdling and root pruning was not effective and the treated trees produced about the same amount of cones as the controls. The treated trees grew more in height than the controls.

HAPLOID PLANT CULTURE

In poplar, anthers were incubated on a Murashige and Skoog (MS) medium (1962) containing 2 mg/l of 2,4-D, 2 mg/l of Kinetin, 3% of sucrose and 0.8% of agar when young pollen grains in the anthers were at the mononucleate stage and prior to the mitotic division (Zhu *et al*, 1980). After about 40 days of incubation, haploid calli have been obtained from pollen grains of 7 clones, i.e., *P. angulata* x *simonii*, *P.* x *euramericana* cv. *bachelierii*, *P.* x *euramericana* cv. *eugenei*, *P.* x *euramericana* cv. *vernirubens*, *P. generosa* x *jackii*, *P. jackii* (*P. tacamahaca* x *deltoides*), *P. maximowiczii* x *deltoides*. Diploid calli from the somatic tissues of anthers were produced from other species and hybrids. The haploid calli will be transferred to a new medium containing .2 mg/l of BAP (benzylaminopurine) and .2 mg/l of NAA for organogenesis.

In white spruce, microsporophylls were incubated on the medium as used for callus induction in poplar. After a month's incubation, only diploid calli were produced from the microsporophylls. The calli have been transferred to a new medium for organ induction.

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SPRUCE AND LARCH GENETICS, ONTARIO FOREST RESEARCH CENTRE, 1979-80

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Key Words: exotics, hybridization, selection and breeding

The spruce and larch program in Ontario has undergone personnel and organizational changes since the previous report (Rauter 1979) submitted to this Association. In April, 1979, R.M. Rauter transferred from the Ontario Forest Research Centre (OFRC), Maple, to the Forest Resources Branch, Program Development and Control Section, in head office, Toronto. From April, 1979, to June, 1980, projects initiated by Rauter were carried out under her guidance by K. Eng, now Tree Improvement Specialist, Central Region. Additional assistance was provided by D. Boufford, who also looked after the project during the remainder of 1980. I joined the OFRC staff as the spruce and larch geneticist in January, 1981.

SPRUCE

Interspecific hybridization

No hybrid crosses were attempted during the 1979 and 1980 breeding season. Field tests of earlier hybrid crosses are due for evaluation in the fall of 1981. Two hybrids that suggest some potential for southern Ontario are Picea glauca (Moench) Voss x P. sitchensis (Bong.) Carr and P. abies (L.) Karst. x P. Koyamii Shir. With these two exceptions, the spruce hybridization work at OFRC will be phased out to concentrate on selection and breeding of native spruces.

Selection and breeding

In both 1979 and 1980 the controlled crossing program was continued in the black and white spruce clonal seed orchards near Angus. Black spruce pollen was collected from the Mattawin seed orchard and used, along with fresh pollen, for controlled pollinations in 1980. The 1980 white spruce flower crop at Mattawin was heavily damaged by late frost, as it had been the previous two years. The resulting seed from these crosses will be used to progeny test the clones in the orchards.

Open-pollinated progeny tests of black spruce plus trees from both the 3E and 3W site regions (Hills 1960) were planted during the 1979-1980 period, as well as an open-pollinated test of the McAcree 3W black spruce seed production area. An open-pollinated test of the O'Connor 4W white spruce seed production area was planted in 1980 on two sites. Clonal tests of both the black and white spruce seed production areas at Limestone Lake were planted in 1980.

LARCH

Exotics and interspecific hybridization

An interspecific crossing program has not been started at OFRC. However, since several hybrids have indicated some promise for short rotation forestry in Ontario (Calvert and Rauter 1979), trials have been initiated with hybrid seed obtained from a number of contributors. In 1980, a combined species and hybrid trial was planted at two sites in southeastern Ontario. The species represented were: *Larix decidua* Mill., *L. dahurica* Turcz., *L. laricina* (DuRoi) K. Koch. x *L. decidua*, *L. gmelini* (Rupr.) Litvin., *L. decidua* x *L. kurilensis* Mayr., *L. decidua* x *L. leptolepis* (Sieb. and Zucc.) Gord. and the reciprocal cross, *L. laricina* x *L. decidua*. A species trial of *L. occidentalis* Nutt., *L. Leptolepis* and *L. decidua* was planted at four southeastern locations in 1979.

Selection and breeding

Stand trials of three different *L. laricina* collections were planted near Thunder Bay and at several locations in southeastern Ontario. Early survival in these plantations and the above hybrid trials was generally good, although a few plantations suffered from man-caused mortality. As with the spruces, I anticipate that the major thrust in the future will be on selection and breeding within the native populations of *L. laricina*.

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DEVELOPMENT OF AN OPERATIONAL TREE IMPROVEMENT PROGRAM IN THE NORTHERN REGION OF ONTARIO

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Key Words: black spruce, jack pine, white spruce, seed collection and production areas, field grafting, fertilization and subsoiling, clonal testing.

Under the auspices of the Department of Regional Economic Expansion (DREE), L.K. Miller was hired as the Regional Tree Improvement Specialist for the Northern Region, Ministry of Natural Resources in October, 1981, to coordinate the tree improvement efforts in the region. A considerable amount of time was spent becoming familiar with the organization, personnel, and existing tree improvement activities throughout the region. At the present time, operational tree improvement programs have been drafted for black spruce (Picea mariana (Mill.) B.S.P.), jack pine (Pinus banksiana Lamb.), and white spruce (Picea glauca (Moench.) Voss.). The author has also assisted field staff in seed collection and seed production area establishment and management, initiated small applied research projects, cooperated with research staff in black spruce clonal tests, and provided technical assistance as requested.

A. TREE IMPROVEMENT PROGRAMS

Based on existing tree improvement programs and expected demand for seed in the regeneration program, draft proposals for future tree improvement strategies in black spruce, jack pine, and white spruce have been written. These plans have been presented to each district, and finalized versions will be written incorporating appropriate changes or modifications. As soon as each long term plan is approved, operational tree improvement can commence.

B. SEED COLLECTION AND PRODUCTION AREAS

At this writing, a new black spruce SPA has been extablished in Cochrane District, a new black spruce SCA has been proposed in Hearst District, and a new jack pine SCA has been proposed in Chapleau District.

C. APPLIED RESEARCH STUDIES

1. Field grafting

With the cooperation and assistance of the Kirkland Lake District staff, a jack pine field grafting study was initiated in late May, 1981. This study is designed to test the success and performance of the field grafting procedure in jack pine.

In early June, 1981, field grafts of black and white spruce were made at the Bonner Tree Improvement Center, Moonbeam, Ontario. The objective of this study is to improve the success and performance of spruce grafting.

2. Fertilization and subsoiling

In an effort to apply proven methods of flower promotion developed in other species to black and white spruce, a study investigating the effects of ammonium nitrate fertilization and subsoiling was initiated in mid-June, 1981. Two levels of fertilizer and two depths of subsoiling were applied singly and in combination to stands of black spruce (aged 12-20 years) and white spruce (aged 14-20 years).

D. BLACK SPRUCE CLONAL TESTS

In cooperation with the Ontario Forest Research Center, Maple, a black spruce clonal test will be outplanted in the Northern Region in the spring of 1982. The planting stock will be rooted cuttings taken from control pollinated families of plus trees selected from the Northern Region. Clonal testing offers several advantages over traditional progeny testing. There is no need to accumulate large quantities of control pollinated seed. Additionally, clonal tests allow estimation of non-additive variance components, and do not require large plots and many replications.

AN OVERVIEW OF THE PROVINCIAL TREE IMPROVEMENT PROGRAM IN ONTARIO

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Key Words: strategies, staffing, facilities, regional programs, support programs.

One of the primary objectives of the tree improvement program in Ontario is to establish improvement strategies for our major commercial species according to seed zone and seed need. Although some of the programs have been underway for several years, advances in breeding knowledge, changes in technology and changes in anticipated seed requirements have necessitated modifications to some of the earlier strategies.

The growing awareness of the need to produce genetically improved seed has resulted in improved funding, staffing and facilities. Since the beginning of 1979, the number of regional programs and support programs has increased substantially.

This paper will highlight some of the changes and the current status of tree improvement in the Province.

TREE IMPROVEMENT STRATEGIES

Tree improvement strategies have been developed for white spruce (*Picea glauca* (Moench) Voss), black spruce (*P. mariana* (Mill.) B.S.P.), jack pine (*Pinus banksiana* Lamb.) and white pine (*P. strobus* L.). The size of each program is based on such factors as the projected seed need for a seed zone, seed periodicity of the species and seed yield per tree at various ages and under different management systems. Strategies are being developed for other species such as black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), tamarack (*Larix laricina* (Du Roi) K. Koch.), European larch (*L. decidua* Mill.) and Japanese larch (*L. leptolepis* (Sieb. and Zucc.) Gord.).

More seed collection and seed production areas are being established in order to provide larger quantities of seed from controlled sources. These areas will provide large quantities of seed until the seed orchards come into production. Depending upon the characteristics of a species, either clonal or seedling seed orchards are being developed.

Some decisions have been made on mating designs and test procedures to evaluate the seed orchard material, but further discussions are still required with Ministry research staff.

STAFFING

The number of individuals specifically assigned to work in tree improvement has increased since the beginning of 1979. In the present organization, the provincial tree improvement and tree seed program is co-ordinated by one silviculturist and supported by a forester and a part-time clerk. Prior to July 1980 there was only one field tree improvement specialist in the Province with the responsibility of covering the 4 northern regions. In July 1980, a second field position was created to cover the 4 southern regions and in October 1980 a third specialist was hired by one of the northern regions to hasten the implementation of its' tree improvement program. These field specialists provide the much needed guidance and support to the field staff and are able to co-ordinate many of the programs at both a Regional and District level.

Due to the shortage of trained tree improvement personnel in Ontario, a 2-year training position was established in 1980 under the direction of Head Office. Training is provided by research staff at the Ontario Forest Research Centre and by some of the field specialists.

In a related program, the Ministry hired a vegetative propagation specialist who is responsible for determining how to manage cutting donors to obtain maximum numbers of cuttings and to retain juvenility of the donor, for determining the best technology for rooting and for mass propagating selections for testing and production.

FACILITIES

Grafting facilities have improved, but are still insufficient to meet the needs of the improvement program. Up to 1979, there were only 2 grafting centres in the Province, but a third and fourth were established in 1979 and 1980 respectively. These 2 new facilities have doubled the annual grafting capacity of the program from approximately 12,000 grafts to 25,000 grafts. Within the next two years, 2 more nurseries should have grafting facilities that will further increase annual production capacity to 40,000 grafts and this will be sufficient to provide the required material for the establishment of clonal seed orchards.

A large greenhouse expansion project is currently underway within the Province in order to accommodate the needs of the container stock production program. One nursery has already provided space in their new complex to grow seedlings for the seedling seed orchard program. As seed is collected from superior tree selections and as the greenhouses are completed throughout the Province, it is expected that additional space will be available as required.

Space has been reserved at several nurseries for the planting of clone banks and breeding orchards, as the nurseries have access to the manpower and equipment necessary for the intensive management of these areas. Additional scions for clonal expansion of the production orchard will therefore be of better quality, more numerous and available in a shorter period of time. Anticipated earlier flower production in these areas will also allow the breeding program to progress more quickly.

REGIONAL PROGRAMS

Regional tree improvement programs have been underway for many years but these are presently very small and insufficient to meet the seed requirements of artificial regeneration programs. Most of their emphasis is in the selection and development of seed collection and seed production areas and in selection of plus trees for seed orchard establishment. In recent years the Regions have increased their emphasis on tree improvement with initiation of new programs and enlargement of established programs. A brief summary of work underway in the eight Regions follows.

Northwestern Region

Tree improvement work in this Region is centred around black and white spruce. For the past several years, plus trees have been selected and scions grafted for clonal orchard establishment for both of these species. In 1979, the Region established its own grafting centre with an annual capacity of approximately 5000 grafts. Selections of white spruce will continue to be grafted until the clonal orchards are large enough to ultimately produce the projected seed requirements. Black spruce grafting and clonal orchard establishment have presently been discontinued in favour of seedling seed orchard development.

The Region embarked on an ambitious program for black spruce in 1978 with the selection of approximately 3500 plus trees within the seed zone for each Administrative District. Cones were collected in 1978 and 1979 and the seed extracted by individual seed lots and in the spring of 1980, several hundred seeds per lot were sown in its greenhouse complex and later transplanted to the nursery in the fall of 1980. The material will be field planted in the spring of 1982 to establish seedling seed orchards and simultaneous progeny trials on sites previously selected in all Districts within the Region.

Northcentral Region

The emphasis in this Region is also on black and white spruce. Plus trees have been selected in both of these species for many years and several clonal orchards have been established and some of these have started to produce small quantities of seed. With the establishment of a grafting centre in the Northwestern Region the grafting facility in the Northcentral Region can now accommodate more of its own material and their plus tree selection targets were increased accordingly.

Northern Region

The Northern Region has detailed improvement strategies prepared in draft form for white spruce, black spruce and jack pine. These strategies summarize the rationale for the approach for a species, work done to date, future work as well as some proposed time frames. These outlines will form the basis for annual work plans and budgeting schedules for the individual districts within the Region. All seed collection areas and seed production areas are being evaluated and recommendations are forthcoming for their future management. The Orono nursery located in the Central Region has recently developed grafting facilities which presently accommodate the Northern Region's program. This allows for increased emphasis on the selection of plus trees for both black and white spruce as well as a regrafting program of earlier selections to increase the size and number of clonal production orchards already established for this Region. A 10-year management and operating plan is in preparation for the Bonner Tree Improvement Centre, where several of the proposed seed orchards for the Region will be developed.

Northeastern Region

This Region is in the process of developing tree improvement strategies for its major species. Major emphasis to date has been on the selection of plus trees of white pine and white spruce. In 1980 a selection program for superior jack pine was initiated and seed collected on an individual tree basis similar to the black spruce program in the Northwestern Region. When a sufficient number of selections have been made, the material will be used for the establishment of seedling seed orchards and progeny trials.

Algonquin Region

A tree improvement strategy has been developed for this Region's most important species, white pine. Nearly 200 plus tree selections have already been made and clonal orchards are being established. A regrafting program to increase the number of ramets per clone will be getting underway to enlarge the orchards to their desired size. White spruce is another important species for this Region and will receive additional emphasis now that the white pine program is well underway.

Eastern Region

The major improvement program in the Eastern Region is the poplar program. Some of the work includes propagating select clones provided by Dr. Zsuffa of the Ontario Forest Research Centre, establishing clonal trials under various management systems and on different sites, plus tree selection of the native poplar species throughout the Region and propagation of these plus trees both vegetatively and sexually.

As well the Eastern Region is currently evaluating all of their seed collection areas, seed production areas and seed orchards. Based on these evaluations and the projected seed requirements for the Region, tree improvement strategies will be prepared for the other important species of this Region. Improvement programs are underway for white spruce, white pine, tamarack, European and Japanese larch. In 1980 the first material for the establishment of a European x Japanese hybrid larch orchard was planted.

Central Region

A white pine tree improvement strategy has been prepared for this Region and in 1980 the number of plus trees selected and grafted was substantially increased in order to accelerate the development of their white pine orchards. Greater emphasis has also been placed on the establishment and management of seed production areas for both white pine and white spruce. This Region is also participating in a black walnut improvement program and is actively seeking a suitable site for the development of black walnut orchards.

Southwestern Region

Most of the valuable species in this Region are hardwoods and most of their effort is in stand management rather than tree improvement. There is a program to select superior black walnut trees and to propagate these selections through grafts and by seed. White pine is also a commercially important species in this Region and efforts have increased in the selection of superior trees for the development of clonal seed orchards.

SUPPORT PROGRAMS

In order to provide answers that are needed in planning and developing our major tree improvement programs and to provide information that will assist the field staff in understanding and carrying out the work programs, many short-term support projects have been initiated and funded by the Forest Resources Branch of the Ministry. Although some of the projects are under the direct supervision of the Tree Improvement Silviculturist or one of the Regional Tree Improvement Specialists, most of these projects are carried out by research scientists and support staff at the Ontario Forest Research Centre, Petawawa National Forestry Institute and the Faculty of Forestry at the University of Toronto as well as by private consultants. A list of some of these projects follows.

1) Identification, selection and evaluation of black walnut and white ash throughout their range in Ontario. Preparation of a tree improvement strategy for these species.

2) Identification of remnant stands of white spruce throughout southern Ontario. Collect seed and/or scions to retain the gene pool of the important populations. Preparation of a tree improvement strategy based on the material available.

3) Determination of cone and seed yields of black spruce on current, 1-year-old, and 2- to 4-year-old cones for various stand age classes throughout the northern part of the Province.

4) Mapping of soils in all seed orchards and proposed seed orchard sites throughout the Province.

5) Determination of variation in wood quality of tamarack.

6) Development of policy statements on establishment and management of seed collection areas, seed production areas and seed orchards.

7) Publication on the cone initiation and seed development of jack pine.

8) Publication of a seed collection manual that includes information from collection procedures to cone, fruit and seed yields by species.

SUMMARY STATEMENT

Field staff as well as senior managerial staff are becoming increasingly aware of the benefits that can be derived from tree improvement. The annual increase in program and budget requirements is indicative of the increased efforts in this field. The many programs that are underway and those being developed will ultimately provide the genetically improved seed that is required for our artificial regeneration program.

WHITE SPRUCE GENE POOL PRESERVATION IN SOUTHERN ONTARIO

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Keywords: Picea glauca, provenance tests, selection.

A survey was initiated in 1980 to identify remnant populations of white spruce (Picea glauca (Moench) Voss) in southern Ontario. The project is the result of past provenance trials which indicated the probability of fast growing populations of white spruce in southern Ontario, with the famous Beachburg source being one example (Teich et al. 1975). The survey will form the basis of a subsequent research program to group sources of similar growth potential and evaluate differences in terms of collection and distribution policy in southern Ontario. Plantations will be established to preserve this gene pool and the selection of plus trees for site region 6E (Hills 1960) seed orchards will be based on this survey.

WHITE SPRUCE

Past provenance trials indicate potential gains in rate of growth of between 10 and 20% after twenty years growth through the selective use of seed sources. It is apparent that even within site regions, the differences are well worth exploiting. This is particularly important in southern Ontario where only residual stands and scattered trees remain from some of the apparently fast growing southern sources.

Two valuable southern Ontario populations were identified in the Lake States and in trials across eastern Canada (Nienstaedt and Teich 1972). Beachburg and Peterborough sources exceeded the experimental mean heights by up to 40% in a wide range in test sites. Ensuring future seed supply from fast growing populations will improve the potential productivity of the over four hundred hectares of white spruce plantations established across site region 6E annually.

Inventory maps and reports will be prepared for each of the four administrative regions in southern Ontario, based on population groupings. A plan of plantation establishment will be prepared to preserve promising sources, to test relative potential growth of different sources and to provide for future seed collection of these sources. Plus tree selections will be made from promising sources within each population to establish seed orchards.

The methodology for surveying white spruce has been set up and ground and aerial surveying for the Central Region has been carried out. A report on existing white spruce gene pools in this region is presently being completed.

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BREEDING OF FAST GROWING HARDWOODS AND WHITE PINES AT ONTARIO FOREST RESEARCH CENTRE, MAPLE, AND FOREST GENETICS AND TREE BREEDING AT THE FACULTY OF FORESTRY, UNIVERSITY OF TORONTO

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Key Words: Poplar breeding, white pine breeding, willow breeding, alder breeding.

Poplar and white pine breeding programs have been active at Maple since mid 1940's. Recently, in addition to poplar, willow and alder breeding has started for biomass production in short rotations. In this report, the work and accomplishments in the period from 1979 to 1981 are summarized.

Since 1980, the author has offered courses in genetics at undergraduate and graduate levels. The initial activities at the Faculty of Forestry, University of Toronto are summarized in this report.

POPLAR BREEDING

Work continued as outlined in the progress report for 1977 and 1978 (Zsuffa, 1980). Population studies, gene-pool collections and selections in trembling aspen (P. tremuloides Michx.) and balsam poplar (P. balsamifera L.) were started, and studies into resistance of poplar clones to diseases and insects were initiated. Karyotype studies in Populus were re-activated.

Studies in Native Poplar Species

In eastern cottonwood (P. deltoides Marsh), the identification of the species-range in Ontario and the selection of representative female-tree specimens have almost been concluded. The analysis and propagation of this material is in progress. To date, 37 selections were made, 12 propagated by cuttings and 27 propagated by half-sibs.

In trembling aspen and balsam poplar, genetic variation studies and collections were initiated in cooperation and under contract with Dr. J. Eckenwalder[1]. The collections are being made (in 1981) according to Hills' site districts. Several sites are sampled within each district and five trees selected from each site. Seeds and vegetative propagules are collected, as well as data to allow taxonomic and genetic evaluations.

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[1] Department of Botany, University of Toronto

Pollination

In early 1980, the following crosses were made:

Parentage (female x male)	No. of Combinations
P. deltoides x nigra L.	4
P. deltoides x Maximowiczii Henry	3
P. grandidentata Michx x alba L.	1
P. grandidentata x canescens (Act) Sm	7
P. tremuloides x tremula L.	1

Thirteen hybrid progenies were produced from the 20 crosses made.

In early 1981, the following crosses were attempted:

P. alba x grandidentata	2
P. alba x nigra	2
P. alba x tacamahaca Mill	2
P. (grandidentata x canescens) x alba	2
P. (grandidentata x canescens) x deltoides	2
P. (grandidentata x canescens) x tremula	2
P. (grandidentata x canescens) x tacamahaca	2
P. (grandidentata x canescens) x nigra	2
P. deltoides x deltoides	4
P. deltoides x nigra	1
P. deltoides x Maximowiczii	2
P. deltoides x tacamahaca	5
P. nigra x deltoides	1
P. nigra x Maximowiczii	2
P. nigra x tacamahaca	2
P. tacamahaca x deltoides	4
P. tacamahaca x Maximowiczii	4
P. tacamahaca x nigra	2

Most of the crosses with P. deltoides as female parent produced good seed, while the results with the rest of the crosses are very variable, with many failures.

Progeny Trials of Interspecific Hybrids

The full-sibs produced by artifical pollination have been planted in the field, in replicated field trials. These trials provide information on genetics and combining ability, and are also important sources of new clonal material. To date, nine progeny trials of interspecific hybrids have been established in southern Ontario, and three in northern Ontario.

New Clonal Selections

In 1980/81, the first clonal selections were made from 4 and 5-year old progeny trials of interspecific hybrids. The outstanding ortets selected were of P. deltoides x Maximowiczii and P. deltoides x nigra parentage (2 clones from each).

Poplar Disease and Insect Resistence Studies

Studies have been initiated in cooperation and under contract with Dr. M. Hubbes[2] and Dr. R. Morris[3]. Investigations have been conducted in clonal trials across Southern Ontario. The disease survey concentrated on resistance to rust (Melampsora spp.), Marssonina leaf spots, Dotchichiza canker, and Septoria canker, while the insect survey focused on Cryptorhynchus lapathi L. and Prodiplosis morrisi Gagne. The data collected is useful in breeding and clonal selection, and contributes to the understanding of resistance mechanisms in poplar.

Cytogenetic Analyses

In cooperation and under contract with Dr. G. Filion[4], chromosomes in mitotic and meiotic divisions were studied in Populus intersectional hybrids and in trees which were treated with polyploidy-inducing agents at an early stage (Zufa, 1968). In some of these latter trees, the status of polyploidy was reinstated. Several hybrids showed a significant level of meiotic abberations, which could lead to sterility.

BREEDING OF OTHER FAST GROWING DECIDUOUS SPECIES

Programs in willows (Salix L. spp) and alders (Alnus Mill spp) were initiated. An expansion and intensification of these programs is expected.

In willows, the selection and collection of specimens of importance for biomass production and their taxonomic identification has started in cooperation and under contract with Dr. J. Eckenwalder. The sampling is according to Hills' site districts and includes plant material for vegetative propagation and documentation of the collection.

An exploratory study in cytotaxonomy of willows has been accomplished in cooperation and under contract with Dr. Y. Raj[5]. The 2n chromosome numbers were checked in root-tips and expanding leaves. Species and interspecific hybrid specimens were included in the study. The results will contribute to the knowledge of taxonomical and genetical relationships in Salix species and hybrids and will help to formulate an effective breeding program. The study is continuing as part of the regular program.

In alders, a worldwide collection of specimens (half-sib seed collection) was started in cooperation with the International Energy Agency's Forestry Energy Program. To date, the following collections have been obtained:

[2,3] Professor of Forest Pathology and Entomologist, Faculty of Forestry, University of Toronto (respectively)

[4] Associate Professor of Botany, Erindale College, University of Toronto

[5] Geneticists, Ontario Forest Research Centre, Maple, Ontario

Alnus cordata Desf. (18 collections); *Alnus cremastogyne* Burk (1); *Alnus glutinosa* (L.) Gaertn. (13); *Alnus hirsuta* (Spach) Rupr. (1); *Alnus incana* (L.) *Moenck* spp. *tenuifolia* Nutt (5); *Alnus japonica* (Thumb) Steud (1); *Alnus jorullensis* H.B.K. (1); *Alnus nepalensis* D. Don (1); *Alnus rubra* Bong. (45); *Alnus sinuata* (Reg) Rydb. (4); *Alnus trabeculos* Hand. (1); *Alnus viridis* DC ssp. *fruticosa* Rupr. (10).

The hybridization of alders by artifical pollination on bottle-grafted female-cones bearing branches was successfully attempted in *A. glutinosa* x *rubra* combination. The vegetative propagation of *A. glutinosa* and *A. rugosa* (Du Roi) Spreng by rooting lignified and green-wood cuttings in tented rooting beds was successful.

WHITE PINE BREEDING

White pine breeding continued as outlined in 1977-78 progress report (Zsuffa, 1980). New series of interspecific hybrids were produced by artificial pollination. A study of blister rust resistance factors was initiated.

Progeny Trials

To date, 85 half-sibs of plus trees have been included into six progeny trials. Of these, two are already outplanted, three are in nursery beds and one is in the greenhouse. The goal is to single out the best combiners and to identify superior progenies. Early results indicate very significant differences in progeny performance.

Pollination

In 1980, artifical pollination was performed in 290 parent-tree combinations, including crosses of *P. griffithii* McClelland x *strobus* L., *P. griffithii* x (*peuce* Griseb x *strobus*), *P. griffithii* x *cembra* L. v. *sibirica* Loud, *P. peuce* x *pumila* Reg., *P. strobus* x *cembra* v. *sibirica*, *P. strobus* x *peuce*, *P. strobus* x *pumila*, *P.* (*monticola* Lamb x *peuce*) x *strobus*.

Rangewide Sampling of *P. griffithii*

Rangewide collection by IUFRO of Himalayan white pine was obtained, and the seedlings outplanted in three areas in Southern Ontario. Early results suggest that only trees from very restricted sources from mountain altitudes can grow in Ontario.

The Factors of Blister Rust Resistance

A study of protein patterns in needles of blister rust resistant and susceptible clones was initiated in cooperation and under contract with Dr. M. Hubbes. Needle samples were taken during the growing season from trees inoculated and free of disease. Early results indicate quantitative and qualitative differences in needle proteins of resistant and susceptible clones.

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

Since 1980, forest genetics and tree breeding has been offered as an elective one-term course for undergraduate students, and as a two-term course on the graduate level. The course is led by the author of this report, and assisted by tree breeders and geneticists of the Ontario Ministry of Natural Resources.

The fall, 1980 undergraduate program was attended by 35-4th year students. The graduate course was taken by three students. One Ph.D. candidate (Ms. K. Falusi) was accepted and started work on "Genetic variation in balsam poplar (P. balsamifera L.)", while the acceptance of another Ph.D. candidate is pending.

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TREE GENETICS AND BREEDING, P.N.F.I.: JACK PINE GENETICS: 1979-1981

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Key Words: Pinus banksiana, provenance, progeny test, breeding strategy.

Changes in personnel and program development are reported for the Tree Genetics and Breeding Project at P.N.F.I. All vacant positions have been filled as of July 1981.

A total of 60 foresters and technicians from Newfoundland to Manitoba attended three one-week courses to train Instructors in Tree Climbing for seed collection and breeding.

Research studies in jack pine have continued. Studies in red pine and Scots pine are on a maintenance basis. Jack pine range-wide provenance test data from New Brunswick, Quebec and Ontario were analyzed. Seed of selected Quebec provenances was sent to Dr. Darroll Skilling, U.S. Forest Service, for testing for resistance to the European strain of scleroderris canker. Work in cooperation with Ontario Ministry of Natural Resources included initiation of a jack pine seed orchard in Algonquin Park, establishment of northern tests of provenance hybrids and detailed discussions of applied breeding of jack pine in Ontario.

Research activities with spruce, larch and hardwoods are described elsewhere in these proceedings by G. Murray and T. Boyle.

PERSONNEL

Changes in personnel, organization and responsibility following the formation of the Petawawa National Forestry Institute in April 1979 were outlined in the previous Proceedings (Carlisle 1980).

Dr. Gordon Murray joined the Project in August 1980 as leader of genetic research studies in deciduous hardwoods and larches. He subsequently assumed senior responsibility for studies in white and Norway spruces.

In January 1981, Mr. Timothy Boyle, formerly U.K. Forestry Commission, accepted a position of forestry officer and assistant geneticist, working primarily with Dr. Murray. Tim is to undertake graduate studies at the University of New Brunswick, commencing fall, 1981.

Dr. E.K. Morgenstern, formerly Project Leader, left PNFI in January, 1981, to take the position of Professor of Forest Genetics at University of New Brunswick, Fredericton. The author was appointed Project Leader and assumed senior responsibility for black and red spruce studies. The vacated position was designated forestry officer and assistant geneticist and staffed in May 1981 by Mr. W.M. Cheliak, Dept. of Forest Science, University of Alberta. Bill will remain at the University until spring 1982 to complete his Ph.D. studies on population structure and mating systems in jack pine.

Dr. Nikhil Bhattacharya, N.R.C. Post-doctoral Fellow, undertook studies of isoenzyme patterns of spruce and pine from September 1978 to December 1980 in collaboration with Dr. Murray during the period of the latter's sabbatical leave.

Mr. Jack Pitel, Biologist, and Mr. Garry Scheer, Technician, transferred from the seed to the Genetics Project in April 1981. Jack is responsible for the isoenzyme laboratory, analyzing seed and vegetative materials supplied by the research geneticists and also continuing to assist the Seed Project with biochemical analyses.

Mr. Paul Viidick retired as Superintendent of Planting Operations in December, 1980, to be succeeded by Mr. Tom Nieman who was formerly technician responsible to the author for work in the Jack pine study. The latter position was occupied in July 1981 by Mr. Peter Copis, who transferred to PNFI from the Great Lakes Forest Research Centre, Sault Ste. Marie.

To complete our present complement, Mr. Bazil Corbett has been appointed to a new and much needed position of Greenhouse Foreman. Bazil is a skilled grafter and is very knowledgable of all practical aspects of tree propagation following some seventeen years working with us on a seasonal basis.

TRAINING

In addition to regular duties, the technical staff of the Genetics Project, together with Mr. Ernie Gilchrist of the Seed Project, assisted the author and Mr. Dave Winston in conducting three one-week courses in Tree Climbing, Genetics and Seed, two in 1979 and one in 1981. Some 60 Canadian foresters and technicians earned Tree Climbing Instructor's Certificates following practical and written examinations on safe tree climbing for seed collection and tree breeding.

Lectures, technical demonstrations and field exercises were given in 1980 and 1981 to students of Forest Technology, Algonquin College, Pembroke, in conjunction with their silviculture course. Brief genetics tours were also given to students from Toronto University School of Forestry and to third year forest technologists from Sir Sandford Fleming College, Lindsay, Ontario.

JACK PINE GENETICS AND BREEDING

Provenance

Analyses of 15-year growth data were completed for range-wide provenance tests planted at 12 locations in New Brunswick, Quebec and Ontario. The results corroborated those of the 10-year measurements and will be published. Climatic adaptation remains the dominant feature of provenance differentiations and genotype environment interaction at the population level. Local provenances are among the best in survival, growth, winter hardiness and disease tolerance at all sites with the exception of that at Caramat, north of Lake Superior and east of Lake Nipigon. Here trees from populations to the east and west within the boreal region are superior in growth, and trees of certain Quebec provenances had the lowest rates of infection by scleroderris canker (*Gremmeniella abietina* [Lagerb] Morelet).

Using seed supplied by the author, Dr. Darroll Skilling, U.S. Forest Service, found certain Quebec sources of jack pine to be tolerant to infection by the European strain of scleroderris canker in tests conducted in Upper New York State. The same seedlots also had a low infection rate of the North American strain when tested in Wisconsin (Skilling 1981; D.D. Skilling, pers. comm.).

Provenance hybrids were planted in 1980 at Petawawa and at two locations in northern Ontario, Kirkland Lake and Fraserdale. Inspection in the late spring, 1981, revealed clear patterns of winter damage at the northern test sites. Detailed analyses will follow.

Selection and Progeny Testing

The first plantings were made in 1980 in the establishment of a demonstation jack pine seed orchard at Spoor Lake in eastern Algonquin Park. This applied research is being conducted in close collaboration with Mr. John Wilson, forester, Algonquin Park District, Ontario Ministry of Natural Resources. The project is also assisted by staff and students of the Forestry Department of Algonquin College, Pembroke.

The objectives are to: provide basic quantitative information of genetic parameters of jack pine; build a foundation population for research in advanced generation breeding; develop operational methodology and record costs for seed orchard management and the establishment of a predigreed breeding population; measure real gain achieved in productivity and quality of jack pine; and to produce genetically improved and regionally adapted seed for use in Algonquin and Pembroke Districts.

Pedigreed and mass-selection components of the seedling seed orchard were planted as well as a demonstration clonal orchard of grafted stock; progeny tests of over 300 open pollinated families are underway; and grafted clones of the parental plus trees are being established in a breeding arboretum.

Breeding

A diallel pollination scheme, including selfs and resiprocals, was completed among seven trees of local origin. It has taken several years to accumulate a minimum of 400 seeds for each combination. One of the randomly chosen trees proved to be a particularly recalcitrant seed parent.

Seed collection was also completed and the seed sown for a test of combining ability among plus trees within and between superior but geographically separate provenances growing at Petawawa. Bulked seed from mass-selected trees growing in young regeneration of fire origin formed the basis for a short term (10 years or less) nursery test planted at two spacings in 1981. The mass-selected material is being compared with three control lots of local origin.

Extension

Consultations were held with the Canadian International Paper Company concerning a jack pine breeding program for company forests north of LaTuque, Quebec. Detailed discussions were held with geneticists, breeders and field staff concerning applied breeding and seed production of jack pine required for central and northern Ontario.

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RED AND BLACK SPRUCE GENETICS, PETAWAWA 1979-1980

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Key words: provenance, progeny, seed orchards, federal-provincial-industry cooperation.

The program with red spruce (Picea rubens Sarg.) and black spruce (Picea mariana [Mill.] B.S.P.) aims to develop a scientific basis for their genetic improvement. During the last two years some progress was made in measurement of experiments, the analysis of results and their publication.

This will be my last report from Petawawa. On 1 January 1981 I joined the Faculty of Forestry at the University of New Brunswick.

PROVENANCE EXPERIMENTS

Red spruce

Results from the nine experiments established between 1958 and 1960 in eastern Canada have been published jointly with Drs. Corriveau and Fowler (Morgenstern et al., 1981). The two most important findings at ages 15 and 22 years from seed were: (1) provenances from the southern Appalachian Mountains are not suitable for reforestation in Canada, and (2) the effects of introgressive hybridization with black spruce were still evident in this particular sample of provenances and influenced the results more than latitude, elevation or precipitation at the place of seed origin.

Black spruce

The five Ontario experiments in the range-wide study were measured in 1979, i.e. at the age of 10 years from seed. The effects of grass competition and frost damage had not been overcome in some experiments so that a comprehensive evaluation was considered premature.

The earlier study, initiated in 1963 primarily with Ontario provenances, was remeasured in 1978. Strong interactions were observed, with very different responses at Chalk River and Kirkland Lake. The results will be published.

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PROGENY TESTS

Ontario Region 3E

The seven open-pollinated progeny tests in Kirkland Lake, Cochrane, Kapuskasing, Hearst, Chapleau, and Wawa (formerly White River) Districts completed their sixth year in the field and were measured for the first time in the fall of 1980.

Ontario Regions 3W and 4S

These two test series, planted in 1976 and 1977, respectively, were visited and some maintenance performed by the cooperating forest districts. Their condition is generally satisfactory but minor maintenance is still required. In several of them more spring frost damage was observed than one would expect in this species, and some mortality due to _Armillaria mellea_ [Vahl ex Fr.] Kummer was also identified.

Controlled crosses

In 1979, two additional Petawawa experiments were measured: a) a field experiment with provenance hybrids (Exp. 358-B), b) the diallel cross of 1970, which consists of four test plantations. The data were summarized and stored in the computer.

SEED PRODUCTION

Messrs. J.A. McPherson, B.S.P. Wang and I analysed the seed production of the grafted clonal black and white spruce (_Picea glauca_ [Moench] Voss) seed orchards of Kimberly-Clark of Canada Ltd. at Longlac, Ontario. The orchards had been gradually established since 1960 and have been monitored since 1970. Although there was wide fluctuation from year to year in flowering, all ramets flowered in the best seed years. In 1980 a bumper crop was harvested in the white spruce orchard. The two orchards are probably the oldest of their kind in Canada and statistics from them will be of great interest. A paper has been submitted for publication (McPherson _et al_., 1981).

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GENETICS OF LARCHES AND DECIDUOUS HARDWOODS, PETAWAWA, 1978-1981

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Key Words: Larix decidua, Larix leptolepis, Larix laricina seed collection, seed production area, progeny test.

Responsibility for studies of native and exotic larches (Larix Mill.), black walnut (Juglans nigra L.), white and green ash (Fraxinus americana L. and Fraxinus pennsylvanica Marsh.), and Norway maple (Acer platanoides L.) was assumed by Dr. G. Murray in June 1980 when he filled the position left vacant for about 18 months following the resignation of Mr. R.F. Calvert. During this interim period, work already started, much of it involving cooperation with other agencies, was continued by Mr. John Veen, research technician, with the guidance of Dr. Morgenstern and Dr. Yeatman. Since June 1980, a review of the work in progress has led to some changes in priorities, the result of which will be to direct more attention to genetic studies on larch.

LARCHES

Exotic larches

Plantations established at Petawawa in 1953 and 1961 with different seedlots of European larch (Larix decidua Mill.), Japanese larch (Larix leptolepis [Sieb. and Zucc.] Gord.), and hybrid larch (Larix eurolepis Henry) were thinned during the winter of 1979/80. This thinning, the purpose of which was to favour selected trees, yielded an estimated 145 cubic metres of merchantable larch logs from a total area of 1.8 hectares. The bulk of these thinnings was used in tests of pulping and paper making properties conducted by Domtar technical services staff at their plant in East Angus, Quebec. Results of this work will be published.

Seed of 79 seedlots of Japanese larch, representing collections from trees in native stands in Japan and in plantations in Japan, Europe, and Canada, were sown in containers at P.N.F.I. in June 1978 and the seedlings were transplanted in the Ontario Ministry of Natural Resources (O.M.N.R.) nursery at Kemptville in August of the same year. In 1979 these trees were planted by O.M.N.R. at two locations near Cornwall and Ottawa, and by the Canadian International Paper Company (C.I.P.) near Trois Rivières, Quebec, according to a design for a seed production area suggested by

Dr. C.W. Yeatman. The objective of this design was the creation of seed production areas in which five percent of the trees planted would ultimately be retained for seed production following selection for hardiness, freedom from pests, growth rate, and stem and crown form.

About 45 of these Japanese larch seedlots were also included in several plantations established in eastern Ontario in 1980 as part of the ENFOR (Energy from the Forest) program carried out by O.M.N.R. under contract.

Scions from superior phenotypes of European larch selected in P.N.F.I. plantations were provided for inclusion in Japanese x European hybrid larch seed orchards being established by O.M.N.R. near Napanee, and by C.I.P. at Harrington, Quebec. Scions from these and other selected trees have also been grafted at P.N.F.I. where they will be used in future breeding work.

Native larch

Since 1977, cooperators in the range-wide provenance study of tamarack (Larix laricina [Du Roi] K. Koch) have received requests for collections of seeds from stands in given areas. Responses to these requests have indicated a high level of interest in this study, but poor seed years, seed losses to insects, and the short period between cone maturity and seed fall have made collection of the required seed very difficult. For example, cone collections in the maritime provinces and in the state of Maine have yielded no significant amounts of seed. Cones have been received from 35 different stands in Ontario, but in only eight cases have these yielded adequate amounts of seed from ten trees in the stand. No collections have been made in Manitoba, while seed were obtained from four stands across central Saskatchewan, and from one stand in Wisconsin. Finally, offers of seed from earlier collections have been received from Quebec and Alberta.

These difficulties in obtaining adequate supplies of tamarack seed were not unexpected, and it was stated in the original proposal that it could take until 1982 to assemble the required seed. Efforts to satisfactorily complete collection of the seed will continue in 1981.

DECIDUOUS HARDWOODS

White ash progeny tests, including seed from Ontario, Quebec, and New Brunswick, were planted in 1980 and 1981 near Orono, Ontario, and Portage-du-Fort, Quebec, with the cooperation of O.M.N.R. and Consolidated Bathurst Ltd. at the respective locations. A white ash provenance test, planted at Petawawa in 1977 as one of a series of tests organized by the U.S. Forest Service, was evaluated for survival, growth, and frost injury and the data sent to Dr. Knud Clausen at the North Central Forest Experiment Station, Carbondale, Illinois. Green ash from Ontario, Quebec and the Maritimes were planted in a number of provenance tests, most of which were part of the ENFOR program in eastern Ontario.

Five black walnut progeny tests were planted in 1978 and 1979 as part of a cooperative P.N.F.I.-O.M.N.R. study. Survival in two of these plantations was very poor and a third plantation was lost when the farm on which it had been planted was sold. Recently, full responsibility for the tests was transferred to O.M.N.R., marking the increasing level of interest and activity in gene conservation and genetic improvement in black walnut within O.M.N.R.

Norway maple seed obtained from three widely separated locations in the Soviet Union in 1977 were grown in the nursery at P.N.F.I. and the seedlings were planted at two locations at P.N.F.I. in 1981. In future years these trees will be evaluated on the basis of their hardiness, growth rate, and stem and crown form.

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WHITE SPRUCE GENETICS, PETAWAWA 1978-1981

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Key Words: provenance, progeny test, isoenzymes.

A number of personnel changes in the past two years have tended to limit research activity on white spruce genetics to continuation of studies already in progress when Dr. Ying resigned in July 1979. Essential work on provenance and progeny tests was carried out by Mr. Hoelke, research technician, under the supervision of Dr. Morgenstern, while isoenzyme studies were continued by Dr. Bhattacharya and Dr. Murray. When Dr. Morgenstern left to join the faculty at the University of New Brunswick in January 1981, responsibility for the white spruce studies passed to Dr. Murray assisted by Mr. Boyle, who joined the tree genetics and breeding project as a forestry officer in January.

PROVENANCE STUDIES

Three more field tests forming part of the range-wide provenance study described by Ying (1980) were planted in Ontario in cooperation with the O.M.N.R.(Ontario Ministry of Natural Resources). Staff from P.N.F.I. supervised the planting, near Sudbury, of one range-wide test that included 86 provenances arranged in five replicates with square nine-tree plots. Two regional tests were planted near Chapleau and Minden under the supervision of Mr. Skeates of O.M.N.R. Planting stock for two additional range-wide tests will be ready for field planting in 1982 and 1984.

One regional test, planted near Red Lake, Ontario, in 1978 was burnt in the spring of 1980. To replace this test, seed were sown in the greenhouse at P.N.F.I. in November 1980 with the objective of producing container stock suitable for field planting in the spring of 1982.

During 1978 and 1979, 15- and 20-year survival counts, and measurements of height and, in some cases, diameter, were taken in the earlier series of tests described by Teich, Skeates, and Morgenstern (1975). Parts of several of these plantations had been destroyed or damaged by agents such as fire, frost, and insects, but preliminary analysis of the height data showed that there had been few significant changes in the ranking of provenances in the surviving plots. Seed sources from Southern Ontario, the Ottawa Valley, and the Lower St. Lawrence had maintained their superiority in tests at Owen Sound, Dorset, Lake Dore, Chalk River, and Thunder Bay. In two tests at Kapuskasing, sources from Northeastern Ontario and Quebec were still tallest but, in one of the tests, a provenance from near Thunder Bay had risen from 11th to 3rd in rank and from 102% to 125% of the overall experimental mean height. These data are being prepared for publication.

PROGENY TESTS

Two progeny tests were planted in 1980, one at P.N.F.I. and the other near North Bay, both located in Ontario site region 5E. The open-pollinated seed used were part of the collection made for the range-wide provenance study and came from 239 trees in 30 stands within, or immediately adjacent to site region 5E.

ISOENZYME STUDIES

Distribution of isoenzymes in a natural stand of white spruce was studied using seed from 48 trees. Dr. N.C. Bhattacharya, a Visiting Fellow sponsored by the Natural Sciences and Engineering Research Council of Canada, modified standard techniques of starch gel electrophoresis for the analysis of isoenzymes in crude extracts of white spruce megagametophyte tissue. Only two enzyme systems, GDH (glutamate dehydrogenase) and MDH (malate dehydrogenase), produced band patterns that were sufficiently clear and consistent to permit genetic interpretation of the results. Genotypic frequencies calculated on the basis of allelic frequencies observed in this population did not differ significantly from those expected in a panmictic population. A short paper based on these results will be presented by Dr. Murray at the second conference of the North Central Tree Improvement Association in Lincoln, Nebraska in 1981.

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NATIONAL TREE SEED CENTRE, 1979-80

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Key Words: Germplasm Bank, processing, testing, artificial ripening, dormancy, storage, seed crop management.

In the last two years the National Tree Seed Centre has continuously expanded its program from five to seven studies with increased funding. The newly initiated research studies were on artificial ripening of tree seed, and predicting and evaluating cone crops and losses due to insects.

From April 1, 1981 Jack Pitel and his technical assistant, Garry Scheer, will be transferred from the current study on biochemical techniques and indices for seed quality control to biochemical systematics, such as isoenzyme studies of forest trees, within the Tree Genetics and Tree Breeding Project. However, Jack will still work in close cooperation with the staff of the Seed Centre. The Centre successfully organized and hosted the 1980 IUFRO International Symposium on Forest Tree Seed Storage with pre- and post-symposium field trips to northern and southern Ontario hosted by the Ontario Ministry of Natural Resources (OMNR).

In this paper we report the progress made in our studies on forest Germplasm Bank and associated services; testing, treatment and storage of tree seed; seed crop production and stimulation; and the two new studies. The progress on the study of control of insect and fungal pests in seed production and distribution and storage is reported separately by Dr. Willard Fogal.

SERVICE

Seed Procurement, Distribution and Processing

In addition to serving as a repository for forest seed and other reproductive material, the Germplasm Bank serves as a clearing house for procurement and distribution. Numerous seedlots have been received from several sources in the U.S.S.R. and the People's Republic of China and distributed to requesting agencies across Canada. A sample of sugar maple (Acer saccharum Marsh.) seeds was recently received from the U.S. Forest Service which should be of particular interest to maple syrup researchers as it was collected from clones selected for superior sap sugar production.

The Germplasm Bank will serve as the North American centre for the International Energy Agency's project, "The Collection and Distribution of Seeds of Alnus Species which are of Importance for Biomass Production in Energy Plantations".

The Centre cooperated with the Ontario Ministry of Natural Resources in an evaluation of black spruce (Picea mariana [Mill.] B.S.P.) seed yields and quality obtained from mechanical cone collection trials.

For the past 10 years Kimberly-Clark of Canada Limited has sent for custom processing cones from its black spruce and white spruce (P. glauca [Moench] Voss) seed orchards at Longlac, Ontario.
Processing and storage services were extended to the Eastern Region of the Ontario Ministry of Natural Resources for its larch program.

A chapter on white spruce (Skeates et al. 1981) and one on red spruce (P. rubens Sarg.) and Norway spruce (P. abies [L.] Karst.) have been submitted for the Ontario seed collection manual currently in preparation. A report on seed procurement and processing across Canada is in preparation as part of the Canadian Forestry Service Forest Resource Data Program.

Seed Testing and Seed Crop Evaluation

Over 2,000 separate tests of 400 seed samples were made for purity analysis, germination, moisture content determination, 1,000-seed-weight determination and x-ray analysis, although the number of commercial tests has greatly declined since the Pacific Forest Research Centre has become an accredited official tree seed testing station with the International Seed Testing Association. Miss Francine Sheridan was newly appointed as an official seed analyst for the Canada Seeds Act.

Wang worked closely with Canadian Forestry Service (CFS) Headquarters and other CFS establishments to assist Agriculture Canada in drafting an amendment to the current Canada Seeds Act to bring about the transfer of all forest tree seed control from Agriculture to CFS and to develop the first draft of new forest tree seed regulations for review.

Because of the variations among replicated samples experienced in both service and research testing of tree seed, a close examination of causes indicated that moisture in the germination medium and the type of germination trays used appeared to be the two principal sources of the variation. In order to overcome this problem, a standard germination box was developed and a contract signed with Spencer-Lemaire Industries of Edmonton for manufacturing proto-types for testing. It is hoped that commercial production of the boxes will be followed after the testing.

The seed laboratory successfully participated in three International referee testing projects: (1) to evaluate prechilling treatment for Abies concolor (Gord & Glend.) Lindl. and A. procera Rehd. seeds, (2) to determine empty seed of P. Abies, and Pinus sylvestris L. after germination test by x-rays and cutting method and (3) to compare rapid viability tests with standard germination tests for A. alba Mill., A. pseudoplatanus L. and Fagus sylvatica L. seeds.

In an evaluation of white spruce seed quality for the Alberta Forest Service, it was found that the low germination was possibly due to the change of seed moisture content and mishandling of cones after collection.

Seed crop assessment services were provided to the Ontario Ministry of Natural Resources and the Nova Scotia Department of Lands and Forests. It was found that the x-ray technique is very useful for evaluating yellow birch (Betula alleghaniensis Britton) seed crops and determining collectability. Seeds extracted from cones collected from black spruce trees after one month from logging (early August) showed 74-80% germination without chilling but 45% germination with chilling. The results will be further confirmed by duplicated trials in 1981.

RESEARCH

Seed Extraction and Cleaning

A small study of moisture content of jack pine (Pinus banksiana Lamb.) seeds during extraction and cleaning was carried out in response to a question which had arisen concerning the tolerance of seeds to low moisture content. Seed moisture content immediately after extraction was very low; just over 2% (fresh weight basis). A study of the effect of initial cone moisture content on cone opening and seed yields of tamarack (Larix laricina [Du Roi] K. Koch) was initiated.

Seeds of alder (Alnus) are difficult to clean. An effective method to up-grade alder seed quality was found to be by liquid separation. A report is being prepared.

Seed Dormancy

Further studies on dormancy problems of whitebark pine (P. albicaulis Engelm.), lodgepole pine (P. contorta Dougl.), red maple (A. rubrum L.), ironwood (Ostrya virginiana [Mill.] K. Koch) and basswood (Tilia americana L.) were completed. Results of these studies have been either published or are in the process of being published. Treatments involved in these studies included acid scarification, chipping, prechilling, exogenous application of hormones and a combination of the treatments.

Studies were carried out to determine some of the fundamental causes of dormancy such as the examination of growth inhibitors, amino acids, isoenzymes and chromosomal proteins during prechilling. As part of an international cooperative research project, a review of literature dealing with deeply dormant tree and shrub seeds is in the final stages of completion.

Seed Germination

An experiment to improve the current germinability testing method of white ash (Fraxinus americana L.) and red ash (F. pennsylvanica Marsh.) seeds was completed and a report is being prepared. Cooperative research with the Alberta Forest Service on lodgepole pine seed germination and effects of seed weight on germination and early seedling development was completed and a technical report was published by the Alberta Forest Service. The report recommends the prechilling requirements for maximum lodgepole pine seed germination, and the importance of seed weight on seed germination vigor and early seedling development.

Preliminary research on *Alnus* germination requirements indicated that the primary cause of low germinability was due to incomplete seed cleaning, sensitivity of the seed to moisture of the medium and photoperiod in germination. Further research on the ecology of *Alnus* seed germination is in progress.

Experiments have been initiated to test a hypothesis of the endogenous control of germination rhythm in white spruce and jack and lodgepole pine seeds. Data from the first year experiment are being analyzed for reporting.

In a cooperative research on seed production with Dr. Morgenstern (UNB) and Mr. McPherson (Kimberly-Clark), evaluation of seed quality of white and black spruce from Kimberly-Clark seed orchards has been made since 1970, and a paper has been jointly prepared for publication.

New studies on the ecology of germination of native tree species will be initiated in 1981.

Seed Storage

Seeds from a long-term storage study to test the effectiveness of the two storage conditions at Petawawa National Forestry Institute were evaluated after 11-13 years and a paper entitled "Long-term storage of *Abies*, *Betula*, *Larix*, *Picea*, *Pinus* and *Populus* seeds" was presented at the 1980 IUFRO International Symposium on Forest Tree Seed Storage held at the Institute. Another paper entitled "Accelerated aging studies of seeds of jack pine (*Pinus banksiana* Lamb.) and red oak (*Quercus rubra* L.)" was also presented at the same symposium. Findings from the former experiment showed that sub-freezing temperature (-18°C) is positively superior to above freezing temperature (2°C) for long-term storage of *A. balsamea* (L.) Mill., *P. glauca*, *P. strobus* L., *Populus deltoides* var. *occidentalis* Rhdb., *P. grandidentata* Michx. and *B. alleghaniensis* seeds. Results from the latter study suggest that the loss of germination and vigor of seeds was associated with membrane damage, degradation of reserve proteins, increases in the levels of soluble amino acids, and with minor structural changes of the chromosomal proteins, ribosomal proteins and isoenzymes. A preliminary report describing the amino acid composition of various coniferous and hardwood seeds has been prepared.

New seed storage experiments are being established to examine the effects of prolonged storage on chromosomal changes and the beneficial effects of freeze-drying on seed storage life. A new study will be established to test the suitability of liquid nitrogen as a long-term, *ex situ* storage condition for forest gene-pool conservation measures.

Seed Crop Management: Forecasting, production and early collection

As a result of a very intensive review of the literature and a survey of most client agencies, a series of research priorities were established for future action in seed crop management. Winston will devote a majority of his time to study factors affecting the production and stimulation of seed crops. Several experiments have been established during 1979-81 examining the effects of spacing and fertilizers on cone production. Applications of the fertilizer, ammonium nitrate (34%N), at the time of vegetative bud flushing to stimulate cone production are being tested at Angus, Ontario in a white spruce seed orchard and at Mackey, Ontario in a red pine seed production area. Six major experiments have been established, in cooperation with W. Fogal (PNFI) and OMNR in both white spruce and black spruce plantations. These trials are designed to test the effects of ammonium nitrate fertilizer, alone and in conjunction with the chemical insecticide carbofuran for control of cone and seed insects, as a means of increasing cone production. Preliminary results are encouraging and further results are being analysed. The effects of frost on the regulation of flowering, while often mentioned, have not been well documented in the literature. Current observations indicate severe frost damage to potential white spruce crops occurred throughout north-eastern Ontario and to red pine (_P. resinosa_ Ait.) in central Ontario in 1980. Similarly, tamarack crops in central Ontario have been damaged in 1981. In cooperation with the OMNR, a detailed assessment of frost damage to flowers in a red pine plantation is underway at Mackey, Ontario.

Problems related to cone collection are being addressed by Haddon and Winston. Experiments have been ongoing since 1978 to determine optimum cone collection periods for different species and to determine if the cone collection periods can be extended through the use of artificial ripening techniques. Results to date indicate that both white spruce and red pine cones can be collected early and ripened artificially to produce healthy, germinable seed (Winston and Haddon 1981). White spruce collected as early as August 1 could be ripened when stored for 12 weeks in a room at $5^{o}C$ with 75%-95% relative humidity. Conversely, red pine was successfully ripened in the PNFI cone air-drying shack when stored for at least 4 weeks after collection as early as August 23. Cold-air ($5^{o}C$) storage of white spruce cones was found to eliminate the need for prechilling of white spruce seed to permit germination. This suggests that prechilling requirements of seed may be affected by cone handling and storage conditions. The retention of germinability of artificially ripened seed was tested following two years of seed storage (Haddon and Winston 1981). In most seedlots, both germinability and fulfillment of prechilling requirements as a result of cone storage at $5^{o}C$ were found to be retained. Further studies are continuing with other species (tamarack, white pine) and new directions are being initiated to more fully document embryo development in seed of native Canadian tree species and the role/relationships of embryo growth to seed maturation.

The forecasting and recognition of potential seed crops is being examined in detail by Winston and Fogal. To date, a series of experiments have been initiated which include sampling buds of white spruce and black spruce in winter conditions and attempts are being made to relate these to potential cone crop. This utilizes the methodology reported by Eis (1967,

1973) and Eis and Inkster (1973) with adaptation to eastern Canada. However, our studies are examining losses to cone and seed insects and should provide more reliability on final crop estimates. In cooperation with the OMNR, a cone collection manual for Ontario is being prepared. A chapter on forecasting methods has been written and techniques for recognizing buds and flowers of spruces have been documented.

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INSECT AND DISEASE RESEARCH IN TREE IMPROVEMENT AND SEED PRODUCTION--PETAWAWA, 1979-80

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Keywords: spruce, seed and cone insects, seed losses, forecasting, sex pheromones, chemical control, biological control, susceptibility, tolerance, phytochemicals.

INTRODUCTION

Research on insects and diseases at Petawawa National Forestry Institute (PNFI) focuses on problems that are a threat to forest regeneration in boreal and eastern Canada. One study is concerned with the use of genetics and breeding in forest pest management and has as its objectives identification of pest-tolerant trees and development of guidelines to prevent planting of susceptible types in forest regeneration. A second deals with management and control of insect and disease problems in production, collection, storage, and germination of seed. Background rationale for these two studies was outlined in a previous report (Fogal 1980a).

Serious shortages of black spruce, (*Picea mariana* [Mill] B.S.P.) and white spruce, (*Picea glauca* [Moench] Voss), seed have prompted us to concentrate our research effort over the past two years on control of losses to insects in these two species. This report outlines our activities and progress for the period 1979-80. It also includes a brief outline of insect pests and fungal diseases which have been investigated as part of tree-improvement studies at Petawawa.

SEED AND CONE INSECTS: WHITE AND BLACK SPRUCE

Spruce budworm, *Choristoneura fumiferana* Clem., coneworm, *Dioryctria reniculleloides* Mutuura and Munroe, seed moth, *Laspeyresia youngana* (Kearfott), cone maggot, *Lasiomma anthracina* (Czerny), and other insects are responsible for shortfalls of white and black spruce seed and are a threat to tree improvement in these species in boreal and eastern Canada. We are seeking solutions by developing an integrated pest management approach that includes evaluation of seed losses, pest monitoring, crop forecasting, control with chemicals and biocides.

Evaluation of Losses, Insect Monitoring and Crop Forecasting

Cone crops, seed yields, and insect damage are being determined to evaluate losses to insects in a variety of tree habitats ranging from unmanaged seed collection areas to intensively managed clonal seed orchards in cooperation with the Ontario Ministry of Natural Resources, Dryden and Kapuskasing districts and Kimberly-Clark of Canada Limited, Longlac, Ontario. Results are beginning to provide valuable information about which insects cause most serious losses, when and where to collect cones in natural stands, and effects of various types and levels of crop management on seed yields and losses to insects (Fogal 1979).

The use of insect sex pheromones to monitor populations of seed moth is being investigated in cooperation with Dr. G.G. Grant, Forest Pest Management Institute, Sault Ste. Marie, Ontario. Field tests were begun in 1980 at PNFI to find an effective and reliable lure for the seed moth and to monitor its population levels and flight season. Twelve lure mixtures, using (E)-7 dodecenal as the principle ingredient, were tested. Choice of effective lures is confounded by differences in infestation levels and by trapping of closely related moths. However, a good picture of the flight season in relation to weather factors and phenology of flowering is emerging (Grant 1980).

A study on crop forecasting and prediction of losses to insects was initiated in 1980 in cooperation with Mr. D.A. Winston to determine possible relationships between crop sizes and insect losses and to develop means for predicting size of white and black spruce cone crops for at least one year in advance of collecting.

Chemical Control

Foliar treatments of a range of concentrations (0.5 to 1.5 percent active ingredient) of dimethoate, lannate, and orthene applied to cone-bearing portions of white spruce trees were carried out in 1978 and 1979 for protection from budworm, coneworm, seed moth, cone maggot, and other insects. The degree of protection appears to be related to tree size.

Stem applications of dimethoate and oxydemeton-methyl in 1980 provided some protection of seed crops from seed moth, coneworm, and cone maggot (Fogal 1980b). Experiments have been started with Mr. V.C. Plowman, Farm and Forest Research Limited, Oakville, Ontario and Dr. E.S. Kondo, Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario to test systemic insecticide injections for control of seed and cone insects in white spruce. This method of insecticide application will reduce environmental hazards to a minimum.

In 1979 and 1980, experiments were begun with D.A. Winston to assess soil applications of carbofuran insecticide and ammonium nitrate as management tools in white and black spruce plantations at the Bonnor Tree Improvement Centre, Ontario Ministry of Natural Resources, Kapuskasing, Ontario. Results to date are very encouraging with respect to budworm control and cone crop stimulation (Fogal 1980b; Fogal et al in press).

Biological Control

Studies were initiated in 1979 and continued in 1980 in cooperation with Dr. M.I. Timonin, Carleton University to determine whether entomopathogenic fungi can be used for control of seed and cone insect pests in white spruce. Several insects that attack cones of white spruce are highly susceptible to infection by *Beauveria bassiana* (Bals.) Veuill. and *Metarrhizium anisopliae* (Metch.) Sor. (Timonin *et al*., 1980). Methods for delivering spores to target insects must be devised.

INSECTS AND DISEASES IN TREE IMPROVEMENT STUDIES

Consideration of variations in susceptibility of native and exotic trees to native and introduced pests has been an integral part of the Petawawa tree improvement program since its inception in 1924. Mortality and damage caused by insects or disease have been carefully recorded for many years in provenance trials, plus-tree selections, and progeny testing. The following fungal diseases and insect pests have been studied: scleroderris canker, *Gremmeniella abietina* (Lagerb) Morelet; shoestring root rot, *Armilleriella mellea* (Vahl ex Fr.) Karst.; sweetfern blister rust, *Cronartium comptoniae* Arth.; pine gall rust, *Endocronartium harknessii* (J.P. Moore) V. Hiratsuka; larch sawfly, *Pristiphora erichsonii* Htg; introduced pine sawfly, *Diprion similis* Htg; white pine weevil, *Pissodes strobi* Peck. A review of literature on variation in susceptibility of native and introduced coniferous trees to some insects of eastern Canada has been accepted for publication (Fogal *et al*., in press).

Phytochemicals that influence insect host preference and protect plants from disease organisms are believed to play an important role along with other factors in acceptability of trees as hosts for insect and disease organisms. Identification of such chemicals in host or non-host plants can lead to their eventual manufacture and use for application in pest control and simple measurements in host tissue may help breeders select tolerant trees. Possible applications to the spruce budworm have been outlined elsewhere (Strunz and Fogal, in press; Fogal and Strunz, in press).

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SOME ACTIVITIES RELATED TO FOREST GENETICS AT LAKEHEAD UNIVERSITY, 1979-1981

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Key Words: phenology, seed orchard, ecotypic variation, population differentiation, needle flavonoids, species-pairs.

Forest genetics remains as one focal point of teaching and research at the School of Forestry. During the past two years Dr. Gordon Murray and Dr. John Barker have each moved on to new positions, but they have been replaced by Dr. Rob Farmer (formerly of Tennessee Valley Authority) and Dr. Peggy Knowles (formerly at University of Colorado, Boulder). Dr. Farmer will be investigating the genecology of poplars and other species in the boreal forest, and Dr. Knowles has begun an investigation of isozyme variation within reforested stands of Pinus banksiana Lamb. My own activities have focused on morphological and flavonoid variation in natural stands of Abies and Picea.

DEGREE OF SELFING IN A BLACK SPRUCE SEED ORCHARD

Mr. Conor O'Reilly recently completed his M.Sc. Degree investigating vegetative and sexual phenology of Picea mariana (Mill.) B.S.P. To estimate the amount of self-pollination in a clonal seed orchard of Picea mariana, periods of pollen release and female receptivity were determined for 4 ramets each of 14 clones located in the Matawin Seed Orchard, Thunder Bay District, Ontario. Stages of pollen release and female receptivity were determined by a qualitative index, and total numbers of male and female strobili were counted. Although the overall duration of pollen release and female receptivity was short, consisting of about 15 days, significant differences in timing were present between clones. However, peak pollen release and maximum female receptivity coincided for most clones, thus increasing the probability of self-pollination. Numbers of both male and female strobili were significantly different between clones, with a few of the clones producing the largest numbers of strobili; this effect was most pronounced for male strobili. As well, clones producing large numbers of male strobili did not necessarily produce large numbers of female strobili. The genetic composition of the seed crop was estimated from 1) the daily stages of pollen release and female receptivity and 2) the number of male and female strobili per clone. A small fraction of the 14 clones made the largest contribution to the genetic composition of the progeny. This result depended most heavily on numbers of male strobili produced by each clone, while the timing of pollen release and female receptivity had little effect. The average percentage of self-pollination was estimated at 9 per cent, but individual clones varied from 1 to 25 per cent.

UPLAND AND LOWLAND VARIATION IN BLACK SPRUCE

Dr. Knowles, several graduate students, and myself have been investigating variation in upland and lowland stands of black spruce. Picea mariana is widely distributed, genetically variable forest species that occuppies ecologically diverse sites in northwestern Ontario. In this area black spruce trees growing on bog sites are stunted and appear strikingly different from nearby forest trees. To determine whether site differences have led to ecotypic differentiation, 10 cone-bearing trees were sampled from each of the following three semi-adjacent stands near the Matawin River, Thunder Bay District, Ontario: 1) an upland forest on well-drained alluvial soil, 2) an abandoned pasture on heavy soil, and 3) a very wet sphagnum bog. Nine cone characters and 8 needle and twig characters were scored for each tree, and these data were analyzed by Principal Components Analysis (PCA) and Canonical Variates Analysis. PCA demonstrated that two major, independent trends of variation existed in the data, one attributable mainly to cone characters and the other attributable mainly to needle characters. Bog trees were slightly differentiated from tree from the drier sites based on cone data, but the differences were not significant. Also, bog trees were more variable than the others with respect to cone characters, but not needle or twig characters. The trees also were compared on the basis of foliar flavonoids. A fraction of the bog trees possessed a flavonoid glycosylation class not present in the other trees indicating greater chemical diversity in the bog trees that paralleled the greater variation in cone characters. Bog and forest trees were further compared using isoenzymes, no differences between sites were detected. Results of morphological and chemical analyses indicate that bog trees are more variable for certain functionally-related groups of traits including cone and flavonoid characters, but not for needle, twig, and isozyme characters. However, discrete ecotypes corresponding to upland and lowland sites could not be distinguished in the sampled trees.

GENECOLOGY OF NORTH AMERICAN ABIES SPECIES

Together with Dr. Jack Maze at the University of British Columbia, and several students, I have been investigating relationships between certain species-pairs of Abies and the nature of variation within the balsam firs and noble firs. Abies balsamea and A. lasiocarpa are closely related North American balsam firs that are generally thought to hybridize and intergrade where their ranges overlap in west-central Alberta. To test this hypothesis, a series of collections was made from 10 populations along an east-west transect between western Saskatchewan and central British Columbia. Each tree was scored for various vegetative and cone characters. The resulting data were analyzed by Principal Components Analysis and Canonical Variates Analysis. Analyses based on vegetative data produced somewhat different results from analyses based on cone data indicating that vegetative and sexual features of the trees respond to different selection pressures at the ecologically diverse sample sites. The combined results of analyses of vegetative and sexual data indicate that the 10 populations do not represent elements of two morphologically distinct taxa. Instead, the results apparently reflect population differentation within a single, regionally variable complex in response to local selection pressures following east-west gene flow. It is recommended that the separate species designations, *A. balsamea* and *A. lasiocarpa*, be retained since 1) present day elements of the complex are evidently derived from separate refugia isolated by the Rocky Mountains during past glacial periods, and 2) gradual morphological differences exist between populations on each side of the Rocky Mountain crest.

Student Projects in Progress

1. Implications of needle flavonoid variation on the relationship of *Abies procera* to *A. magnifica*.

2. Comparison of phenotypic plasticity in upland and lowland clones of *Thuja occidentalis* under adaptive and non-adaptive conditions.

3. Alternate methods of *Picea mariana* plus-tree selection emphasizing competitive performance.

Undergraduate (4th year) B.Sc.F. Theses

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Millard, M.A. 1981. The effect of topping on seed production in white spruce.

O'Reilly, G.J. 1981. Correlation of major environmental effects with morphological variation in *Abies balsamea* (L.) Mill. accross northwestern Ontario.

Simmonds, F.M. 1981. Effect of ortet age and crown position on rooting ability of *Picea glauca*.

Van Dyke, A. 1981. Rooting ability of nine willow (*Salix*) species common to the Thunder Bay area.

Graduate M.Sc. Thesis

O'Reilly, C. 1981. Vegetative and sexual phenology, reproductive dynamics and bud differentiation in a clonal seed orchard of white and black spruce.

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A REGIONAL RARE WOODY-PLANT PROGRAM FOR SOUTHERN ONTARIO

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Key Words: forest gene resources, Deciduous Forest Region.

The Deciduous Forest Region occurs in extreme southern Ontario along a narrow band above the southern Great Lakes. In the biologically diverse forests of this region, many species of eastern North America reach their northern limits of distribution. While these Carolinian species are considered rare due to their restricted distribution in Ontario (Argus and White, 1977), many are also threatened due to loss of habitat associated with the high level of human activity here. Beyond the recognized need to conserve critical habitats, this program's objectives are to survey, collect seeds of, and gene bank the rare woody plants of Ontario. While this program is co-ordinated through the Arboretum, considerable support is received from a province-wide network of Arboretum Associates.

THE ONTARIO RARE WOODY PLANT PROGRAM

The program is now assessing the current status of 52 species of rare woody plants. While most of these have typical Carolinian distributions (e.g., *Liriodendron tulipifera* L., *Quercus muehlenbergii* Engelm.), a few have limited western (e.g., *Oplopanax horridus* (Sm.) Miq.) or eastern (e.g., *Pinus rigida* Mill.) distributions. Most of the Ontario populations of these species represent the northern limits of their distributions. These may represent genetic variants not present farther south or elsewhere through the species range due to their disjunct distribution or isolation by the Great Lakes. Thus, they represent a regional resource worthy of recognition and conservation, both to maintain the genetic diversity of the species as well as provenances likely best suited for economic utilization in Canada.

The documentation of the current natural occurrence of these species has allowed a better assessment of their status in Ontario. Duplicate herbarium specimens are being sent to the National Museum of Natural Science where they will be useful in the Rare Plant Atlas Project. As species are identified as potentially threatened or endangered in Ontario, attention can be drawn to the need for more detailed studies.

The collection of seeds of these rare species offers an unusual focus to our international seed exchange program. By extending the effective reservoir of documented collections of Ontario populations to botanical institutions around the world, we might at some time in the future be able to draw on this expanded distribution for various types of evaluation data, or even propagation material.

Many of the seed collections are also being grown in our nursery facilities for inclusion in the Gene Bank Collection. Here we would like to ideally include as much genetic variation as is identified in Ontario populations, providing a suitable resource for a future selection and breeding program.

Habitat conservation is an essential concern of forestry gene resources. This program is meant to complement--not supplant--that equally important concern. Even under good forestry management practices, most of these species are threatened due to their current status as non-commercial species. When provinically significant habitats are identified through this program, such information will be communicated to the Ministry of Natural Resources for consideration in the Nature Reserve system.

PROGRESS

During the past year, approximately 250 sightings or herbarium specimens of rare woody species were recorded. Of 142 seed collections of native plants for the Arboretum's Index Seminum, 50 were of rare woody species. These were distributed to 132 requesting botanical institutions and individuals. Significant assistance was received from the Arboretum Associates for both the survey and seed collecting.

We are now better able to define the distribution of many of these species, with several range extensions noted both from recent literature (Campbell and Reznicek, 1977) and herbarium specimens collected through this program. New species of native woody plants are also being recorded in the literature (Maycock, et al. 1980) as well as by Associates. An example of the latter is the discovery of *Quercus shumardii* Buckl. in Essex Co. by Gerald E. Waldron. The identity of the specimens was subsequently verified and additional stands of this species were located.

With this accumulating data, it is clear that certain species have a very restricted distribution in Ontario and are potentially endangered. Two such species, *Gymnocladus dioica* (L.) K. Koch and *Fraxinus quadrangulata* Michx., were selected for detailed study during 1981. Status reports will be prepared for the Committee on the Status of Endangered Wildlife in Canada. If these reports indicate a level of endangerment warranting official designation, then these species, and their habitats, will be afforded protection under the Endangered Species Act of Ontario.

During the past two springs, the Gene Bank was prepared for later planting of lots of rare tree seedlings. A shelterbelt and blocks of intolerant nurse crop trees were established for later inter-planting with the tolerant rare species. In addition, a small plantation of Black Walnut (*Juglans nigra* L.) was established, according to the ministry recommendations (Johnson, 1979), inter-planted with White Pine (*Pinus strobus* L.).

The plantation represents 42 collection sites throughout Ontario, received as a duplicate set of seedlings from the Petawawa Forest Experiment Station (Calvert, 1976).

With the recognized significance of regional rarity, and the need to conserve forest gene resources for future economic utilization, arboreta and botanical gardens often represent ideal coordinating institutions for such programs as this. Appropriate staff are present, contacts with the interested public are established, and land is available for long term commitments.

ACKNOWLEDGEMENTS

This program is supported by a grant to the University of Guelph Arboretum from the Ontario Ministry of Natural Resources. The preparation of the endangered species status reports is supported by the World Wildlife Fund (Canada). The accomplishments of the program are to a significant proportion a credit to the voluntary support of numerous Arboretum Associates and the technical assistance of Steven Aboud.

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AMÉLIORATION DES ARBRES FORESTIERS AU SERVICE DE LA RECHERCHE FORESTIÈRE DU MINISTÈRE DE L'ÉNERGIE ET DES RESSOURCES DU QUÉBEC

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PROJET G 68-1. SÉLECTION DE CLONES ET AMÉLIORATION DU PEUPLIER (POPULUS L.), PAR G. VALLÉE

Mots-clés: Populus L., test de provenances, test clonal, sélection de clones, croisements, introduction.

Plantations comparatives

Les tests clonaux de 3^{e} génération ont débutés en 1979 pour comparer les nouveaux clones de la collection avec les meilleurs des tests clonaux de la 2^{e} génération. En 1979 et 1980, deux dispositifs ont été établis, dont l'un a été conçu pour fournir des informations sur le potentiel de production en biomasse des clones comparés.

Un test clonal spécifique a été réalisé avec 76 clones de Populus nigra L. afin d'identifier les clones les mieux adaptés et les plus productifs pour, par la suite, les utiliser comme géniteurs dans les croisements. P. nigra est particulièrement résistant à la rouille Melampsora medusae Thum. très fréquente au Québec, d'où l'intérêt d'utiliser P. nigra dans les hybridations, sans compter aussi sa bonne aptitude au bouturage.

D'ailleurs, dans le but d'identifier des bonnes sources de gênes de P. nigra L., un test de provenances-descendances a été entrepris avec l'installation de deux dispositifs dans les régions de Québec et Montréal comprenant respectivement 27 et 18 descendances-provenances représentées par 6281 et 3894 plants. Les plants d'un troisième dispositif ont été donnés sur une base d'échange au Ministère des Ressources naturelles de l'Ontario (aux soins du Dr Zsuffa), afin d'exploiter au maximum ce matériel génétique.

Enfin, la plantation en 1980 de 1887 plants représentant 16 provenances a complété le test de provenances, entrepris en 1976, sur P. trichocarpa Torr. et Gray.

Croisements

Durant l'hiver 1980, 72 croisements intra et inter-spécifiques ont été faits en utilisant 21 géniteurs choisis en général parmi les meilleurs clones ou familles des plantations comparatives des arboretums de Villeroy et Lotbinière. Seulement 12 croisements ont donné 2 493 semis représentant les hybrides suivants:

P. balsamifera	× P. nigra
P. × jackii	× P. nigra
P. × jackii	× P. deltoides (et le réciproque)
P. × jackii	× P. × jackii
P. × euramericana	× P. × jackii
P. × euramericana	× P. nigra

Récolte de semences

Dans le but de compléter l'échantillonnage génétique de l'aire de distribution au Québec du P. deltoides Marsh., les semences de trente-cinq descendances-provenances ont été récoltées particulièrement dans la vallée de l'Outaouais et dans les régions du sud de Montréal et des Cantons-de-l'Est. Des semences de cette récolte ont été expédiées en Ontario et en Chine.

Étude particulière

Dans un test de provenances-descendances de P. deltoides Marsh. de la vallée du Saint-Laurent âgé de 10 ans et établi au populetum de Villeroy par le Service de la recherche forestière, une étude de certaines caractéristiques du bois des arbres a été effectuée par monsieur Marco Delucchi (1981) sous la direction du professeur Jean Poliquin de la Faculté de Foresterie et Géodésie de l'université Laval. Les résultats très intéressants de cette étude seront publiés.

Salix spp.

Deux tests de 26 clones de Salix spp. ont été établis, dont l'un en mélange ligne par ligne avec l'aulne glutineux (Alnus glutinosa Gaertn.) pour la sélection de clones aptes à la production de biomasse, l'aulne faisant office de fixateur d'azote.

AMÉLIORATION GÉNÉTIQUE ET HYBRIDATION DES AULNES, PAR GILLES VALLÉE

Mots-Clés: Alnus L., tests de provenances et descendances, hybridations.

Les aulnes sont des espèces qui présentent un fort potentiel pour la production de biomasse en plantation pure ou en mélange avec d'autres espèces. En particulier, l'aulne glutineux, espèce introduite depuis 1970 dans les arboreta du Service de la recherche forestière, montre un comportement très intéressant pour l'enrichissement des taillis naturels. Planté immédiatement après coupe à blanc, des plants d'aulne glutineux de ± 1 m de hauteur réussissent à croître au même rythme que la régénération naturelle, y compris les rejets et les drageons, sans nécessité de dégagement.

Plantations comparatives

Les 28 plantations comparatives faites dans les arboretums comprennent des tests de provenances sur Alnus glutinosa (13 provenances) et Alnus incana var. rugosa (Du Roi) Spreng. (17 provenances) et un test de 45 descendances demi-fratries d'arbres sélectionnés dans les meilleures provenances d'aulne glutineux. Cinq ans après plantation, la meilleure provenance à l'arboretum de Lotbinière est celle du verger à graine d'Ost-preussen de la République fédérale d'Allemagne, avec une hauteur moyenne de 3,12 m.

Croisements

En 1979, 31 croisements A. glutinosa × A. incana var. rugosa ont été réalisés sur les arbres en plantation à l'arboretum de Lotbinière (tableau 1). De ce nombre, 20 croisements ont produits 605 hybrides qui sont plantés maintenant en comparaison avec des aulnes glutineux descendant des mêmes arbres-mères.

Dans ces croisements, la pollinisation a été faite avec du pollen de 2 arbres-pères de provenances différentes (Sorel et Villeroy). Deux croisements (n° 3388 et 3389) Alnus incana var. incana × Alnus incana var. rugosa ont été aussi réalisés et ont produits un nombre équivalent de descendants, soit 20 et 25, pour un total de 45. On remarquera au tableau 1 que certains arbres-mères A. glutinosa montrent une plus grande aptitude à l'hybridation avec A. incana var. rugosa, en particulier 462-4 (croisements 3360, 3361), 161-16 (3393, 3394) et 160-18 (3399, 3400). De plus, pour les croisements 3360 et 3393, il faut noter le nombre beaucoup plus grand de descendants obtenus avec A. incana var. rugosa de Sorel par rapport à celui de Villeroy, ce qui laisse entrevoir une aptitude préférentielle à l'hybridation entre les arbres parents impliqués.

Durant l'hiver 1980-81 vingt et un croisements A. glutinosa × A. incana var. rugosa, 5 croisements A. incana var. incana × A. incana var. rugosa, 6 croisements A. glutinosa × Betula papyrifera et 2 croisements A. var. incana × Betula papyrifera ont été réalisés en serre sur des rameaux floraux greffés en bouteille. Les croisements A. glutinosa × Betula papyrifera ont produits des fruits mais il est trop tôt, au moment de cet écrit, pour présager de la fertilité des semences.

Propagation végétative

Des semis hybrides A. glutinosa × A. incana var. rugosa ont été soumis à des essais de bouturage à partir de boutures herbacées mononodales enracinées sous mist. Des taux de reprises de l'ordre de 90 p. 100 laissent entrevoir la possibilité de réaliser des sélections clonales de façon à obtenir le maximum de gain génétique.

Tableau 1. Liste des croisements Alnus glutinosa × Alnus incana var. rugosa et nombre de descendants obtenus

n° croisement	n° arbre, provenance × provenance		nombre de descendants
3352	510 - 1, Allemagne, Oberbayern	× Villeroy	1
3353	510 - 19, Allemagne, Oberbayern	× Sorel	1
3354	510 - 2, Allemagne, Oberbayern	× Sorel	0
3355	510 - 2, Allemagne, Oberbayern	× Villeroy	2
3356	161 - 3, Suisse, Zugerberg	× P.L.[1]	12
3357	161 - 3, Suisse, Zugerberg	× Sorel	0
3358	161 - 3, Suisse, Zugerberg	× Villeroy	0
3359	462 - 4, Hongrie, Sellye	× P.L.	26
3360	462 - 4, Hongrie, Sellye	× Sorel	163
3361	462 - 4, Hongrie, Sellye	× Villeroy	28
3362	511 - 5, Allemagne, Ostpreussen	× P.L.	80
3363	511 - 5, Allemagne, Ostpreussen	× Sorel	1
3364	511 - 5, Allemagne, Ostpreussen	× Villeroy	3
3365	511 - 6, Allemagne, Ostpreussen	× P.L.	1
3366	511 - 6, Allemagne, Ostpreussen	× Sorel	0
3367	511 - 6, Allemagne, Ostpreussen	× Villeroy	0
3368	511 - 7, Allemagne, Ostpreussen	× P.L.	+ 100
3369	511 - 7, Allemagne, Ostpreussen	× Sorel	10
3370	511 - 7, Allemagne, Ostpreussen	× Villeroy	3
3371	462 - 8, Hongrie, Sellye	× P.L.	+ 100
3372	462 - 8, Hongrie, Sellye	× Sorel	2
3373	462 - 8, Hongrie, Sellye	× Villeroy	4
3374	462 - 9, Hongrie, Sellye	× P.L.	+ 100
3375	462 - 9, Hongrie, Sellye	× Sorel	0
3376	462 - 9, Hongrie, Sellye	× Villeroy	3
3377	462 - 10, Hongrie, Sellye	× P.L.	40
3378	462 - 10, Hongrie, Sellye	× Sorel	2
3379	462 - 10, Hongrie, Sellye	× Villeroy	0
3380	431 - 11, Hongrie, Novajidrany	× P.L.	+ 100
3381	431 - 11, Hongrie, Novajidrany	× Sorel	2
3382	431 - 11, Hongrie, Novajidrany	× Villeroy	2
3383	161 - 12, Suisse, Zugerberg	× P.L.	65
3384	161 - 12, Suisse, Zugerberg	× Villeroy	0
3385	160 - 13, Suisse, Frick-Ag	× P.L.	31
3386	160 - 13, Suisse, Frick-Ag	× Villeroy	0
3387	512 - 14, Roumanie, Arges	× P.L.	+ 100
3388	512 - 14, Roumanie, Arges	× Sorel	20
3389	512 - 14, Roumanie, Arges	× Villeroy	25
3390	431 - 15, Hongrie, Novayidrany	× P.L.	45

[1] P.L.: Pollinisation libre.

Tableau 1 (suite)

n° croisement	n° arbre, provenance × provenance		nombre de descendants
3391	431 - 15, Hongrie, Novayidrany	× Villeroy	0
3392	161 - 16, Suisse, Zugerberg	× P.L.	+ 100
3393	161 - 16, Suisse, Zugerberg	× Sorel	80
3394	161 - 16, Suisse, Zugerberg	× Villeroy	10
3395	161 - 17, Suisse, Zugerberg	× P.L.	+ 100
3396	161 - 17, Suisse, Zugerberg	× Sorel	0
3397	161 - 17, Suisse, Zugerberg	× Villeroy	3
3398	160 - 18, Suisse, Frick-Ag	× P.L.	+ 100
3399	160 - 18, Suisse, Frick-Ag	× Sorel	13
3400	160 - 18, Suisse, Frick-Ag	× Villeroy	34

PROJET G 79-1. AMÉLIORATION DE L'ÉPINETTE NOIRE PAR G. VALLÉE

Mots-clés: étude de populations, densité basale.

Travaux réalisés en 1979 et 1980

Dans un secteur d'amélioration du nord-ouest du Québec situé entre les longitudes 77°O et 79°30'O et entre les latitudes 48°N et 49°N, vingt-deux peuplements d'épinette noire ont été localisés avec une distribution la plus uniforme possible sur ce territoire. Dans chaque peuplement 10 arbres, espacés d'au moins 100 m, ont été sélectionnés dans le but de les utiliser comme géniteurs dans un verger à graines et pour réaliser des études génétiques.

Deux campagnes de greffage des arbres sélectionnés ont eu lieu au printemps 1979 et 1980 avec très peu de succès.

Durant l'été 1980, deux carottes ont été prélevées, à l'aide d'une sonde Pressler de 10 mm de diamètre, du côté sud et du côté nord des troncs de chaque arbre sélectionné (220 au total), dans le but de réaliser une étude sur la densité basale et la longueur des fibres du bois. Cette étude a été faite en collaboration avec le professeur Jean Poliquin qui a supervisé les analyses et dirigé le mémoire de fin d'études de monsieur Guy Boucher, étudiant à la faculté de foresterie et géodésie de l'université Laval.

Résultats

Les premiers résultats sur 8 peuplements (Boucher 1981) montrent une différence très significative de la densité basale moyenne des peuplements après correction, par analyse de covariance, de l'influence de la largeur des cernes annuels du bois (taux de croissance radial). De plus, il y a une relation très significative entre la densité basale du bois juvénile (0 à 10 ans) et celle du bois adulte (r = 0,72) et il n'y a pas de différence significative entre les côtés nord et sud des troncs.

La densité basale moyenne des 8 peuplements varie de 0,399 à 0,452 du côté nord des troncs avec une moyenne de 0,427. Ces variations équivalent à une différence de 13,3 p. 100 entre le peuplement ayant la densité la plus élevée et celui ayant la plus faible, et de 8,3 p. 100 par rapport à la moyenne des 8 peuplements. Les différences de densité basale entre les arbres d'un même peuplement sont beaucoup plus faibles (± 0,01) en général et ne semblent pas favorables à une sélection individuelle.

En conclusion, les différences de densité basale entre les 8 peuplements suggèrent de faire un choix des populations dans lesquelles sera effectuée la sélection d'arbres-plus pour la réalisation de vergers à graines. Il faut espérer que les données provenant des 14 autres peuplements étudiés confirmeront ce résultat qui a un impact direct sur les gains de production en fibres, vu que l'épinette noire intéresse particulièrement l'industrie des pâtes et papiers. Un rapport détaillé sera produit sur cette étude.

PROJET G 70-3 AMÉLIORATION DU MÉLÈZE (*LARIX*, Mill.) par A. STIPANICIC

Mots-clés: *Larix*, Mill., test de provenances, test de descendances, sélection des arbres, croisements, introduction.

Les travaux concernant le projet d'amélioration du mélèze ont été poursuivis durant les deux dernières années avec la même intensité qu'au cours des années précédentes. Nous avons concentré nos efforts sur *L. decidua* et *L. leptolepis* pour lesquels nous pouvons exploiter une bonne réserve de matériel génétique dans les plantations déjà existantes, mais nous avons aussi continué les travaux avec *L. laricina*, dont l'importance pour nos forêts boréales est indéniable. Notre Service a collaboré avec le professeur Jean Poliquin à la réalisation d'une étude sur les qualités physico-mécaniques des bois des mélèzes d'Europe, du Japon et laricin, réalisé par A. Verville (1980) au Département d'exploitation et utilisation des bois de l'université Laval. Les résultats de ce travail montrent que ces mélèzes, en plantation de 20 à 25 ans, ont une densité basale et une résistance mécanique comparables à l'épinette noire en peuplement naturel, ce qui laisse présager une utilisation comparable pour le sciage.

Récolte des graines

Les deux dernières années n'étaient pas très bonnes au point de vue de la fructification du mélèze. Ainsi, en automne 1979, nous avons récolté seulement 220 arbres de mélèze laricin dans 24 peuplements à travers le Québec.

Plantations expérimentales

En janvier 1980, nous avons mis en marche une expérience comprenant plus de 400 descendances de mélèze laricin. Ce matériel représente une grande partie de l'aire de distribution du L. laricina au Québec et il nous servira pour la formation d'un test de descendances-provenances. L'ensemencement a été fait en serre dans des contenants; au mois de juin, nous avons transplanté les semis dans la pépinière et nous prévoyons les sortir sur le terrain au printemps 1982.

Au printemps 1980, nous avons installé 5 tests de provenances comprenant trois provenances de mélèze d'Europe et neuf provenances de mélèze du Japon. Les graines pour cette expérience, reçues du Service de la restauration, ont été récoltées dans des plantations connues au Québec et le but de l'expérience est de vérifier la qualité de ces plantations comme sources de graines.

Les plants obtenus à partir de 51 lots de graines provenant d'un parc à clones de mélèze en Finlande et pouvant donné des hybrides, nous ont servi à installer un autre test de descendances au printemps 1981. Ce dispositif nous permettra de comparer différents hybrides dont l'arbre-mère était le plus souvent L. sibirica. Le comportement de certains de ces hybrides était très satisfaisant au niveau de la pépinière: l'accroissement moyen était de 50 cm en 2 ans et les familles démontraient une résistance prononcée au froid.

Vergers à graines et parc à clone

En collaboration avec l'Institut National de Foresterie de Petawawa et la compagnie C.I.P. ltée, nous avons continué la sélection des arbres de L. decidua dans la plantation «Avoca» à la Station forestière de Harrington. En nous basant sur l'analyse faite en 1977 par l'I.N.F.P., nous voulons mettre sur pied un verger à graines clonal qui va réunir les meilleures provenances (de Pologne et des Sudètes) représentées dans cette expérience. Au total, 100 arbres ont été sélectionnés dans la plantation «Avoca» et dans une plantation de Petawawa réalisée avec le même matériel que celle de Harrington.

Dans l'arboretum de Lotbinière, nous avons installé un autre verger à graines clonal qui contient 76 clones de L. leptolepis sélectionnés dans une plantation de Harrington. Dans chacune des dix répétitions de cette expérience, nous avons inclus un clone de L. decidua, en espérant obtenir l'hybride L. × eurolepis. Ce verger n'est pas encore complété et nous comptons reproduire les ramets des clones sélectionnés par greffage ou bouturage au cours des deux prochaines années.

Nous avons continué à augmenter notre collection de clones. Présentement, dans le parc à clones de la Station Forestière de Duchesnay, nous avons réuni 100 clones de L. laricina, 100 clones de L. decidua, 75 clones de L. leptolepis, 20 clones de L. × eurolepis, 1 clone de L. sibirica et 2 clones de L. dahurica. Malheureusement, la floraison de ces clones n'était pas suffisamment abondante jusqu'à présent pour nous permettre de procéder à des essais de pollinisation contrôlée.

PROJET G 74-1 AMÉLIORATION DU PIN GRIS (PINUS BANKSIANA LAMB.), PAR R. BEAUDOIN

Mots-clés: Pinus banksiana Lamb., parc à clones, test de descendances, densité basale, population, sélection individuelle.

Tests de descendances

Dans le cadre du programme de recherche sur l'amélioration du pin gris, un test additionnel de provenances-descendances a été réalisé en 1980 dans le canton de Céloron (latitude 49°04' nord, longitude 78°32' ouest) afin d'obtenir de la graine de qualité supérieure pour les reboisements du nord-ouest québécois. Ces quelque 235 lots de graines provenant d'arbres sélectionnés avaient été établis en 1979 sur une station argileuse dans un canton voisin. Avec ce test, le comportement des mêmes provenances-descendances sera étudié sur un sol sableux. Le potentiel de croissance ou l'expression du bagage génétique de chaque provenance ou descendance sera ainsi en relation avec la qualité de la station et l'aptitude de chaque provenance ou descendance à utiliser au maximum chaque saison de croissance.

Dix-huit descendances de la provenance Mattawin ont été installées à Cabano en 1980 (lat. 47°30' N., long. 69°03' O.). Les cônes avaient été récoltés sur des arbres de très belle venue (moyenne de 50 arbres sélectionnés, hauteur 24,8 m, d.h.p. 33,8 cm, âge 95 ans. Ce test a été effectué dans l'optique de suppléer à la faible qualité des populations locales de pin gris comme source d'approvisionnement en semences pour les reboisements de cette région de l'Est du Québec.

Provenance Baskatong

Un parc à clones a été implanté à l'arboretum de Lotbinière (lat. 46°30' N., long. 71°55' O.) en 1980. Quelque 174 clones totalisant 487 ramets provenant du greffage des arbres sélectionnés de la provenance Baskatong y sont représentés.

L'étude de cette provenance montre que les différences de densité basale entre les arbres sélectionnés d'un même peuplement sont assez fortes. La densité du bois juvénile (0 à 10 ans) et celle du bois adulte

(25 à 35 ans) au niveau du d.h.p. varient respectivement de 0,42 à 0,32 et 0,54 à 0,39. Cette variation de la densité basale et sa forte héritabilité incitent à pratiquer une sélection individuelle pour ce caractère afin d'augmenter la production en fibres même si actuellement la majorité des arbres récoltés sont destinés au sciage.

La densité basale du bois juvénile est en relation très significative avec celle du bois adulte au niveau du d.h.p. Le coefficient de corrélation pour l'analyse de 88 échantillons est de 0,32. La sélection pour ce caractère peut donc se faire en bas âge.

L'analyse de la densité basale moyenne du bois juvénile de 88 arbres à deux niveaux du fût indique que celle-ci est similaire au d.h.p. et à 13,56 m du sol (d = 0,38). De plus, il y a une relation très significative entre les densités du bois pour des échantillons prélevés à ces deux endroits (r = 0,65). Un rapport détaillé sera produit sur l'étude des arbres sélectionnés de cette provenance.

PROJET G 77-1. TESTS DE PROVENANCES SUR LE PIN DE MURRAY (*PINUS CONTORTA* DOUGL. VAR. *LATIFOLIA* ENGELM.)

PAR R. BEAUDOIN

Mots-clés: *Pinus contorta* Dougl. var. *latifolia* Engelm., introduction, test de provenances.

Matériel

Vu l'importance de cette espèce sur le plan rendement dans des conditions de croissance semblables à celles du Québec, le Service de la recherche forestière a cherché à exploiter au maximum le matériel (semis) qui lui était offert par d'autres organismes et à utiliser les lots de graines accumulées dans sa banque de semence (collection I.U.F.R.O.).

Observation en pépinière

À l'automne 79 et au printemps 80, des observations portant sur la couleur des aiguilles, les dégâts de gel, la pousse d'août et la hauteur des plants, ont été faites à la pépinière de Duchesnay sur les 134 provenances semées en 1977. Les provenances de Californie avaient un taux élevé de pousses d'août (80 à 90 pour cent des semis) et certaines d'entre-elles présentaient des dégâts de gel.

Plantations comparatives

L'installation des dispositifs expérimentaux a été effectuée en 1980 dans 9 arboretums situés à l'extérieur de l'aire principale de distribution de *Pinus banksiana* (dans l'est du Québec, en Gaspésie, aux Îles-de-la-Madeleine et au sud du fleuve Saint-Laurent), à cause de la sensibilité de *Pinus contorta* à la rouille *Cronartium comptoniae*.

Par la sélection des meilleurs individus parmi les provenances les plus intéressantes, nous espérons constituer des vergers à graines et faire que cette espèce pourra être une option valable pour les reboisements au Québec.

Le comportement, sur les plans croissance et forme, de trois provenances de Colombie-Britannique de Pinus contorta var. latifolia (Beaver Creek, Reid Lake, Cariboo), installées en 1972 à l'arboretum de Matapédia, est très prometteur. Ce matériel (semis 2-3) avait été reçu de la pépinière de Berthierville par l'entremise de monsieur Yves Lamontagne. La hauteur totale des meilleurs sujets, après 10 ans de croissance à partir de la plantation, est de 4 mètres.

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RECOLTE DE CONES ET AMELIORATION DES ARBRES PAR LE SERVICE DE LA RESTAURATION DU MINISTERE DE L'ENERGIE ET DES RESSOURCES DU QUEBEC

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Mots-clés: semences forestières, peuplement semencier, verger à graines, sélection.

Pour réaliser le programme de régénération artificielle prévu dans la politique de développement de l'industrie des pâtes et papiers, le ministère de l'Energie et des Ressources du Québec doit accentuer les efforts au niveau de la récolte des semences, afin de se constituer une réserve adéquate de toutes les essences requises dans chacune des zones où l'on prévoit de la régénération artificielle.

Environ 10 mille hectolitres de cônes sont requis annuellement pour répondre aux besoins du programme de régénération artificielle. Le service de la Restauration du ministère de l'Energie et des Ressources a mis sur pied un programme d'établissement de vergers à graines de production qui devrait permettre dans le futur, l'utilisation de semences améliorées génétiquement pour les besoins des plantations.

RECOLTE DE CONES

Au cours de 1979, 7 123,7 hl de cônes furent cueillis alors qu'en 1980, ce volume a été porté à 10 518,0 hl (tableau 1). 1980 marque une année record pour le volume de cônes récoltés au Québec. Les deux dernières années furent semblables quant à la fructification moyenne de certaines essences comme l'épinette de Norvège, l'épinette noire, le pin gris, le pin rouge et le pin blanc.

AMELIORATION DES ARBRES

Peuplements semenciers

Durant les deux dernières années, des travaux ont été réalisés sur une superficie d'environ 300 ha. Les travaux ont surtout consisté à nettoyer les peuplements déjà établis, à dégager les arbres choisis comme semenciers, à tailler quelques flèches terminales et à arroser certains peuplements contre la tordeuse des bourgeons de l'épinette.

Tableau 1. Quantité de cônes récoltés, par essence, en 1979 et 1980 au Québec.

Essence	Cônes récoltés en 1979	Cônes récoltés en 1980
	.... hl	
Abies balsamea	14,4	0,2
Larix decidua	6,2	1,5
Larix laricina	64,8	6,6
Larix leptolepis	10,2	4,7
Picea abies	643,5	538,8
Picea glauca	154,7	24,2
Picea mariana	1 635,7	631,4
Picea rubens	154,0	--
Pinus banksiana	3 104,4	5 290,8
Pinus resinosa	568,2	333,8
Pinus strobus	671,6	3 511,4
Pinus sylvestris	100,0	174,6
Total	7 123,7	10 518,0

Vergers à graines

Au cours des deux dernières années, l'entretien des vergers à graines déjà établis s'est poursuivi et quelques nouveaux vergers ont été établis.

Dans le canton Briand, la superficie du verger a été portée à 40 ha par l'addition de 24 ha de semis de pin gris. Un verger à graines de semis de pin gris a aussi été installé dans le canton Duvernay, sur une superficie de 12,5 ha avec des descendants de 334 arbres sélectionnés dans la région immédiate.

Avec la collaboration du Centre de recherches forestières des Laurentides, nous avons établi un verger à graines de semis d'épinette blanche avec 200 familles provenant de diverses régions de la Province. Il est situé à St-Georges-de-Beauce.

Un petit verger de semis d'épinettes noires fut installé dans le canton Normandin avec 60 descendances sélectionnées dans les environs. Egalement, 86 provenances de pin rouge furent utilisées dans un verger à graines de semis dans le même canton.

La superficie totale de vergers à graines requise pour les besoins des plantations a été évaluée à 550 ha pour la Province dont une centaine d'hectares sont déjà établis.

Sélection d'arbres

Le programme de sélection d'arbres s'est accentué au cours des dernières années. En date d'avril 1981, 2500 arbres de diverses essences ont été sélectionnés. Ils ont été ou seront multipliés dans des vergers à graines clonaux ou de semis, de première génération, selon les espèces. Ces arbres sont sélectionnés dans les meilleurs peuplements naturels ou artificiels. Ce matériel de base sera aussi utilisé dans divers tests de descendances ou de provenances pour des améliorations futures.

VARIABILITÉ SPATIALE ET TEMPORELLE DE LA CROISSANCE JUVÉNILE DES PROVENANCES D'ÉPINETTE NOIRE AU QUÉBEC

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Mots clefs: épinette noire, black spruce, Picea mariana, provenance, variation.

Plus les exploitations forestières avancent dans la forêt boréale, encouragées par la demande soutenue et l'absence d'une régénération naturelle adéquate après la coupe, et plus les essences proprement nordiques, tel le mélèze laricin (Larix laricina (Du Roi) K. Koch), le pin gris (Pinus banksiana Lamb.) et l'épinette noire (Picea mariana (Mill.) B.S.P.) prennent de l'importance dans les reboisements. Cette dernière espèce, en plus de fournir un bois de première qualité pour la pâte et le sciage, a la capacité de croître sur une gamme de sites allant des tourbières à sphaigne aux affleurements rocheux en passant par les sables peu fertiles et les argiles trop lourdes. Si elle a acquis la réputation d'essence à croissance lente, c'est qu'elle s'accommode souvent d'habitats ne permettant pas un développement rapide. Lorsqu'elle est plantée sur des sites de bonne qualité, son rendement est supérieur à celui de l'épinette rouge (Picea rubens Sarg.), trop sensible aux vents froids et dessèchement de l'hiver et comparable à celui de l'épinette blanche (Picea glauca (Moench) Voss) plus exigeante en éléments nutritifs. Sa résistance partielle à la tordeuse des bourgeons de l'épinette, étroitement liée à sa phénologie, ajoutée à ses caractéristiques spécifiques en fait l'essence numéro 1 pour le reboisement au Québec et dans tout l'est du Canada.

Des études antérieures (Khalil, 1978; Morgenstern, 1969, 1973, 1978) ont démontré qu'il existe des variations génétiques d'origine géographique importantes dans la croissance de l'épinette noire permettant d'espérer des gains substantiels par l'identification et l'utilisation de sources supérieures lors des reboisements. La rapidité d'accumulation des gains génétiques sera fortement liée à la précision avec laquelle l'améliorateur pourra identifier, à bas âge, les populations ou génotypes supérieurs. Plus hâtives et plus sûres seront les sélections et plus rapides seront les gains. Les observations précoces en pépinière permettent-elles vraiment de déceler les provenances à fort rendement chez

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1) Le lecteur est prié de se référer à Corriveau et Vallée, 1981 pour un rapport sommaire des progrès réalisés au cours des dernières années.

l'épinette noire? Quelles sont les relations entre les coordonnées géographiques du lieu d'origine et la performance des sources dans le temps, et dans divers milieux? Telles sont les questions auxquelles nous essayons de répondre dans cette étude.

MATÉRIEL ET MÉTHODES

L'essai de provenances d'épinette noire a été initié en 1968 par l'échantillonnage génétique d'un grand nombre de populations et l'échange de semences entre les collaborateurs. Cent provenances, échelonnées sur quelque 20 degrés de latitude et 110 degrés de longitude, dont 45 du Québec, 15 des Maritimes, 24 de l'Ontario et des états américains des Grands Lacs, et, 16 sources du centre, de l'ouest canadien et de l'Alaska, furent ensemencées à la pépinière de Valcartier au printemps 1970, selon un dispositif aléatoire complet de six répétitions. A l'automne de la même année, dix semis par provenance et répétition furent choisis au hasard et mesurés quant à leur taille et poids. Un nombre égal de semis fut identifié en permanence dès l'année suivante et des mesures de croissance en hauteur furent prises au cours des trois années suivantes. Six essais de provenances furent établis en 1974 et 1975 en milieux forestiers représentatifs des grandes régions d'exploitation du Québec soit les Laurentides, l'Abitibi, la Côte-Nord, et la Gaspésie (tableau 2). Des mesures de croissance et de survie après plantation furent prélevées à l'automne 1979 dans chacun de ces essais.

Les analyses de corrélation, et de régression multiple par étape, conduites à partir des moyennes des provenances, furent utilisées pour interpréter les observations recueillies.

RÉSULTATS ET DISCUSSIONS

Variabilité temporelle

Les coefficients de corrélation de Pearson entre les valeurs moyennes des groupes à différents âges, nous offrent une mesure de l'efficacité des sélections précoces des provenances d'épinette noire. Le tableau 1 indique que ces coefficients sont généralement forts entre deux années consécutives en pépinière mais qu'ils s'affaiblissent proportionnellement au lapse de temps séparant les observations. La corrélation entre la taille des provenances observée en pépinière et celle observée en milieux forestiers, quatre ou cinq ans après la plantation est de faible ($.3 < r < .5$) à très faible ($r < .3$). Remarquons également que les corrélations sont généralement de signe négatif entre les croissances juvéniles observées en pépinière et celles obtenues en milieux forestiers alors qu'elles étaient positives entre les observations faites en pépinière à des âges différents. Outre le choc de transplantation plus sévère que peuvent avoir subi les provenances à croissance rapide, dû à leur plus forte taille, ce phénomène reflète sans aucun doute l'influence des conditions climatiques et édaphiques des différents milieux d'expérimentation sur l'expression du potentiel génétique des sources. Les provenances ayant démontré un fort taux de croissance dans des conditions favorables de climat et de sol de la pépi-

Tableau 1. Coefficients de corrélation de Pearson entre les caractéristiques de croissance juvénile des provenances d'épinette noire en pépinière et milieux forestiers[a)b)c)].

	TEMPS						ESPACE					
	H_1	H_2	H_3	H_6	H_5	H_4	C_1	C_2	C_3	C_4	C_5	C_6
L_1	.54	.42	.40	.49	NS	.37	-.25	NS	-.42	NS	NS	-.54
L_2	.81	.66	.66	.75	.37	.62	NS	NS	-.44	NS	-.23	-.57
L_3	.53	.43	.42	.40	.23	.39	-.28	NS	-.26	NS	NS	-.37
D_1	.35	NS	NS	.30	NS	.19	-.27	-.27	-.29	NS	NS	-.54
P_1	.73	.62	.59	.68	.37	.55	NS	NS	-.43	NS	NS	-.56
P_2	.77	.66	.64	.72	.39	.60	NS	NS	-.41	NS	NS	-.55
P_3	.29	.23	NS	.25	NS	NS	-.23	NS	-.37	NS	NS	-.45
H_1	1.0	.87	.85	.99	.54	.81	NS	-.26	-.52	NS	-.33	-.59
H_2	.87	1.0	.97	.88	.89	.91	NS	-.24	-.58	.25	-.31	-.50
H_3	.85	.97	1.0	.98	.85	.86	NS	-.31	-.55	.24	-.33	-.49
H_6	.99	.88	.98	1.0	.55	.81	NS	-.28	-.50	NS	-.33	-.55
H_5	.54	.89	.85	.55	1.0	.79	NS	NS	-.50	.31	-.23	-.31
H_4	.81	.91	.86	.81	.79	1.0	NS	-.35	-.49	-.22	-.32	-.45

a) Statistiquement significatif à .05 pour $r > .22$, à .01 pour $r > .28$

b) Voir tableau 2 pour la définition des variables

c)

Milieux forestiers	Latitude	Longitude	Altitude m
Mont Laurier	46°36'	75°48'	230
Valcartier	46°52'	71°32'	180
Lac St-Ignace	49°00'	66°20'	430
Labrieville	49°12'	69°33'	490
Amos	48°40'	78°30'	335
Chibougamau	50°03'	74°10'	410

Tableau 2. Coefficients de corrélation de Pearson entre les caractéristiques de croissance des provenances d'épinette noire et les coordonnées géographiques de leur lieu d'origine[a)].

VARIABLES	LATITUDE	LONGITUDE	ALTITUDE
A) Observations en laboratoire			
D_1 Diamètre au collet à 1 an	-.27	-.34	-.27
P_1 Poids total à 1 an	-.58	-.63	-.37
P_2 Poids de la tige à 1 an	-.63	-.64	-.37
P_3 Poids des racines à 1 an	NS	-.31	-.20
L_1 Longueur totale à 1 an	-.43	-.56	-.31
L_2 Longueur de la tige à 1 an	-.73	-.75	-.48
L_3 Longueur des racines à 1 an	-.47	-.56	-.39
B) Observations en pépinière			
H_1 Hauteur totale à 2 ans	-.86	-.72	-.42
H_2 Hauteur totale à 3 ans	-.71	-.51	-.31
H_3 Hauteur totale à 4 ans	-.70	-.49	-.33
H_4 Accroissement de la 4° année	-.66	-.45	-.34
H_5 Accroissement de la 3° année	-.40	NS	NS
H_6 Accroissement de la 2° année	-.85	-.08	-.39
C) Observations en milieux forestiers			
S_1 Hauteur à 10 ans à Mt Laurier	-.44	NS	NS
S_2 Hauteur à 10 ans à Lac St-Ignace	-.35	NS	NS
S_3 Hauteur à 10 ans à Chibougamau	-.33	NS	NS
S_4 Hauteur à 10 ans à Valcartier	-.41	NS	-.23
S_5 Hauteur à 10 ans à Labrieville	-.24	NS	NS
S_6 Hauteur à 10 ans à Amos	NS	.57	NS
C_1 Accroissement périodique à Mt Laurier	NS	NS	NS
C_2 Accroissement périodique à Lac St-Ignace	.22	NS	NS
C_3 Accroissement périodique à Chibougamau	.40	.34	.31
C_4 Accroissement périodique à Valcartier	NS	NS	NS
C_5 Accroissement périodique à Labrieville	.35	NS	NS
C_6 Accroissement périodique à Amos	.44	.38	.37
M_1 Survie à Mt Laurier	NS	NS	NS
M_2 Survie à Lac St-Ignace	NS	NS	NS
M_3 Survie à Chibougamau	.34	NS	NS
M_4 Survie à Valcartier	NS	NS	NS
M_5 Survie à Labrieville	.41	NS	NS
M_6 Survie à Amos	.49	.24	.21

a) NS = Non significatif à 95%

nière sont déclassées au cours des premières années suivant la plantation, par des sources à croissance plus lente. Remarquons que la relation négative entre les hauteurs et accroissements observés en pépinière et ceux mesurés en milieux forestiers s'accentue au fur et à mesure que nous passons à des conditions environnementales plus difficiles par exemple Mont Laurier, Lac St-Ignace, Labrieville, Amos et Chibougamau, par ordre croissant de sévérité. C'est donc dire, que plus le climat et les sols des sites de reboisement sont sévères et moins la sélection précoce, effectuée en fonction d'une croissance rapide en pépinière, risque d'être efficace et plus il est nécessaire de tester les sources dans des conditions environnementales se rapprochant de celles des sites de reboisement.

Variabilité intrinsèque et spatiale

Toutes les caractéristiques de croissance juvénile des provenances d'épinette noire observées en pépinière montrent une diminution significative avec l'augmentation de la latitude, de la longitude et de l'altitude du lieu d'origine de celles-ci. L'effet d'origine est surtout marqué au cours des première, deuxième et quatrième saisons de croissance; ($r = -.7$ avec la latitude, $r = -.5$ avec la longitude et $r = -.3$ avec l'altitude) (tableau 2). L'écart noté à la 3° saison de croissance peut s'expliquer par l'effet du repiquage des semis effectué au printemps de la même année.

Les analyses de régression multiple par étape renforcent les constatations précédentes. Entre 49 et 74 pourcent de la variabilité de la hauteur totale des provenances d'épinette noire, au cours des quatre années en pépinière est expliqué par la variabilité des coordonnées géographiques du lieu d'origine des provenances tel qu'estimé par les coefficients de détermination R^2 (tableau 3). La latitude est de loin la variable indépendante la plus importante suivie de la longitude alors que l'altitude n'apporte une contribution significative qu'à l'accroissement obtenu la quatrième année de croissance. Le fort niveau de signification statistique des équations et des plans de régression calculés dénote l'existence d'une variation de nature clinale importante dans la croissance juvénile de l'épinette noire à travers son domaine. Une telle variation a été notée par Morgenstern (1969) à l'aide de l'analyse de variance. Nous verrons lors d'une étude ultérieure que cette tendance est beaucoup moins marquée dans l'est du domaine de l'espèce.

L'effet d'origine, indiqué par les coefficients de corrélation, sur les hauteurs des provenances observées en milieux forestiers est beaucoup plus saccadé. L'altitude seulement a alors une influence significative. A Amos, site où prévalent des conditions climatiques et édaphiques très sévères, une corrélation positive a été trouvée entre la longitude et la hauteur des provenances, quatre ans après la plantation (tableau 2). Cette relation s'étend aux deux autres variables indépendantes lorsque l'accroissement en milieux forestiers seul est considéré. Dans ces conditions sévères les sources nordiques se sont donc mieux développées que les sources plus sudistes même si les provenances n'ont pas encore atteint une taille suffisante pour subir les froids extrêmes de l'hiver et qu'entre vraiment en ligne de compte leur différentiel de rusticité. Notons qu'aux deux sites de climat continental et froid soit Amos et Chibougamau, les

Tableau 3. Régression multiple par étape de la hauteur totale et de l'accroissement annuel des provenances d'épinette noire sur les coordonnées géographiques de leur lieu d'origine à la pépinière forestière de Valcartier (X_1 = latitude, X_2 = longitude, X_3 = altitude)

AGE	RÉGRESSION MULTIPLE[a)]	R^2
A) Hauteur totale		
1 an	$Y= 3.41 - .0214X_1 - .0066X_2$	.62
2 ans	$Y= 24.47 - .343X_1$	.74
3 ans	$Y= 42.82 - .511X_1$	.50
4 ans	$Y= 93.13 - 1.144X_1$	.49
B) Accroissement annuel		
1° saison	$Y= 3.41 - .0214X_1 - .0066X_2$	.62
2° saison	$Y= 20.52 - .300X_1$	.72
3° saison	$Y= 20.89 - .268X_1 + .029X_2$	.20
4° saison	$Y= 50.30 - .623X_1 - .073X_2 - .0016X_3$	.49

Tableau 4. Régression multiple par étape de la hauteur totale et de l'accroissement périodique en milieux forestiers des provenances d'épinette noire sur les coordonnées géographiques de leur lieu d'origine: X_1 = latitude, X_2 = longitude, X_3 = altitude, Y = centimètre

SITE	RÉGRESSION MULTIPLE[a)]	R^2
A) Hauteur totale à 10 ans		
Valcartier	$Y = 139.2 - .0152X_1 + .0017X_2$	.21
Mont Laurier	$Y = 143.0 - .0223X_1 + .0042X_2$	.58
Lac St-Ignace	$Y = 80.2 - .0072X_1 + .00077X_2$	.15
Labrieville	$Y = 90.6 - .0107X_1 + .0022X_2$	.22
Amos	$Y = 93.3 - .0145X_1 + .0043X_2$	.81
Chibougamau	$Y = 88.9 - .0112X_1 + .0024X_2$	.39
B) Accroissement périodique, 5 à 10 ans		
Valcartier	$Y = 36.29 + .803X_2 - .0018X_3$	.05
Mont Laurier	$Y = 42.75 - .429X_1 + .917X_2$	.05
Lac St-Ignace	$Y = -11.22 + .755X_1 - .194X_2 - .0025X_3$	.30
Labrieville	$Y = -11.39 + .742X_1 - .118X_2 + .0018X_3$	.19
Amos	$Y = - 9.14 + .498X_1 + .0024X_3$	.25
Chibougamau	$Y = - 9.72 + .394X_1 - .0016X_3$	.20

a) Les régressions multiples sont celles dont la dernière variable entrée contribue à accroître la valeur de R^2 par plus de 20% de sa valeur antérieure.

coefficients de corrélation sont de même signe et amplitude. Cette similitude des corrélations se présente également aux sites de climat humide et froid que sont Labrieville et Lac St-Ignace reflétant une certaine stabilité dans la réaction des sources face au climat.

Ce phénomène est moins apparent dans les plans de régression multiple de la hauteur totale des provenances en milieux forestiers sur les coordonnées géographiques de leur lieu d'origine (tableau 4). La diminution de hauteur des provenances avec l'augmentation de la latitude reflète encore la réponse des provenances aux conditions environnementales de la pépinière. Quinze à 81 pourcent de la variation en hauteur des provenances est expliqué par les plans de régression. Quant au signe positif des coefficients de régression de la variable longitude, alors que la corrélation avec la hauteur des provenances est négative, il s'explique par sa colinéarité avec la latitude, (r = .78). Cette aberration pourrait être corrigée par l'utilisation de la régression pseudo-orthogonale (Boudoux et Ung 1978) mais au prix d'une perte de quelque dix pourcent de la variation expliqué.

Les plans de régression multiple obtenus à partir des accroissements en milieux forestiers confirment les observations soulignées antérieurement, soit une grande similitude entre les résultats obtenus aux sites de conditions climatiques comparables. Ces plans indiquent de façon générale un accroissement plus rapide des provenances nordiques dans des sites de conditions climatiques plus sévères que celles de la pépinière (tableau 4).

Probablement dû au choc de transplantation et à la difficulté d'implantation des semis sur les sites d'expérimentation, les plans de régression multiple expliquent une faible fraction seulement de la variation de l'accroissement des provenances soit entre 5 et 30 pourcent. Notons que les R^2 les plus faibles ont été obtenus sur les sites aux conditions climatiques comparables à celles de la pépinière et aux conditions édaphiques les moins sévères. Ceci porte à croire que les pentes des plans de régression obtenus ne sont pas dues exclusivement aux caractéristiques d'adaptation des provenances mais plutôt à une relation de cause à effet entre l'origine des sources et leur facilité d'implantation sur les sites. Les sources nordiques, de taille plus petite, auraient subi un choc de transplantation moins sévère que les sources sudistes de plus forte taille et ainsi auraient repris une croissance normale plus tôt que les provenances sudistes. Cette hypothèse est appuyée par des corrélations négatives calculées à la fois entre les hauteurs des provenances au moment de la plantation et leurs accroissements subséquents ainsi qu'avec leurs taux de survie à Chibougamau (r = -.37**), Labrieville (r = -.45**) et Amos (r = -.29**).

Il semble donc qu'il faudra attendre que les plants se soient bien installés dans chacun des sites et que l'effet de plantation ait disparu avant qu'une interprétation sûre des performances démontrées en milieux forestiers puisse être faite et qu'une sélection efficace des meilleures provenances en fonction des grandes régions de reboisement puisse être effectuée.

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AMELIORATION GENETIQUE DES ARBRES DANS LA MAURICIE

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Mots-clefs: Verger clonal, verger de semis, test de descendance, test de provenance, pin gris, épinettes, mélèze japonais.

Dans la division Saint-Maurice, la recherche en amélioration génétique s'oriente vers la production hâtive d'arbres possédant de bonnes qualités papetières. On s'intéresse surtout aux essences indigènes dont le pin gris (Pinus banksiana Lamb.) et l'épinette noire (Picea mariana (Mill.) BSP) sans pour autant négliger les essences d'avenir comme le mélèze japonais (Larix leptolepis Sub. and Zucc. Gord.) et l'épinette de Norvège (Picea abies (L.) Karst).

PIN GRIS ET EPINETTE NOIRE

Le gros du travail en amélioration porte sur les essences indigènes qui ont déjà manifesté leur adaptation à la région. Une première reconnaissance sur le terrain permet de localiser les réserves de semenciers. Ce sont le plus souvent des peuplements jeunes (20 à 50 ans pour P. banksiana et 30 à 70 ans pour P. mariana) où, de façon consistante, poussent des arbres vigoureux et de belle venue. Les plus beaux sujets sont identifiés lors d'une seconde reconnaissance et on récolte, l'hiver venu, leurs cônes et leurs greffons.

Un total de 119 tiges de P. banksiana et 50 de P. mariana ont ainsi fait l'objet d'une sélection dite "idéaliste" au cours de l'année 1980. Les semences obtenues de ces arbres serviront dans un premier temps à constituer un test de descendance. Parallèlement, on préparera en 1982 des vergers à graines où seront repiqués les semis-plus produits dans les serres de C.I.P. à Harrington. Toutefois, d'ici à ce que ces vergers commencent à fructifier, l'approvisionnement en semences viendra de peuplements choisis (réserves de semenciers) rehaussant ainsi la qualité des semis produits.

Parallèlement à la localisation et à la récolte du matériel génétique se planifie l'installation des différents vergers et tests de descendance. On compte déjà un terrain de 9 ha devant servir de test de descendance. Les autres travaux vraiment tangibles sont axés sur la reproduction asexuée des arbres-plus.

Plus de 169 arbres jugés supérieurs ont ainsi été reproduits à une moyenne de quinze "exemplaires" chacun pour former une banque clonale de 2400 ramets vivants. On se propose de repiquer ces ramets au cours de l'été prochain pour amorcer l'installation d'un verger clonal.

MELEZE JAPONAIS

Parmi les essences exotiques susceptibles de reboiser la région du Saint-Laurent et des Grands Lacs, le mélèze japonais (L. leptolepis) compte parmi les essences les plus prometteuses. Soixante dix-neuf provenances de mélèze japonais faisant partie de l'expérience 428-B-3 ont été plantés à Batiscan près de Trois-Rivières. Chaque provenance est représentée par un total de cent semis formant dix répétitions. Cette disposition permettra de convertir le test en un verger à graines une fois les meilleures provenances connues.

L'évaluation des 79 lots de semis se fera surtout d'après leur croissance et leur résistance au froid.

EPINETTE DE NORVEGE

Bien que susceptible aux gelées et au charençon du pin blanc (Pissodes strobi (Peck)), l'épinette de Norvège (Picea abies (L.) Karst) n'en présente pas moins un bon potentiel comme essence de reboisement. Des tests ont permis d'isoler les provenances les plus prometteuses.

De concert avec le Service Canadien des Forêts et le Centre Ecologique de Harrington, nous établirons l'an prochain un verger clonal des meilleures provenances de cette espèce. Ce verger sera situé à Ste-Angèle-de-Laval, près de Trois-Rivières.

Par ailleurs, poursuivant l'opinion émise par NIENSTAEDT (1965), nous avons implanté 50 greffons d'épinette de Norvège (P. abies) sur de jeunes gaulis d'épinette blanche (Picea glauca (Moench) Voss.). L'expérience regroupait cinq clones de P. abies (AS 81401 à AS 81405) appartenant à l'expérience 277-D-1 de la provenance Proulx, Que. (4027). Cet essai pourrait bien se poursuivre sur une quarantaine d'autres clones si les résultats s'avèrent concluants.

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TREE IMPROVEMENT AT NEW BRUNSWICK DEPARTMENT NATURAL RESOURCES

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Key Words: Stand test, plus tree selection, seed orchards, family test

The New Brunswick Department of Natural Resources has been involved with tree improvement work since the early 1970's. In 1974 an operational tree improvement program was initiated with the Canadian Forestry Service, Fredericton, providing much of the research and technical guidance.

The New Brunswick Tree Improvement Council was formed two years later in order to consolidate the tree improvement efforts of both government and industry (Coles 1979).

The reforestation effort of the New Brunswick Department of Natural Resources includes the outplanting of 30 million seedlings annually. At present, this involves planting 16 million black spruce, 10 million jack pine, 3 million white spruce, 1 million tamarack. Accordingly, the improvement effort has concentrated on these species. A summary of this effort follows.

STAND TESTING

To date, 48 promising black spruce (*Picea mariana* (Mill.) B.S.P.) and 52 promising jack pine (*Pinus banksiana* Lamb.) stands have been reserved. Stand testing has been conducted for most of these stands and 5-year height measurements have been taken. Based on these measurements, a few of the best ones have been designated as seed collection stands. So far, approximately 50 Kg. of black spruce seed has been collected from designated stands.

PLUS TREE SELECTION AND BREEDING

To date, 261 black spruce and 301 jack pine have been selected. Open pollinated families from these selected trees will be used for seedling orchards. Also, 40 white spruce (*Picea glauca* (Moench) Voss) and 24 tamarack (*Larix Laricina* (Du Roi) K Koch) superior individuals have been selected for use in clonal orchards. Some of the grafted material will be outplanted in hedges in order to provide sufficient numbers of scions for all Council members wishing to put in an orchard.

ORCHARD ESTABLISHMENT AND FAMILY TEST

To date, 13 hectares of black spruce, 5 hectares of jack pine, 8 hectares of Ottawa Valley white spruce, and 2 hectares of tamarack seedling orchard have been outplanted. Corresponding family tests have been outplanted by the various Council members throughout each species planting range with the exception of tamarack for which no family testing was conducted. Plans for 1981 include outplanting of an additional 4 hectares of black spruce and 3.5 hectares of jack pine seedling orchard.

Forty (40) hectares have been reserved for white spruce and tamarack clonal orchard. Outplanting will begin in 1982 with a small area of 1 to 2 hectares.

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TREE BREEDING AT THE MARITIMES FOREST RESEARCH CENTRE, 1979 AND 1980

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Key words: population studies, provenance tests, species hybridization, applied tree improvement, tissue and organ culture, Picea, Larix.

It is estimated that almost 100 million trees will be planted annually in the Maritimes by 1987. An opportunity exists to substantially increase forest growth in the Region by utilizing genetically superior seeds and seedlings in these reforestation programs. The objectives of the tree breeding work at the Maritimes Forest Research Centre (MFRC) are 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 obtain a realistic genetic improvement.

HYBRIDIZATION IN PICEA AND LARIX

Interspecific crossing work was continued in 1979 and 1980. In 1979, a total of 268 tree x pollen combinations was attempted using white spruce (Picea glauca (Moench) Voss.) black spruce (P. mariana (Mill.) B.S.P.) red spruce (P. rubens Sarg.) and Norway spruce (P. abies (L.) Karst.) as female parents for crosses with white, black, Sitka (P. sitchensis (Bong.) Carr.), Brewer (P. breweriana S. Wats.), Taiwan (P. morrisonicola Hayata), and Wilson spruce (P. wilsonii Mast.). The hybrid Serbian spruce (P. omorika (Pancic) Purkyne) x black spruce was back-crossed to both parents. Of the crosses attempted, 118 were white x Sitka and yielded almost 40,000 full seeds. The cross black x Sitka which was first made successfully in 1974 was again successful in 20 of 24 attempts. Aside from the backcrosses of the Serbian x black spruce hybrid which were highly successful, the other crosses yielded only a few seedlings which as yet have not been verified as hybrids.

In 1980, 163 tree x pollen combinations were attempted using white, black, red, Norway, and blue spruce (P. pungens Engelm.) as female parents for crosses with black, Sitka, Taiwan, blue, and Oriental spruce (P. orientalis (L.) Link). The hybrid Serbian x black was crossed with Sitka and again backcrossed to black spruce. In addition, two 5-tree diallels of black spruce were successfully completed in cooperation with University of New Brunswick graduate student T.J. Mullin. The white x Sitka crosses were again highly successful; 11 of the 14 black x Sitka crosses yielded viable seeds and all 18 crosses of (Serbian x black) x Sitka produced a few viable seeds.

During 1979 and 1980 work on vegetative propagation of selected hybrid spruces was continued with emphasis on the white x Sitka and black x Sitka hybrids. The first clonal field tests of these hybrids were planted in 1980.

Thirty selected Japanese larch (*Larix leptolepis* (Seib. and Zucc.) Gord.) were used as pollen parents in crosses with up to nine tester females. These materials are being used for progeny testing.

SPECIES AND PROVENANCE TRIALS

The objective of this work is to improve forest growth in the Maritimes by determining the best adapted and productive species and the best provenance within these species for use in various locations in the Region.

A publication on provenances of Norway spruce based on evaluation of 10 provenance experiments planted in the Maritimes between 1961 and 1972 was completed. Norway spruce from eastern Poland and from mid-elevations in the Sudeten and Carpathian Mountains of southern Poland perform well when planted over a wide range of sites in central and southern New Brunswick, Prince Edward Island, and Nova Scotia. Provenances from east of the Baltic Sea, i.e., northeastern Poland, Latvia, Lithuania, western Russia, and White Russia are recommended for use in northern New Brunswick.

In the late summer of 1979, 5-year height and survival were recorded for the cooperative range-wide black spruce provenance trial. This trial is planted in 10 locations in the Maritimes with 50-100 provenances represented at each location. Preliminary evaluation of the data suggests that "best" provenances for the Maritimes can be found between latitudes 45°-47°N over a wide range of longitude extending from the east coast well into the Lake States.

POPULATION STUDIES

In 1979, all the work on population structure was consolidated under this study. Major constituent experiments include five white spruce population structure studies; as well as other inbreeding studies and progeny tests with black spruce and tamarack (*Larix laricina* (Du Roi) K. Koch.). The objectives of these studies are to determine average degree of inbreeding in the natural populations of the respective species and its effects on both quantitative and qualitative traits, and to provide assistance in development of tree improvement strategies.

A progeny test in black spruce designed to provide genetic parameters of unimproved plantations has been started. An objective of this study is to explore the possibility of converting young plantations to seed collection areas to be used until genetically improved seeds are available from seed orchards. This test includes 100 families from plantation-grown trees and 30 families from natural populations, and is field planted in three locations in New Brunswick.

Population studies of tamarack received major emphasis in 1980 in accordance with increased interest in the species among industry and tree breeders. A neighborhood inbreeding study of tamarack by means of four-subpopulation disconnected diallel crosses including selfs and disconnected factorial crosses has been analysed for percent sound seed, survival, greenhouse height, and nursery height and a manuscript was prepared. Estimates of relationship coefficient among near-neighbor (radius 22 m), mid-distance (59 m), and long-distance (135 m) trees were found to be 0.256, 0.226, and 0.112, respectively. Self pollination resulted in a significant reduction in seed set. Estimates of lethal equivalents for the selfed trees ranged from 3.0 to 19.3 with an average number of 10.8. Relatively large specific combining ability variances were obtained for early seedling heights, however, interpretation and application of the variance components were not clear because of the degree of relatedness among neighboring trees.

An open pollinated progeny test of tamarack from three local populations has been established in four locations in the Maritimes Region. This test involved 48 open-pollinated families and, at each location, four replicates of four-tree plots were field planted.

The materials for a clonal progeny test of tamarack for the 1981 field season are being propagated. This work involved production of first stage rooted cuttings from 30 seed propagated families. Within each family, 10 trees were selected, amounting to a total of 300 clones. Up to nine cuttings per clone were produced through juvenile cuttings technique. Eighty rooted cuttings per clone were produced from the first stage rooted cuttings, amounting to a total of 24,000 rooted cuttings for the experiment. The rooting success was satisfactory, but refinement of the juvenile cutting technique for mass production of material would prove useful, especially because the percentage of sound seed in the species has been very low.

TECHNICAL ASSISTANCE PROGRAM

Operational tree improvement in the Maritimes Region is progressing rapidly with technical assistance being provided to all three provinces by the Maritimes Forest Research Centre.

Prince Edward Island has recently completed a large greenhouse-headerhouse complex, part of which is being used for tree improvement. The province has begun a program of selection in black spruce and tamarack and expects to expand to other species in the near future. In 1980, the Department of Forestry outplanted a 3 ha seedling seed orchard of black spruce from New Brunswick sources and this will be expanded with Prince Edward Island and New Brunswick sources in 1982.

The cooperative tree improvement program in Nova Scotia is working with white, red, black, and Norway spruce, and white pine (Pinus strobus L.) and will be reported separately.

The New Brunswick Tree Improvement Council's cooperative program with industry and government is continuing to concentrate on black and white spruce, jack pine (Pinus banksiana Lamb.) and tamarack. The black spruce improvement program has selected approximately 450 plus trees to date, most of which have been established in seedling seed orchards and family tests by the cooperators. About 40 ha of black spruce orchard has been established by five cooperators since 1979 and these will be expanded in subsequent years. The one small orchard established in 1978 is doing extremely well and we expect to have some flowers next year.

The jack pine program in New Brunswick was stalled during 1980 but the two orchards established in 1979 will be expanded in 1981 with seedlings from 105 additional selected families. The Council recently reported the results of 5-year measurements on our first jack pine stand test. Five stands have been designated as seed collection areas.

The white spruce and tamarack programs are expanding. It has been difficult to produce sufficient ramets to establish clonal orchards. Because of this, MFRC and New Brunswick Department of Natural Resources have established hedges to be managed for scion production and hopefully, these will produce enough material to satisfy the orchard demand.

APPLIED TREE IMPROVEMENT PROBLEMS

Many small, but important development problems arise in conjunction with the initiation and implementation of applied tree improvement programs. Studies have been initiated to determine the effect of different thinning and fertilizer regimes upon flower production in young plantations of white and black spruce. White spruce and tamarack cone development has been monitored over the past two growing seasons in an attempt to obtain maturity indices for use in extending their effective collection periods. Preliminary work has been done on establishing a damage appraisal system for cone and seed insects. Finally, the cone/seed storage and handling techniques currently used in the Region are being studied to determine if the full potential of the crops is being realized.

TISSUE AND ORGAN CULTURE

1) In Vitro Vegetative Propagation of Mature Conifers

Small, adventitious embryo- and shoot-like structures have been produced in bud cultures of several conifers. Their formation is stimulated by cold storage and pretreatments with EDTA and malonic acid. (Bonga 1980, 1981). So far none of the adventitious structures have developed into normal plants.

2) The Production of Homozygous Haploid Plants from Halploid Tissue Cultures of Conifers

Male and female gametophytes readily form callus _in vitro_. The callus of female gametophyte origin is completely haploid and remains so through many subcultures over several years. The callus from male gametophytes on the other hand is composed of haploid, diploid, triploid, and aneuploid cells. The non-haploid cells may have arisen from bi-or-tri-nucleate cells in the pollen or pollen tubes in which the nuclei have fused. If so, then the diploid cells in the callus would be homozygous diploid and, theoretically, these cells could serve as the source for the production of homozygous diploid plants. To determine the origin of the non-haploid cells, new karyological techniques are required. Some progress has been made in that direction (Bonga 1978, 1979) and efforts to perfect the techniques are in progress.

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UPDATE OF TREE IMPROVEMENT AT FRASER INC. EDMUNDSTON, NEW BRUNSWICK

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Keywords:Plus tree selection, family test, seedling, seed orchard, stand test.

Fraser's tree improvement program has been directed to gradually obtaining improved stock to plant 14 million seedlings annually. Also, to fulfill Fraser's commitment as a member of the N.B. Tree Improvement Council, Fraser's objective is to supply the nursery with improved seed by the year 2000. Since late 1976, Fraser Inc. have been participating in the Council's recommended program to select and test black spruce (Picea mariana (Mill.) B.S.P.), White Spruce (Picea glauca (Moench) Voss) and tamarack (Larix lariciana (Du Roi) K. Koch).

The following report contains an update of Fraser's activities in the tree improvement field since it started in 1976/77. Activities are herein reported for the first time to the Canadian Tree Improvement Association:

PLUS TREE SELECTION

To date, six (6) tamarack plus trees have been selected. Scions from two (2) tamaracks were collected and grafted at Acadia Forest Experiment Station near Fredericton. A total of fifty (50) white spruce plus trees were selected. Scions from forty (40) of these were grafted at Acadia. Also, a total of 169 black spruce plus trees were selected. Cones were collected from 143 of these. Twenty four (24) plus trees are banked for future selections. Two (2) plus trees were cancelled due to cone damage. Seed from black spruce plus trees have been used within the N. B. Tree Improvement program for seedling seed orchard and family test establishments since 1978.

BLACK SPRUCE SUPERIOR STAND SELECTION

In 1977, two high quality black spruce stands were located and used for stand tests in the 1978 N.B.T.I.C. programs.

GRAFTING OF WHITE SPRUCE SCIONS

In 1979, scions from 27 white spruce plus trees were grafted by Fraser employees. Sixty per cent (60%) of the grafts survived the first growing season. In 1980, scions from thirteen (13) white spruce plus trees were grafted by Fraser employees. Survival rate was 40.4%.

BLACK SPRUCE SEEDLING SEED ORCHARD ESTABLISHMENT

In 1978, a 3.8 ha site near Fraser's Forest Tree Nursery at Second Falls, N. B. was laid out and planted with seedlings from 77 plus trees selected in 1977. A total of 14,000 seedlings were planted.

Late in 1978, a new site near Plaster Rock, N. B. was selected to establish further seed orchard plantings. The site contained 20 ha of prime agricultural land.

In 1979, four (4) ha were planted with seedlings from 158 families selected throughout New Brunswick. A total of 18,000 seedlings were planted. In 1980, an additional 3.8 ha was planted with 16,700 seedlings representing 136 plus trees selected in 1979 throughout New Brunswick. During 1979 and 1980, the seed orchard sites were kept in well maintained condition.

BLACK SPRUCE FAMILY TEST ESTABLISHMENT

In 1978, three (3) black spruce family tests were established in Green River, Kedgwick and Plaster Rock areas. The tests represented 76 families planted at the Second Falls seedling seed orchard. Each test site included 1.22 ha to contain 3,040 seedlings.

In 1979, two (2) black spruce family tests were established. The tests were located in Plaster Rock and Green River areas. Each test represented 136 families, planted with 5,440 seedlings on 3.0 ha.

In 1980, two black spruce family tests were established in additional locations on Fraser limits. The Plaster Rock family test included 125 families (4,800 seedlings on 2.5 ha) and the Green River test site was established on 2.5 ha, representing 112 families (4,480 seedlings). Test sites varied in condition and locations to cover a variety of typical planting sites on Fraser limits.

STAND TESTS

Two (2) stand tests were established in 1978. The Green River stand test contained 3,440 black spruce seedlings, representing 43 stands, on a 1.42 ha site. The Plaster Rock stand test site contained 3,440 jack pine seedlings representing 44 stands on a 1.42 ha site. Both tests suffered 20% to 25% mortality due to drought. Dead seedlings could not be replaced.

OTHER PROJECTS

Approximately 1,800 white spruce seedlings were repotted late 1980 to be used as root stock in a 1982 white spruce grafting program.

1981 TREE IMPROVEMENT PROGRESS REPORT
J.D. IRVING, LIMITED, NEW BRUNSWICH, CANADA

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This report covers the initiation of a genetic tree improvement program and other research activities during the period 1979 - 1981. It describes the annual reforestation effort for company lands and species selected for tree improvement activities. It also describes the acquisition and development of a clonal orchard site, greenhouse propagation, cooperative efforts with the Canadian Forestry Service at Fredericton, the New Brunswick Tree Improvement Council and other associated research projects. The overall objective of all activities is to develop operational company seed orchards and related breeding strategies for the production of genetically superior reforestation nursery stock.

REFORESTATION

During the past 25 years, more than 130 million seedlings have been successfully planted in forest plantations on Irving lands in New Brunswick. At the present time approximately 15 million seedlings are produced annually at our nurseries and outplanted on site-prepared areas. Site preparation measures are varied depending upon the harvesting residues and topography but do include tractor-drawn rollers (choppers), crushing machines, bulldozing, V plows and burning. Plantations are established at a density of about 900 seedlings per acre and all planting to date is done by hand.

The major species grown in the nurseries and outplanted on company lands are black spruce (32%), white spruce (32%), jack pine (28%) and tamarack (8%). Other species such as exotic larches, red pine, Norway spruce, red spruce and miscellaneous hardwoods are also produced and outplanted on a very small scale on selected sites.

Commercial seed collections are made annually based upon the need by species. Since J. D. Irving, Limited has older spruce plantations of known origin, cone collections occur here. Collections are made from only the most vigorous and best phenotypes in an effort to improve the genetic quality somewhat through mass selections. The collections of jack pine and tamarack are made from natural stands with emphasis on vigor and quality. Collections from plantations involve ladders, while pine and tamarack trees are usually felled for collection. Some seed is also collected on a contract basis for sale or exchange with cooperating agencies.

GENETIC IMPROVEMENT

Prior to the initiation of a seed orchard program, plans were activated for the genetic improvement of seed needed for nursery production. Collections were made from only the best phenotypes within a plantation of known origin or from natural stands. In addition, stands were marked and heavily thinned for the establishment of seed production areas. Seed production areas now exist for black spruce, white spruce, jack pine, tamarack and red pine.

For maximum genetic gain, a genetic tree improvement was planned and initiated in the late 1970's. The four species selected were those of major importance in reforestation activities and superior tree searches began. During 1980, a total of 44 superior trees were located and accepted for the four species involved. These trees were grafted during March 1981 in a company greenhouse at the Sussex Nursery for eventual orchard establishment. A total of 1,500 grafts were made. However, additional superior tree searches and propagation will continue until a minimum of 100 selections per species are located.

A clonal orchard site was located during 1980. This forested site is presently being harvested and land cleared, with anticipation of beginning orchard establishment in 1982. A total of 250 acres of clonal orchard is planned for the species involved. The orchard site is about 400 acres in size to permit adequate pollen isolation, and soils are sandy loam for access year round. The area is nearly level and has good cold air drainage. In addition, a small breeding orchard (clonal bank) is being sought at another location. This orchard will be used to preserve all clones used in the production orchard and to complete the controlled pollination work needed for progeny testing. Additional testing will also be possible at this site.

J. D. Irving, Limited is an active member of the New Brunswick Tree Improvement Council and participates in the establishment of co-operative family tests and seedling seed orchards involving all participants. Company plantations are also used for research efforts with the Canadian Forestry Service and University of New Brunswick. CFS and NBTIC have provided good recommendations and assistance in the initiation of the Irving program.

Cooperative efforts have also begun with the USFS-NEFES in the establishment of a loblolly x pitch pine hybrid outplanting on Irving lands in Southern New Brunswick. These efforts, in addition to working with other companies and Government agencies on superior tree exchanges, selections for budworm resistance, preservation of outstanding genotypes of miscellaneous species, etc. increase the progress made for genetic improvement. However, genetic improvement is only one phase of intensive forest management. This, accompanied with protection from fire, insects and disease, weeding with herbicides to reduce competition and thinning, will maximize growth and final harvest from our New Brunswick forests.

FOREST GENETICS, TREE IMPROVEMENT, AND RELATED WORK AT THE UNIVERSITY OF NEW BRUNSWICK 1979-1981

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With the advent of rapidly expanding reforestation programs and the formation of cooperative, industry/government tree-improvement organizations in the Atlantic Provinces, the profile of work in forest genetics, tree improvement, and seed production has been significantly raised at the University of New Brunswick. This, and the establishment of an industry-sponsored Chair in Forest Tree Improvement, has affected teaching and projects at the undergraduate level, and research by graduate students and faculty. The following is a summary of the activity in these areas during the period May 1979 to April 1981.

THE CHAIR IN FOREST TREE IMPROVEMENT

During 1979 nine forest-based industries in New Brunswick agreed to fund for five years a Chair in Forest Tree Improvement in the Department of Forest Resources of the University of New Brunswick. E.K. Morgenstern was appointed to this position and took up his duties 1 January 1981. Research projects are being developed in close liaison with the sponsoring agencies, personnel of the Maritimes Forest Research Centre, the New Brunswick Department of Natural Resources, and other faculty members. A program of graduate courses in forest genetics and tree improvement has been developed in cooperation with D.P. Fowler, Y.S. Park and J.F. Coles, who are Honorary Research Associates of the University. It is anticipated that graduate studies to the Ph.D. level will be added to those at the M.Sc.F. and M.F. level in the near future.

UNDERGRADUATE COURSES AND PROJECTS

All students in the Department of Forest Resources are exposed, in the second year of the B.Sc.F. program, to some of the principles upon which tree improvement is based. This is through a course 'Tree Development and Variation' given by G.R. Powell. In the third year, students whose area of concentration is Tree Biology take a 'Genetics' course in the Department of Biology. All students receive some exposure to tree improvement in Silviculture courses in their fourth year. In each of the past two years, 10 senior students have enrolled in G.R. Powell's course on 'Tree Development in Relation to Reproduction'. In that course, details of the full cycle of seed production for the six Canadian genera of the Pinaceae are dealt with and the topics of cone analysis, seed quality and seed germination are explored through a class project. In 1979, 13 senior students took a 'Forest Genetics' course from C.M. Harrison, who held a two-year appointment in the Department (and who acquired his Ph.D. in Forest Genetics from the University of Idaho in 1980). In the past academic year E.K. Morgenstern taught a Forest Genetics course to 14 senior students.

Undergraduate students are required to write a thesis or report in their final year. In the past two years, 12 students have worked on topics related to tree improvement. Some topics arose from the students' summer work, and some students developed their own projects, while others developed topics from the literature.

Several students have made use of germinators or growth chambers in working with seeds or seedlings. Frame (1980) found that seven Ontario sources of *Picea glauca* (Moench) Voss seed germinated better than seven Nova Scotia sources. All seed sources benefited from stratification, but stratification for 21 days was as good as stratification for 42 days. In assessing maturity of seed on six *P. glauca* trees growing in northern Nova Scotia, Oxenham (1981) found that the numbers of full seeds per cone increased between 3 and 10 August but then varied little through to the final collection 14 September. Seeds extracted immediately after cone collection germinated better than those extracted after the cones had been subjected to cold-air or shack-air storage. Stratification of the seeds for 21 days increased rate of germination but not percentage germination. Eddy (1980) found that heavier seeds from individual trees of black spruce (*Picea mariana* [Mill.] B.S.P.) and Scots pine (*Pinus sylvestris* L.) produced seedlings, at four harvest dates up to 72 days, with longer hypocotyls, a greater number of cotyledons and a greater dry-root mass. Seedlings of *P. mariana* from two lowland and two upland sites in the Thunder Bay area of Ontario were grown for ten weeks on peat and on sand by Trueland (1980). Seedlings of one of the lowland sites grew considerably better on peat, and somewhat poorer on sand than did those of the other sites. The small sample and differences in seed weight, however, call for a cautious interpretation of these results.

Mifflin (1981), after working for D.P. Fowler (Maritimes Forest Research Centre), wrote on hybridization between *P. mariana* and *Picea sitchensis* (Bong.) Carr. She showed that first-year seedlings of the hybrid were intermediate between those of the parents in number of cotyledons and in height growth. However, the hybrid showed heterosis for height growth in the statistical sense because it exceeded the mid-parent value.

According to data of D.P. Fowler, the seed yield per cone of *Larix laricina* (Du Roi) K. Koch in New Brunswick in 1979 was abnormally low. Patch (1980), using Eriksson's (1970) hypothesis, showed that abnormally warm temperatures in late January 1979, followed by very low temperatures in mid February, could have been responsible for the low seed set.

Stewart (1980) investigated crown development and cone bearing in a series of ages of young Pinus banksiana Lamb. trees. He found that initial seed-cone production occurred two years after planting, whereas initial pollen-cone production occurred four years after planting. Cone production generally increased with age and had no apparent detrimental effect on vigor of shoot growth or numbers of branches.

The specific gravity of the wood of discs from different levels in the stem, and of discs and cores from breast height, of 20 P. glauca trees was investigated by Caron (1980). He determined that, in comparison with breast-height discs, cores underestimated specific gravity by 3%, and that the specific gravity of the whole tree could be estimated from two cores at breast height with a coefficient of determination of 0.74. In a study of the specific gravity of 180 comparison and plus trees of P. glauca and Picea rubens Sarg. from Nova Scotia, Birkett (1980) found that nearly half of the plus trees exceeded the mean values of the pair of comparison trees. There was also a difference in specific gravity among seed zones in P. rubens but not in P. glauca which had fewer samples.

Survival and height growth at five years of stock produced from 25 New Brunswick populations of P. banksiana and planted at five sites in the Province were examined by Cherry (1981). Significant differences in performance were apparent and preliminary recommendations were made regarding use of seed from the parent stands.

Ideas for a tree improvement program for Newfoundland were developed by Kelly (1980), and Stocker (1981) wrote on the use of genetics in controlling the spruce budworm (Choristoneura fumiferana [Clem.]), e.g. by changing chromosomes through radiation.

SEED AND CONE PRODUCTION BY YOUNG BLACK SPRUCE

An intensive study of the intrinsic patterns and morphogenesis of the cone and seed production processes in young black spruce trees was begun by G.R. Powell in 1980. The aims of the study, which relate to the use of seedling seed orchards and to stimulation of cone production, are to determine

1. the nature of the build-up of numbers of seed cones and pollen cones borne as plantation-grown trees progress through their first 13 years;
2. the nature of within-crown patterns of production of seed cones and pollen cones, and the relationships between these patterns and those of vegetative development;
3. the precise phenology and morphogenesis of buds, cones and seeds;
4. the effects of variations in site on cone production; and
5. the effects of quantity of cone bearing in one year on that of the subsequent year.

The study has largely been funded through the New Brunswick Tree Improvement Council. A graduate student, Guy E. Caron, received a Bradfield Graduate Fellowship from Noranda, through Fraser Inc., specifically to work on this project. Most of the field work is being conducted in plantations between 4 and 13 years of age located on J.D. Irving lands in northwestern New Brunswick. The Irving company is also providing much on-site assistance.

The older plantations being used bore cones heavily in 1980 and a large quantity of data was acquired and more data will be gathered in 1981 when a poorer cone crop is anticipated. Preliminary analyses of the 1980 data have shown that by 6 years from planting, about 60% of the trees bore seed cones, but only 21% bore pollen cones. Corresponding percentages at 8 years from planting were 93 and 60. At 10 years from planting, over 90% of the trees bore both seed cones and pollen cones. The proportion of the crown which bore cones increased with age of the tree. At 6 years from planting, cones were borne only on the upper two ages of branches whereas by 12 years from planting, seed cones were borne on the upper three ages of branches and pollen cones on the upper nine ages of branches. The numbers of seed cones borne per tree increased substantially between ages 6 and 8 years from planting, and then rose slowly. The numbers of pollen cones per tree were low for trees of both 6 and 8 years from planting and then increased greatly.

Pollen-cone and seed-cone buds burst about 2 weeks before vegetative buds. Pollen-cone growth was rapid and culminated with pollen shedding about 2 weeks after pollen-cone buds had burst. By that time seed cones were fully receptive. Seed-cone closure occurred within about 9 days from full receptivity and was followed immediately by seed-cone inversion. Seed cones reached their full size by early August, about 8 weeks after pollination. At that time shoot elongation had been completed and buds were growing rapidly. Samples of buds and cones at all stages of development were collected for laboratory analyses.

Young plantations of black spruce in northwestern, northeastern and central New Brunswick were used in a study by another graduate student, J. Dale Simpson, of some effects of site features on cone production (Simpson 1981). A total of 300 trees was examined and it was determined that a greater proportion of trees growing on south aspects produced pollen cones and seed cones than trees growing on north aspects. Trees on south aspects (and level sites) produced 2 to 5 times more pollen cones and seed cones than trees on north aspects. The number of seed cones was most signigicantly correlated with tree height, and the number of pollen cones was significantly correlated with the number of seed cones. This study, thus, provided quantitative information to substantiate the recommendation that seedling seed orchards of black spruce be located on southerly sloping sites. On the basis of a literature review, Simpson (1981) also made recommendations for management techniques for seed orchards in New Brunswick.

GENOTYPE X NITROGEN INTERACTIONS IN BLACK SPRUCE SEEDLINGS

A third graduate student, T.J. Mullin (of the Nova Scotia Department of Lands and Forests), is undertaking a greenhouse study of the genotype x nitrogen interactions during the first 25 weeks of growth of seedlings of 40 full-sib families of black spruce. The seeds were sown in January 1981. The objective is to investigate variation in the inherited capacity of black spruce seedlings to take up and use nitrogen.

FUTURE OUTLOOK

Teaching and research are the traditional roles of the university, and as a result of the recent advent of undergraduate teaching in forest genetics, much remains to be done to strengthen this part of the program. Teaching must be interesting to the student, stimulate creativity, and be broadly based to illustrate the complex interrelationships in biological systems. At UNB, we have a chance to reach this goal through interdisciplinary work among faculty and through participation of research associates who have developed many experiments that illustrate important principles.

Research, too, will be cooperative to a large extent. The New Brunswick Tree Improvement Council and Nova Scotia Tree Improvement Working Group will offer opportunities for a variety of studies while providing training opportunities for students at the same time. During the next few years an increasing number of provenance experiments, progeny tests, and other trials will require measurement, analysis, and interpretation. These experiments are primarily concerned with *Picea mariana*, *P. glauca*, *Pinus banksiana*, *Pinus resinosa* Ait, *Pinus strobus* L., and *Larix laricina*, with some variation in the order of importance from one province to the next. Broad-leaved species (for example, those in the genus *Betula*) are only of local importance but will receive attention. More consultation with the individual companies and cooperative agencies will lead to definite plans in the near future.

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SITE SELECTION FOR BLACK SPRUCE (PICEA MARIANA (MILL.) B.S.P.) SEEDLING SEED ORCHARDS AND MANAGEMENT TECHNIQUES FOR SEED ORCHARDS IN NEW BRUNSWICK

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Key Words: black spruce, female strobili, male strobili, slope, aspect, seed orchard site selection, seed orchard management.

The following is an abstract of a report submitted for the M.F. degree at the University of New Brunswick, April, 1981.

Seed orchards are important for the production of quality seed for reforestation. To ensure maximum seed yield, orchards must be located on sites conducive to seed production and must be intensively managed. The objective of this study was to make recommendations on site selection for seedling seed orchards of black spruce and to review, on the basis of the available literature, seed orchard management techniques applicable in New Brunswick.

Ten plantations of black spruce of four ages were selected and a total of 300 trees were examined to elucidate the influence of site, tree age, and height on strobilus production on young trees. Trees growing on south-sloping sites produced two and one-half times more female and five times more male strobili than trees growing on north-sloping sites. Strobilus production on trees growing on south-sloping sites was also greater than that on trees growing on level sites. Number of female strobili was most significantly correlated with tree height. Number of male strobili was significantly correlated with number of female strobili. It is recommended that seed orchards be established on southeast through southwest-sloping sites or level sites with sandy loam or loamy sand soil.

The literature review of seed orchard management techniques revealed that the two types of seed orchards (seedling and clonal) should be treated differently. Generally, however, sites should be thoroughly prepared before orchard establishment, competing vegetation must be controlled at all times, and fertilizer may be applied to maintain and/or enhance tree growth and development and increase strobilus production. Irrigation may also be beneficial to tree growth and strobilus production. Seed orchards must be constantly monitored for and protected against insects, diseases, mammals, birds, and fires. Cone collection crews must be properly trained so as to minimize damage to the trees.

THE TREE IMPROVEMENT WORKING GROUP IN NOVA SCOTIA -- A FIRST REPORT

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Key Words: government-industry cooperation, selection, seed orchards, grafting, genotype-nitrogen interaction.

This is the first formal report to the C.T.I.A. by a representative of the Nova Scotia Tree Improvement Working Group (TIWG). The time period covered is somewhat longer than usual, as an attempt has been made to provide an historical account of the development of tree improvement in Nova Scotia, and the formation of the TIWG program. Progress in plus-tree selection and seed orchard establishment is described.

HISTORICAL

The Early Days

The early work in tree improvement in Nova Scotia, and indeed all of the Maritime Provinces, was done primarily by the Canadian Forestry Service. Of particular note is the work of Dr. H.G. MacGillivray (retired) and Dr. D.P. Fowler, both of the Maritimes Forest Research Centre who established field tests of several species and provenances over much of the Maritimes. They were also responsible for the first delineation of seed zones and rules for seed transfer in the Maritimes (Fowler and MacGillivray 1967).

Interest in tree improvement within the province itself increased markedly in the early '70s as reforestation efforts were expanded to meet fibre requirements. Initial efforts focused on identification of high quality seed sources. Contracts were arranged to locate "superior" stands which could be reserved for seed collections (Sidhu 1972, Bailey 1973).

By the mid-70s, reforestation efforts had gained a higher priority, and both government and industry became interested in plus-tree selection and seed orchard establishment. A report on the potential of tree breeding in Nova Scotia determined that an applied tree improvement program was economically attractive, and could greatly enhance the productivity of planted stands (Mullin 1976). However, it was pointed out that a breeding program would not likely be productive unless it was carried out as a cooperative project among several agencies.

The TIWG Is Formed

The idea of a cooperative tree improvement effort was not new, and appealed to the larger agencies who came together in April of 1977 to form the Tree Improvement Working Group. Membership in the TIWG is as follows:

Bowater Mersey Paper Company Limited
Nova Scotia Forest Industries
Scott Paper International, Inc.
Nova Scotia Department of Lands and Forests (NSLF)
Canadian Forestry Service (Maritimes Forest Research Centre)

With the exception of the CFS, all members participate in the operational aspects of the program: selection, seed orchard management, testing, etc. Planning and coordination of the overall program is carried out by the Tree Breeding Section of the Department of Lands and Forests, working closely with technical advisors and research scientists at the Maritimes Forest Research Centre.

During the first year of the TIWG program, members participated on a completely informal basis, becoming familiar with breeding methods and developing ideas for a cooperative improvement strategy. Late in 1977, the Management Committee of the TIWG assembled a five-year work plan which spelled out performance targets for each agency (TIWG 1977). The allocation of workload (and benefits) was proportioned according to the nursery production targets of each agency. High-level officials then exchanged letters of commitment to the five-year plan.

PROGRESS TO DATE

Selection

Since the TIWG was formed, over 650 plus-trees have been selected for inclusion in the program. Emphasis was placed on selection of white spruce (*Picea glauca* (Moench) Voss), black spruce (*Picea mariana* (Mill.) B.S.P.), and red spruce (*Picea rubens* Sarg.), as these make up the majority of nursery stock planted in the province. However, plus-trees have also been selected in white pine (*Pinus strobus* L.), jack pine (*Pinus banksiana* Lamb.), and Norway spruce (*Picea abies* (L.) Karst.).

Selection is performed using a comparison tree method based on the North Carolina State University system, with slightly different criteria used for each species. All selected candidates are inspected by Tree Breeding Section staff before being approved for breeding work. Black spruce and jack pine plus-trees are felled and seed collected for development of seedling seed orchards. Scions from red, white, and Norway spruce, and white pine are grafted for establishment in clonal seed orchards.

Seed Orchards

A small (1.6 hectares) red spruce orchard was established in 1977 by the Department of Lands and Forests in Lawrencetown, Annapolis Co., as a result of early selection and grafting efforts. Since the formation of the TIWG, an additional 4.7 hectares of grafted orchard (3750 ramets) have been established at three locations. Scions are collected from plus-trees by climbing crews employed by the industrial members. Grafting is done by Tree Breeding Section staff, who tend the seedlings until ready for shipment to orchard sites. Over 6000 ramets are currently being held in transplant beds at the Tree Breeding Centre in Debert. A clone bank containing over 700 ramets has also been established to produce additional scion material and to facilitate controlled pollination work.

Grafted orchards are planted at 5 x 2.5 m spacing, anticipating removal of 50% of the trees through mortality and roguing as a result of progeny testing. The orchard design is based on the permutated neighbourhood concept, using a computer program adapted from Bell and Fletcher (1978). Output from the program was modified somewhat to simplify packing procedures in the nursery and identification of planting locations in the field.

A 3.6 hectare seedling seed orchard was established in 1978 using white spruce seed collections from the Ottawa Valley. Preliminary test results indicate that these sources may have significant potential in this region (Fowler and Coles 1977). Seed collections have been made for two black spruce seedling seed orchards and associated family tests to be established in the spring of 1982. One of these orchards will produce seed intended for use on the Highlands of Cape Breton. The second orchard will serve the remainder of the province, and will be established from selected trees in Nova Scotia and southern New Brunswick.

Virtually every member of the TIWG has experienced difficulties in locating seed orchard sites. Large areas with suitable soils, topography, access and climate are extremely rare on freehold and leased lands. This has led some members to negotiate purchases of land in the Annapolis Valley of Nova Scotia which is considered to have climate and soils highly suited to seed production (Coles 1980).

Test Plantations

Since 1977, members of the TIWG have outplanted over 20 hectares of test plantations. These include tests of black spruce stands in Nova Scotia and New Brunswick, white spruce from Nova Scotia and the Ottawa Valley, and red spruce from local sources. Tests of hybrid spruce and larch (*Larix* Mill.) materials have also been established in cooperation with the Maritimes Forest Research Centre.

Tree Breeding Centre

Until recently, grafting and production of test seedling stock was carried out at Provincial forest nurseries, and at the Acadia Forest Experiment Station near Fredericton, New Brunswick. Early in 1981, facilities at the Tree Breeding Centre at Debert in central Nova Scotia were put into operation (Figures 1 and 2). The Centre is operated by Tree Breeding Section personnel and was built with assistance from The Department of Regional Economic Expansion.

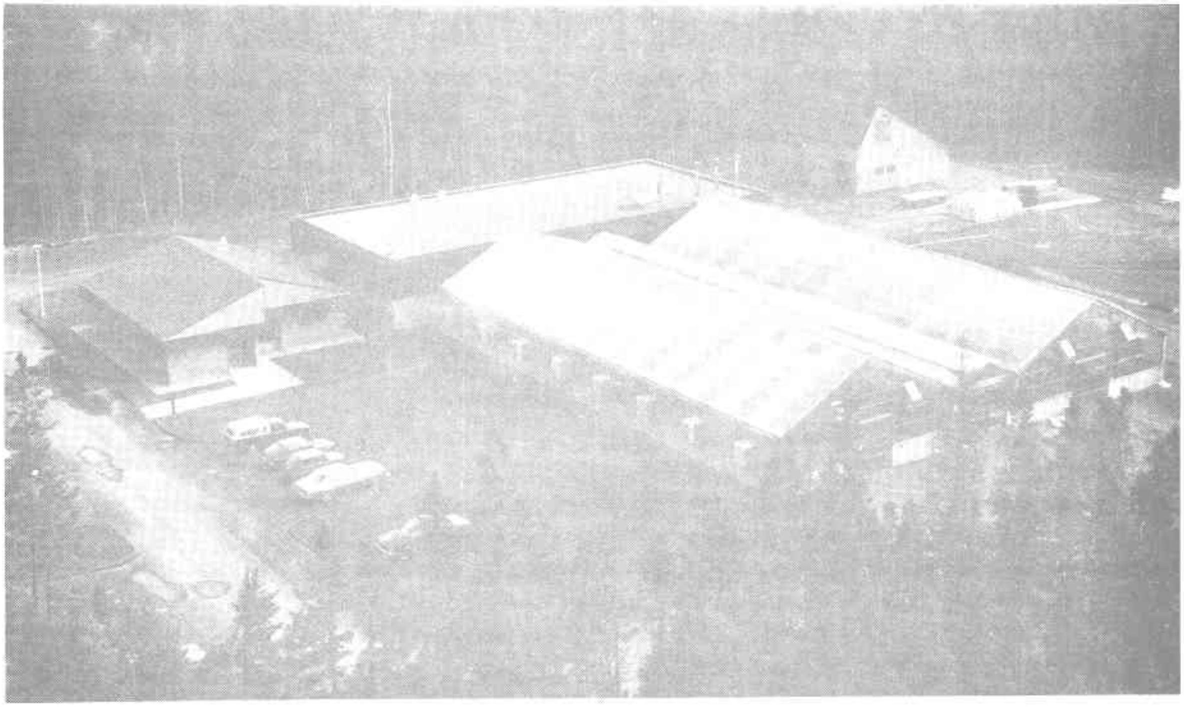

Figure 1. The Tree Breeding Centre, Debert, Nova Scotia began operation early in 1981. Built by the Department of Lands and Forests with assistance from DREE, the Centre provides nursery, office, and lab facilities to serve the Tree Improvement Working Group program.

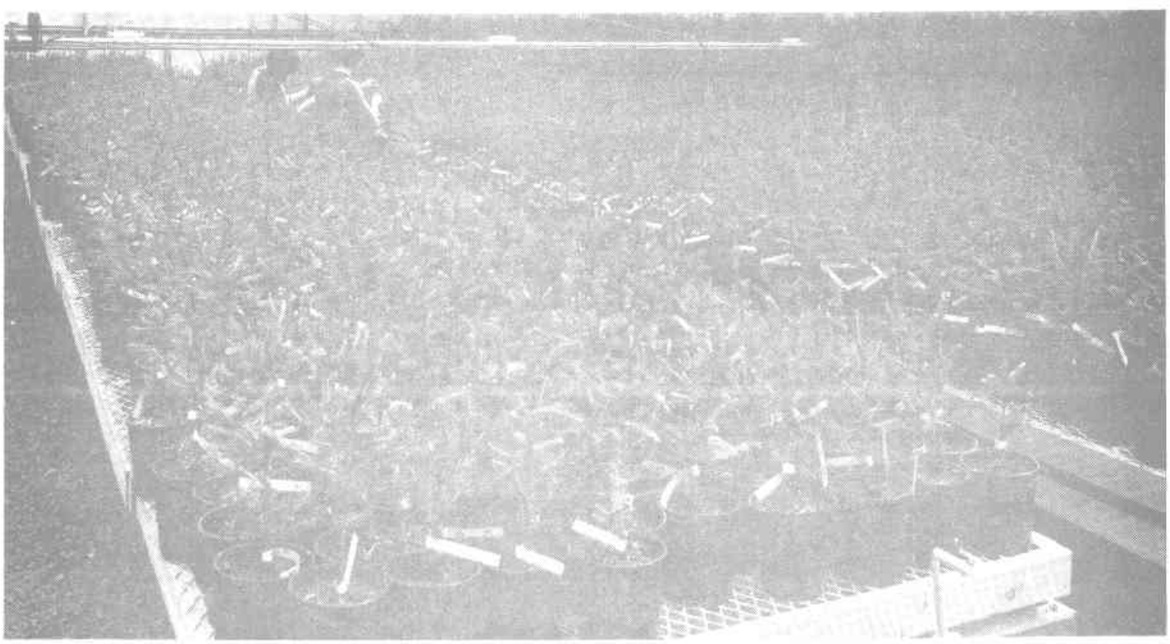

Figure 2. Over 6,000 spruce grafts are tended in one of the Centre's greenhouse zones. The zone is equipped with a double poly roof, rolling bench system, under-the-bench heating, pad cooling, combination irrigation/fertilization/photoperiod control boom, high-pressure sodium lighting, and shade/thermal blanket system.

The facility consists of greenhouse, laboratory and office space devoted to providing special services to the TIWG program, and is located adjacent to a 210 ha area reserved for seed orchard development by NSLF. The 930 m^2 greenhouse is divided into four equal-sized zones, each under independent climate control. This configuration has proven to be extremely useful, as ideal climate conditions can be maintained for grafted or rooted seedlings, while a neighbouring zone is being used to germinate a family test.

MISCELLANEOUS

From September 1980 to May 1981, I was on educational leave from NSLF to fulfill the residence requirements for an M.Sc.F. degree at the University of New Brunswick, specializing in forest genetics. Dr. E.K. Morgenstern and Dr. D.P. Fowler are co-supervising my thesis research, investigating genotype-nitrogen interactions in black spruce seedlings. A disconnected diallel mating design was used to produce 40 full-sib families which were grown under three levels of nitrogen in a replicated greenhouse experiment. Work in this area will continue beyond the scope of the thesis as part of the TIWG program.

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TRIALS OF EXOTIC SPECIES AND GENETIC IMPROVEMENT OF LARCH IN NEWFOUNDLAND

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Key Words: exotics, hybridization, microsporogenesis, seed yield.

Trials of exotic conifers have now been underway in Newfoundland for fifteen years and preliminary assessments are now being made of their suitability. In general, the pines and spruces tested have not proven superior in growth rates to native species but Larix kaempferi and L. eurolepis have.

The effects of low temperature on pollen development in Larix is being studied to determine if pollen sterility results in low seed yields. Early data indicate that low temperatures do not cause pollen sterility in native Larix but may in exotic Larix.

A series of controlled pollinations has been done on Picea mariana and P. glauca to compare the effects of self-pollination, cross-pollination and open-pollination.

I. TRIALS OF EXOTIC SPECIES

1. Plantation of Exotic Pinus Species

This plantation was established on a burned cutover in 1966 with two year old stock. Four species, P. sylvestris, P. banksiana, P. contorta and P. resinosa had survival of 75% or greater. Three species, P. albicaulis, P. cembra and P. nigra v. corsicana were rated as failures. Average total height was greatest for P. banksiana and least for P. resinosa (Table 1). Differences between replications were also statistically significant, a reflection of the varied site conditions within the plantation.

Compared to black spruce regeneration in the area, however, the heights attained by the pines are not impressive. At 15 years black spruce natural regeneration can be expected to grow to a height of 3.5 to 4.0 metres so there is little advantage in terms of productivity gained by use of the exotic species.

Table 1. Average total height of 15-year old *Pinus*.

Species	Origin	Avg. total ht. (m)
Pinus banksiana	Newcastle, New Brunswick	3.58*
P. sylvestris	Kuorevesi, Finland	2.70 a
P. sylvestris	Morayshire, U.K.	2.50 ab
P. contorta	Long Beach, Washington, U.S.A.	2.39 ab
P. resinosa	Petawawa NFI, Ontario	1.84 b

*Means followed by the same letter are not statistically different from each other at p level 0.95.

2. Plantation of Native and Exotic *Larix*

Remeasurements were made in 1980 on a plantation of exotic *Larix* when the trees were eight years old from seed. Survival was poor in some species (Table 2) because many trees had poor root development

Table 2. Survival and average total height of *Larix* plantation trial.

Species	Origin	Percentage survival	Avg. total ht. (m)
Larix laricina	Petawawa NFI, Ontario	97.8 a	1.21 a
L. eurolepis	Mabie Seed Orchard, Scotland	83.3 ab	1.49 b
L. eurolepis	Newton Seed Orchard, Scotland	67.8 b	1.56 b
L. sibirica	Krasnojarsk, USSR	57.8 bc	1.32 a
L. kaempferi	High Meadow Forest, England	50.0 c	.62 c
L. sibirica	Krasnojarsk, USSR	43.3 c	.92 d

in the nursery and because both *L. kaempferi* and *L. sibirica* had flushed before planting. (It is essential in Newfoundland to grow late flushing varieties of larch and to plant them as early in the spring as possible.) None of the exotics have survived as well as the native *L. laricina*. Once established, however, both *L. kaempferi* and *L. eurolepis* grew faster than the *L. laricina*. Both seedlots of *L. eurolepis* were significantly taller than *L. laricina*.

3. Comparison of 15-Year-Old Native and Exotic Species

Comparisons of planted native and exotic species on both upland and barren sites (Tables 3, 4) have shown that *Larix* generally outgrows native black spruce and other exotic pines and spruces and that on some sites *L. kaempferi* outgrows all other larches.

The results indicate an excellent potential for the introduction of Larix as reforestation species in Newfoundland.

Table 3. Average total height of planted Picea mariana and Larix spp. on three productive upland sites in western, central and eastern Newfoundland.

Species	Origin	Avg. total ht. (m) after 15 yrs.		
		Western	Central	Eastern
Picea mariana	Northumberland Co., N.B.	3.13	1.48[1]	1.68
Larix laricina	Guysborough Co., N.S.	4.58	4.68	2.90
L. decidua	Central Europe	4.72	2.16	1.88
L. decidua	Region VI, Germany	4.52	1.86	2.27
L. kaempferi	Region VII, Germany	4.97	3.03	2.52
L. kaempferi	Region VII, Germany	4.79	3.64	3.15
L. kaempferi	Mt. Yatsugatake, Nagano, Japan	5.31	2.45	2.87

[1]This seedlot was severely suppressed by nearby regeneration. Natural regeneration in the area averages about 4 m at age 15.

Table 4. Average total height (m) of Larix and other conifers on ploughed peat bog and on a ploughed heath.

Species	Origin	Ploughed peat bog	Ploughed heath
Larix laricina	Guysborough Co., N.S.	-	4.12
L. kaempferi	Region VII, Germany	2.35	-
Picea mariana	Badger, central Newfoundland	.53	1.20
P. glauca	Guysborough Co., N.S.	-	1.21
P. abies	Vilppula, Finland	.24	-
P. sitchensis	Terrace, B.C.	.24	-
Pinus banksiana	Northumberland Co., N.B.	-	3.28
P. sylvestris	Kuorevesi, Finland	1.31	-
P. sylvestris	Morayshire, U.K.	-	2.73

II. GENETIC IMPROVEMENT OF NATIVE CONIFERS

1. Genetic Improvement of Larch, *L. laricina*

(i) Pollen development

The relationship between pollen development and climate is being studied in *L. laricina*, *L. kaempferi*, *L. decidua* and *L. eurolepis*. Studies of pollen development have been completed in *L. laricina*. Results showed that pollen mother cells began development from Interphase in early to mid-October passing through Leptotene, Zygotene and Pachytene by 10 November. They remained in Diplotene until mid-March to early April when meiosis was completed over a two to four week period. Microspores were produced by early May. The general pattern of meiotic divisions, their sequence, duration and variability within and between trees was similar to that reported earlier for *L. decidua*, *L. kaempferi*, *L. sibirica* and *L. eurolepis*.

Deviation from the normal pattern occurred infrequently. In six trees the "resting Diplotene" of the winter was interrupted on one occasion and some male strobili had a "delayed meiosis" which occurred several days after meiosis in all other sampled strobili. Abnormal chromosome separations were observed on a few occasions, these consisted mostly of lagging chromosomes, a common abnormality in *Larix*.

There appeared to be no causal relationship between temperature and the onset of the various stages of meiosis. The number of abnormalities observed indicated that the low seed sets observed in *L. laricina* could not be attributed to sterile pollen arising from temperature-induced damage.

Examination of the pollen mother cells of the exotic larches indicated that meiotic development occurs two to four weeks earlier than *L. laricina*. A higher proportion of damaged cells was observed in the exotics but as yet, data are too few to show whether seed production is likely to be affected.

(ii) Inter-specific and intra-specific hybridization

A series of controlled pollinations was done on *L. laricina*, *L. kaempferi*, *L. eurolepis* and *L. decidua* in 1980. Inter- and intra-specific crosses were made and year-old stored pollen was tested. Seed has been extracted and seedlings will be grown as soon as local facilities are available. Self-pollinations were also done on each mother tree.

2. Genetic Improvement of Black Spruce

A series of single-tree pollinations was done to assess yields of seed after open-pollination, cross-pollination and self-pollination. A total of six mother trees 15 to 18 years old of natural origin were used. Seed has been extracted and will be sown in 1981.

A study on plus tree selection was continued. The object was to determine if it was practical to select plus trees for high density without sacrificing growth rate. Most of the fieldwork has been completed and preliminary results indicate that the two variables are not related meaning that selection can be based on one but not both criteria. There also appears to be an equally wide range of variability in growth rate and density.

3. Genetic Improvement of White Spruce

Trees in a 20-year old provenance trial were selected for a series of controlled pollinations. A series of intra- and inter-provenance crosses was done using both fresh pollen and pollen stored for one year. Some cones were lost to squirrels, only recently introduced into Newfoundland. Seed has been extracted and will form part of a seedling seed orchard to be established by the provincial government.

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SEED ORCHARDS AND
STRATEGIES FOR TREE IMPROVEMENT

ATTENDANCE, AUGUST 1981

PROCEEDINGS, PART 2

SYMPOSIUM:

SEED ORCHARDS AND STRATEGIES FOR TREE IMPROVEMENT

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Field Excursion

Workshop: Seed Technology for Seed Orchards

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Eighteenth Meeting, Canadian Tree Improvement Association
Duncan, British Columbia, August, 1981

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